# Standard Bidding Document

## Procurement of EPC Contractor for Package-III Electrical and Mechanical Works
## (Works)

International

Single Stage-Two Envelope

| CORRIGENDUM # 7 | CORR-P13301-007 |
|---|---|
| Initiation Date | August 10, 2026 |

*August 10, 2026*

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# Table of Contents


**REQUEST FOR BIDS** 1

**Instructions to Bidders** 3

**Bid Data Sheet** 31

Bids Data Sheet (BDS) 32

Eligibility Criteria 38

Evaluation Criteria 42

Jobs/Lots 48

Related Services : 51

Work Specifications and Market Rates 52

Scope of Work 53

Price Schedule 55

**General Conditions of Contract** 57

**Special Conditions of Contract** 67

**Bid Securing Declaration** 73

**Contract Form** 75

**Integrity Pact** 78

**Performance Guarantee Form** 80

**Annexure** 83

Cover Annexure – Supersession of PPRA SBD Sections by Project Specific EPC Bidding Documents Volume-I 84

EPC Bidding Document Volume II Employer's Requirement Part 1 Specific Provisions 1

EPC Bidding Document Volume II Employer's Requirement Part 2 Technical Provisions 1

EPC Bidding Document Volume II Employer's Requirement Part 3(1) Drawings 1

EPC Bidding Document Volume II Employer's Requirement Part 3(2) Drawings 1

EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume 1 Part 1 86

EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume 1 Part 2 86

EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume II Part 1 86

EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume II Part 2 86

EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume II Part 3 87

EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume II Part 4 87

EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume II Part 5 87

EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume II Part 6 87

EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume II Part 7 87

EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume III 88

EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume IV 88

EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume V 88

EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume VI 88

EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume VII 89

EPC Bidding Document Volume III Additional Information Part 2 Feasibility Review Report Part 1 89

EPC Bidding Document Volume III Additional Information Part 2 Feasibility Review Report Part 2 89

EPC Bidding Document Volume III Additional Information Part 3 Topographic Mapping Part 1 89

EPC Bidding Document Volume III Additional Information Part 3 Topographic Mapping Part 2 89

EPC Bidding Document Volume III Additional Information Part 4 EIA Report 90

Addendum No. 1 90

Technical Bid Submission Part 1 Form of Proposal / Bid Security 90

Technical Bid Submission Part 2: Application Submission Letter – Employer’s SEA and/or SH Disqualification 90

Technical Bid Submission Part 3: ELI 1.1 with Attachments – Nationality, Eligibility, State owned Entity of the 91

Technical Bid Submission Part 4: ELI 1.2 with Attachments – Nationality, State owned Entity of the Employer' 91
Technical Bid Submission Part 5: Letter of Proposal – Technical Part – Conflict of Interest, Suspension Based c 91
Technical Bid Submission Part 6: PEC Standard License – PEC Licensing (Category C-2) 92
Technical Bid Submission Part 7: Income Tax Certificate (ATL) – Pakistani Firm Tax Registration 92
Technical Bid Submission Part 8: Form CON-2 – History of Non-Performing Contracts, Pending Litigations, Li 92
Technical Bid Submission Part 9: Form CON-3 ES Performance Declaration – Environmental, Social, Health an 93
Technical Bid Submission Part 10 Form CON-4 – Employer's SEA and/or SH Disqualification 93
Technical Bid Submission Part 11 Form CCC – Current Contract Commitments / Work Progress 93
Technical Bid Submission Part 12 Form FIN-3.1 with Attachments – Financial Capabilities 93
Technical Bid Submission Part 13: Form FIN-3.2 – Average Annual Construction Turnover 94
Technical Bid Submission Part 14: Form FIN-3.3 – Current Contract Commitments / Work Progress 94
Technical Bid Submission Part 15: Form EXP-4.1 with Attachments – General Experience 94
Technical Bid Submission Part 16 Form EXP-4.2(a) with Attachments – Specific Construction & Contract Man 1
Technical Bid Submission Part 17: Form EXP-4.2(b) with Attachments – Experience in Key Activities 95
Technical Bid Submission Part 18 Form EXP-4.2(c) with Attachments – Specific Experience in managing ESH 95
Technical Bid Submission Part 19 Design Methodology 95
Technical Bid Submission Part 20: Method Statement for Key Construction Activities 96
Technical Bid Submission Part 20: Testing and Commissioning Strategy 96
Technical Bid Submission Part 21:: Optimization of Timelines for E&M Equipment 1
Technical Bid Submission Part 22: Code of Conduct 97
Technical Bid Submission Part 23: EPC/Turnkey Work Program 97
Technical Bid Submission Part 24: Proposer's Personnel Organization Chart 98
Technical Bid Submission Part 25: Risk Assessment and proposed management plan 98
Technical Bid Submission Part 26: Form EQU – Proposer's Equipment 99
Technical Bid Submission Part 27: Form PER-1 – Key Personnel Qualification and Resource Schedule 99

Technical Bid Submission Part 28 Form PER-2 – Resume and Declaration EPC Contractor's and Key Personne 99
Technical Bid Submission Part 29: Sub-Contractors (if Applicable) – Proposed Sub-contractors and/or Manufac 99
Technical Bid Submission Part 30:Sub-Contractor's Authorization 100
Technical Bid Submission Part 31: Integrity Pact – Fraud and Corruption 100
Technical Bid Submission Part 32: Summary of Procedure for Delay Damages for Interface Milestones (Table- 100
Technical Bid Submission Part 33: Appendix-A Performance Guarantees 100
Technical Bid Submission Part 34: Environmental and Social (ES) Metrics for Progress Reports 101
Technical Bid Submission Part 35: Declaration of Ultimate Beneficial Owners Information for Public Procurem 101
Technical Bid Submission Part 36: any other Miscellaneous document 101
Financial Bid Submission Part 1 Letter of Proposal – Financial Part 102
Financial Bid Submission Part 2 : Table of Adjustment Data – Table A: Local Currency 102
Financial Bid Submission Part 3: Table B Foreign Currency 102
Financial Bid Submission Part 4: Table C: Summary of Payment Currencies 102
Financial Bid Submission Part 5: Price Schedule No. 01 – Supply of Plant from Abroad (Pre-Engineered Structu 103
Financial Bid Submission Part 6: Price Schedule No. 02 – Supply of Plant from within the Employer's Country 103
Financial Bid Submission Part 7: Price Schedule No. 03 – Design Services 103
Financial Bid Submission Part 8: Price Schedule No. 04 – Installation and All other Services 104
Financial Bid Submission Part 9: Price Schedule No. 05 – Summary 104
Financial Bid Submission Part 10: Price Schedule No. 06 – Recommended Spare Parts 104
Financial Bid Submission Part 11 Priced Sub-Activity Schedule for E&M Works – Breakdown of Prices 1
Financial Bid Submission Part 12: Schedule of Payments for E&M Works – Currency Wise Break-Up of Priced 1
Financial Bid Submission Part 13: Schedule of Payments for E&M Works – Apportionment of Contract Price A 1
Financial Bid Submission Part 14: Schedule of Daywork Rates – Labour 105
Financial Bid Submission Part 15: Schedule of Daywork Rates – Materials 106
Financial Bid Submission Part 16: Schedule of Daywork Rates – EPC Contractor's Equipment 106

Financial Bid Submission Part 17: Daywork Summary 106

Financial Bid Submission Part 18: Specified Provisional Sums 106

Financial Bid Submission Part 19: Grand Summary 107

Financial Bid Submission Part 20: Miscellaneous 107

Addendum No. 02 107

Addendum No. 03 107

Addendum No. 04 108

Pre-Proposal Clarifications from Potential Proposers 108

Adjustment Data 109

**Procurement Forms** 111

Past Experience and Completed Contracts 1

Historical Contract Non-Performance, and Pending Litigation and Litigation History 1

Current Contracts and Their Progress 1

Financial Capacity and Net Worth Evaluation Form 1

Average Annual Turnover 1

Past Construction Experiences 1

Contractor's Key Personnel Representative and Their Schedules 1

Financial Resources 1

**Additional Forms and Documents** 115

# REQUEST FOR BIDS

## PROCUREMENT OF CIVIL WORKS

1. The **Attabad Lake Hydropower Project (Member (Water) WAPDA)** has reserved Funds for the procurement planned for FY **2025-26**. The **Attabad Lake Hydropower Project (Member (Water) WAPDA)** intends to apply part of the proceeds of this Fund to cover eligible payments under the contract for the "**Procurement of EPC Contractor for Package-III Electrical and Mechanical Works**" with the reference of "**P13301**".

2. The **Attabad Lake Hydropower Project (Member (Water) WAPDA)** invites sealed Bids from eligible Bidders for procurement of Works **(Procurement of EPC Contractor for Package-III Electrical and Mechanical Works)** described in the bidding documents on **EPADS v2.0**.

3. **Single Stage-Two Envelope** will be used by adopting **Quality Based Selection (QBS)** Technique for the subject procurement, in line with the Public Procurement Rules, 2004 and any Regulations, Regulatory Guides, Procurement Guidelines or Instructions issued by the Authority from time to time.

4. All Bids must be accompanied by a Bid Security amount described in Bid Security Section in Bidding Document in the form of **Bank Guarantee**. Or all bids must be accompanied by bid securing declaration in the format specified in the Bidding documents

5. E-Bidding documents, containing detailed terms & conditions, specifications and requirements etc. are available on **e-Pak Acquisition and Disposal System (EPADS)** at **https://epads.gov.pk/opportunities/federal/procurements/13301** for all the interested bidders registered on **EPADS v2.0**. Bidders are required to get themselves registered on **EPADS v2.0** to participate in Bidding process.

6. The e-bids, prepared in accordance with the instructions in the e-Bidding documents, must be submitted through **EPADS v2.0** on or before **Thursday, August 20, 2026 11:00 AM**. E-bids will be opened by using **EPADS v2.0** on the same day at **Thursday, August 20, 2026 11:30 AM**. Manual submission

of Bids shall not be entertained. Those vendor who have not yet registered on the new version of **EPADS v2.0**, may register themselves on **https://vendors.epads.gov.pk/**. A tutorial to explain the registeration process is available at **https://www.youtube.com/watch?v=MNW6T38v7tc.**

In terms of Rules 48 of Public Procurement Rules, 2004 Grievance Redressal Committee (GRC) is notified for the subject procurement and notification copy is available on the procuring agency's website and on Authority's website at ( **www.ppra.org.pk**).

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# Instructions to Bidders

# A. INTRODUCTION

## 1. **Scope of Bid**

1.1. The Procuring agency/Employer (PA), as indicated in the Bid Data Sheet (BDS) invites Bids for the execution of Works as specified in the BDS and Section V- Works Requirements. The name, identification, and number of lots (contracts) of this National/ International Competitive Bidding process are specified in the BDS.

## 2. **Source of Funds**

2.1. Source of funds as referred in Clause 2 of Bid Data Sheet.

## 3. **Eligible Bidders**

3.1. A bidder may be natural person, company or firm or public or semi-public agency of Pakistan or any foreign country, or any combination of them with a formal existing agreement (on Judicial Papers) in the form of a joint venture or consortium. In the case of a joint venture or consortium, all members shall be jointly and severally liable for the execution of the Contract in accordance with the terms and conditions of the Contract. The joint venture or consortium shall nominate a Lead Member as nominated in the BDS, who shall have the authority to conduct all business for and on behalf of any and all the members of the joint venture or consortium during the Bidding process, and in case of award of contract, during the execution of contract. Verifiable copy of the agreement that forms a joint venture, consortium or association shall be required to be submitted as part of the Bid.

Any bid submitted by the joint venture, consortium or association shall indicate the part of proposed contract to be performed by each party and each party shall be evaluated (or post qualified if required) with respect to its contribution only, and the responsibilities of each party shall not be substantially altered without prior written approval of the Procuring Agency and in line with any instructions issued by the Authority.

*(The limit on the number of members of JV or Consortium may be prescribed*

*in BDS, in accordance with the guidelines issued by the PPRA)*.

3.2. The invitation for bids is open to all prospective bidders subject to any provisions of incorporation or licensing by the respective national/ international incorporating agency or statutory body established for that particular trade or business. Procuring agencies shall specify the registration/licensing requirements for the foreign bidder keeping in view the requirement of that business.

3.3. A Bidder shall not have a conflict of interest. All Bidders found to have a conflict of interest shall be disqualified. A Bidders may be considered to have a conflict of interest with one or more parties in this Bidding process, if they:

3.3.1. are associated or have been associated in the past, directly or indirectly with a firm or any of its affiliates which have been engaged by the Procuring agency/Employer to provide consulting services for the preparation of design or technical specifications of the works that are the subject of the bid; or

3.3.2. have controlling shareholders in common; or

3.3.3. receive or have received any direct or indirect subsidy from any of them; or

3.3.4. have the same legal representative for purposes of this Bid; or

3.3.5. have a relationship with each other, directly or through common third parties, that puts them in a position to have access to information about or influence on the bid of another bidder, or influence the decisions of the Procuring agency/Employer regarding this Bidding process; or

3.3.6. Submit more than one bid in this bidding process.

3.4. A Bidder may be ineligible if –

3.4.1. he is declared bankrupt or, in the case of company or firm, insolvent;

3.4.2. payments in favor of the bidder is suspended in accordance with the judgment of a court of law other than a judgment declaring bankruptcy and resulting (in accordance with the national laws) in the total or partial loss of the right to administer and dispose of its property;

3.4.3. the bidder is convicted, by a final judgment of a Court of Law or relevant Professional Statuary Body, of any offence involving professional conduct;

3.4.4. The bidder is debarred/ blacklisted by a national level Procuring agency/Employer and hence debarred due to involvement in corrupt and fraudulent practices, or performance failure or due to breach of bid securing declaration.

3.5. As and when required, bidders shall provide to the Procuring agency/Employer evidence of their eligibility, proof of compliance with the necessary legal requirements to carry out the contract effectively.

3.6. Bidders shall submit proposal relating to the nature, conditions and modalities of sub-contracting wherever the sub-contracting of any elements of the contract is envisaged.

4. **Eligible Material and Equipment**

4.1. All the material and equipment to be mobilized under the contract shall have their origin in eligible source countries, and all expenditures made under the contract will be limited to such materials and equipment. For this purpose, ineligible countries are stated in the section-IV titled as “Eligible Countries”.

# B. BIDDING DOCUMENTS

5. **Contents of Bidding Documents**

5.1. The scope of Works, bidding procedures, and terms and conditions of the contract are prescribed in the bidding documents. In addition to the Invitation for Bids, the bidding documents which should be read in

conjunction with any addenda issued in accordance with ITB 7.1 include:

Section I -Invitation for Bids

Section II Instructions to Bidders (ITBs)

Section III Bid Data Sheet (BDS)

Section IV Eligible Countries

Section V Evaluation and Qualification Criteria

Section VI Works Requirements Technical Specifications & Schedule of Requirements

Section VII Standard Bidding Forms

Section VIII General Conditions of Contract (GCC)

Section IX Particular Conditions of Contract (PCC)

Section X Contract Forms

5.2. The bidder is expected to examine all instructions, forms, specifications, terms and conditions prescribed in the bidding documents. Failure to furnish all the information required in the bidding documents will be at the bidder’s risk and may result in the rejection of his bid.

6. **Clarification of Bidding Document, Pre-bid Meeting**

6.1. A prospective bidder requiring any clarification of the bidding document may notify the Procuring agency/Employer through EPADS.

6.2. The Procuring agency/Employer shall respond to the request for clarification in accordance with Rule 31 of the Public Procurement Rules 2004.

6.3. Should the Procuring Agency deem it necessary to amend the BIDDING document as a result of a clarification, it shall do so following the procedure under ITB 7.

6.4. If indicated in the BDS, the bidder’s designated representative is invited at the bidder’s cost to attend a pre-bid meeting at the place, date and time mentioned in the BDS. During this pre-bid meeting, prospective bidders may request clarification of the schedule of requirement, the evaluation criteria or any other aspects of the bidding documents.

6.5. Minutes of the pre-bid meeting, if applicable, including the text of the questions asked by bidders, including those during the meeting (without identifying the source) and the responses given, together with any responses prepared after the meeting will be uploaded on EPADS. Any modification to the bidding documents that may become necessary as a result of the pre-bid meeting shall be made by the Procuring agency/Employer exclusively through the use of an Addendum pursuant to ITB 7. Non-attendance at the pre-bid meeting will not be a cause for disqualification of a bidder.

6.6. The bidder is advised to visit and examine the Site of Works and its surroundings and obtain for itself on its own responsibility all information that may be necessary for preparing the bid and entering into a contract for construction of the Works. The costs of visiting the Site shall be at the bidder's own expense.

6.7. The bidder and any of its authorized personnel will be granted permission by the Procuring agency/Employer to enter upon its premises and lands for the purpose of such visit, but only upon the express condition that the bidder and its personnel will release and indemnify the Procuring agency/Employer from and against all liability in respect thereof, and will be responsible for death or personal injury, loss of or damage to property, and any other loss, damage, costs, and expenses incurred as a result of the inspection.

7. **Amendment of Bidding Documents**

7.1. The procuring agency may issue notification of any change, addition, modification or deletion in accordance with Rule 23 of the Public Procurement Rules 2004 i.e. Bidding Documents.

7.2. To give prospective bidders reasonable time in which to take an addendum/corrigendum into account in preparing their bids, the Procuring agency/Employer may, at its discretion, extend the deadline for the submission of bids:

Provided that the Procuring agency/Employer shall extend the deadline for submission of bid in pursuance of Rule 27 of the Public Procurement Rules 2004, i.e. Extension of time for submission of bids, if such an addendum is

issued within last three (03) days of the bid submission deadline.

# C. PREPARATION OF BIDS

8. **Language of Bid**

8.1. The bid prepared by the bidder, as well as all correspondence and documents relating to the bid exchanged by the bidder and the Procuring agency/Employer shall be written in the English language unless specified in the BDS. Supporting documents and printed literature furnished by the bidder may be in another language provided they are accompanied by an accurate translation of the relevant pages in the English language unless specified in the BDS, in which case, for purposes of interpretation of the bidder, the translation shall govern.

9. **Documents Constituting the Bids**

9.1. The Bids prepared by the Bidder shall constitute of all the documents required in the BDS.

10. **Documents Establishing Eligibility of Material, Equipment and Works, their Conformity to Bidding Documents**

10.1. The bid prepared by the bidder shall constitute the following components: -

10.1.1. Documentary evidence established in accordance with ITB 10 that the material and equipment to be utilized by the Bidder for the executions of works are eligible material and equipment and conform to the Bidding Documents;

10.1.2. Documentary evidence established in accordance with ITB 11 that the bidder has been authorized to carry out the Construction works;

10.1.3. Documentary evidence established in accordance with ITB 11 that the bidder is eligible and/or qualified for the subject bidding process;

10.1.4. Form of Bid and Bid Prices completed in accordance with ITB 12 and 13;

10.1.5. Completed schedules as required, including priced Bill of Quantities in accordance with ITB 13.

10.1.6. Technical Proposal completed in all aspects in accordance with ITB-15.

10.1.7. Bid security or Bid Securing Declaration furnished in accordance with ITB 17;

10.1.8. Any other document required in the BDS.

10.2. In addition to the requirements, bids submitted by a JV shall include a copy of the Joint Venture Agreement entered into by all members. Alternatively, a letter of intent to execute a Joint Venture Agreement in the event of a successful bid shall be signed by all members and submitted with the bid, together with a copy of the proposed Agreement.

10.3. The bidder shall furnish, as part of its bid, all those documents establishing the eligibility in conformity to the terms and conditions specified in the bidding documents for all material, equipment and works which the bidder proposes to execute.

10.4. The documentary evidence of conformity of the material, equipment and works to the Bidding Documents may be in the form of literature, drawings, and data, and shall consist of:

10.4.1. a detailed description of the work methodology, approach, schedule and resources to be mobilized at site;

10.4.2. an item-by-item commentary on the Procuring agency/Employer’s Technical Specifications demonstrating substantial responsiveness of the material, equipment and works to those specifications, or a statement of deviations and exceptions to the provisions of the Technical Specifications;

10.4.3. any other procurement specific documentation requirement as stated in the BDS.

10.5. The required documents and other accompanying documents must be in English. In case any other language than English is used the pertinent translation into English shall be attached to the original version.

## 11. **Documents Establishing Eligibility and Qualification of the Bidder**

11.1. The bidder shall furnish, as part of its bid, all those documents establishing the bidder's eligibility to participate in the bidding process and/or its qualification to perform the contract if its bid is accepted.

11.2. The documentary evidence of the bidder's eligibility to bid shall establish to the satisfaction of the Procuring agency/Employer that the bidder, at the time of submission of its bid, is from an eligible country as defined in Section-IV titled as "Eligible Countries".

11.3. The documentary evidence of the bidder's qualification to perform the contract if its bid is accepted shall establish to the satisfaction of Procuring agency/Employer that:

11.3.1. The bidder has the financial and technical capability necessary to perform the Contract, meets the qualification criteria specified in Section-V, Evaluation and Qualification Criteria and BDS.

11.3.2. In the case of a bidder not doing business within Pakistan, the bidder is or will be (if awarded the contract) represented by a local bidder (Joint Venture) in accordance with the PEC works bylaws, and in case of award of works such foreign firm is required to participate in the execution of works to carry out its obligations as prescribed in the Conditions of Contract and /or Technical Specifications.

11.3.3. That the bidder meets the qualification criteria listed in Section-V, Evaluation and Qualification Criteria and BDS.

## 12. **Forms of Bid**

12.1. The Bidder shall fill the Form of Bids furnished in the bidding documents. The Bids Form must be completed without any alterations to its format and no substitute shall be accepted.

13. **Bid Prices**

13.1. The bid prices quoted by the bidder in the Standard bid Forms, Bill of Quantities and in the Price Schedules shall conform to the requirements specified below or exclusively mentioned hereafter in the bidding documents.

13.2. The bidder shall fill in rates and prices for all items of the Works described in the Bill of Quantities. If a Price Schedule shows items listed but not priced, their prices shall be construed to be included in the prices of other items in the Bill of Quantities and will not be paid for separately by the Procuring agency/Employer.

13.3. Items not listed in the Price Schedule shall be assumed not to be included in the bid, and provided that the bid is still substantially responsive in their absence or due to their nominal nature, the corresponding average price of the respective item(s) of the remaining substantially responsive bidder(s) shall be construed to be the price of those missing item(s):
Provided that:

13.3.1. where there is only one (substantially) responsive bidder, or

13.3.2. where there is provision for alternate proposals and the respective items are not listed in the other bids,
The Procuring agency/Employer may fix the price of missing items in accordance with market survey, and the same shall be considered as final price.

13.4. The Bid price to be quoted in the Form of Bid in accordance with ITB 12 shall be the total price of the bid.

13.5. Unless otherwise specified in the BDS and the Contract, the rates and prices quoted by the bidder are subject to adjustment during the performance of the Contract in accordance with the provisions of the

Conditions of Contract.

13.6. If so specified in ITB 1.1, bids may be invited for individual lots (contracts) or for any combination of lots (packages).

13.7. Prices quoted by the Bidder shall be fixed during the bidder's performance of the contract and not subject to variation on any account. A bid submitted with an adjustable price will be treated as non-responsive and shall be rejected, pursuant to ITB 27, unless otherwise price adjustment is permissible under Conditions of the Contract.

13.8. All duties, taxes, and other levies payable by the Contractor under the Contract, or for any other cause, as of the date twenty-eight (28) days prior to the deadline for submission of bids, shall be included in the rates and prices and the total bid price submitted by the bidder.

## 14. **Currencies of Bid and Payment**

14.1. Prices shall be quoted in Pakistani Rupees unless otherwise specified in the BDS. Comparison of bids and tie of bid shall be treated in accordance with the Rule 30(2) of Public Procurement Rules, 2004.

## 15. **Documents Comprising the Technical Proposal**

15.1. The bidder shall furnish a Technical Proposal including a statement of work methods, equipment, personnel, schedule and any other information as stipulated in Section VII – Standard Bid Forms, in sufficient detail to demonstrate the adequacy of the bidder's proposal to meet the work requirements and the completion time.

## 16. **Bid Validity Period**

16.1. Bids shall remain valid for the period specified in the BDS after the bid submission deadline prescribed by the Procuring agency/Employer. A bid valid for a shorter period shall be rejected by the Procuring agency/Employer as non-responsive. The period of bid validity will be determined from the complementary bid securing instrument i.e. the expiry period of bid security or bid securing declaration as the case may be.

16.2. Under exceptional circumstances, prior to the expiration of the initial Bids/Bid validity period, the Procuring Agency may request the Bidders' consent to an extension of the period of validity of their Bids/Bid. Such request for extension of the period of bid validity shall be carried out in accordance with Rule 26 of the Public Procurement Rules, 2004.

## 17. **Bid Security or Bid Securing Declaration**

17.1. Pursuant to ITB 11.1 unless otherwise specified in the BDS, the bidder shall furnish as part of its bid, a Bid Security in accordance with Rule 25 of the Public Procurement Rules, 2004 in the amount and currency specified in the BDS or Bid Securing Declaration as specified in the BDS in the format provided in Section VII (Standard Bidding Forms).

In case Procuring agency/Employer is inviting bids in lots / packages, the bidder shall be required to submit his bid security against the respective lot/ package for which he is submitting his bid.

Until the development of functionality of auto verification of financial instrument in EPADS, the scanned copy of bid security or bid securing declaration, as the case may be, shall be uploaded on E-PADS whereas the original instrument to be submitted to the procuring agency before closing of bid submission deadline,

17.2. The Bid Security shall be denominated in the local currency or in another freely convertible currency, and it shall be in the form specified in the **BDS** which shall be in any of the following:

17.2.1. A bank guarantee, an irrevocable letter of credit issued by a Scheduled bank in the form provided in the Bidding Documents or another form acceptable to the Procuring agency/Employer and valid for twenty-eight (28) days beyond the end of the validity of the Bid. This shall also apply if the period for Bid Validity is extended. In either case, the form must include the complete name of the bidder;

17.2.2. A cashier's or certified cheque; or

17.2.3. Another security as indicated in the **BDS**.

17.3. The Bid Security or Bid Securing Declaration shall be in accordance with the Form of the Bid Security or Bid Securing Declaration included in Section VII (Standard Bidding Forms) or another form approved by the Procuring agency/Employer prior to the bid submission.

17.4. The Bid Security shall be payable promptly upon written demand by the Procuring agency/Employer in case any of the conditions listed in ITB 17.9 are invoked.

17.5. Any bid not accompanied by a Bid Security or Bid Securing Declaration in accordance with ITB 17.1 or 17.3 shall be rejected by the Procuring agency/Employer and shall be declared as non-responsive bid, pursuant to ITB 27.

17.6. Unsuccessful bidders' Bid Security will be discharged or returned as promptly as possible, however in no case later than thirty (30) days after the expiration of the period of Bid Validity prescribed by the Procuring agency/Employer pursuant to ITB 16. The Procuring agency/Employer shall make no claim to the amount of the Bid Security, and shall promptly return the Bid Security document, after whichever of the following that occurs earliest:

17.6.1. The expiry of the Bid Security;

17.6.2. The entry into force of a procurement contract and the provision of a performance security (or guarantee), for the performance of the contract if such a security (or guarantee), is required by the Biding documents;

17.6.3. The rejection by the Procuring agency/Employer of all Bids;

17.6.4. The withdrawal of the bid prior to the deadline for the submission of bids, unless the biding documents stipulate that no such withdrawal is permitted.

17.7. The successful bidder's Bid Security will be discharged upon the bidder signing the contract pursuant to ITB 40, or furnishing the performance security (or guarantee), pursuant to ITB 41.

17.8. The Bid Security may be forfeited or the Bid Securing Declaration executed:

17.8.1. if a Bidder:

17.8.1.1. Withdraws its Bid during the period of Bid Validity as specified by the Procuring agency/Employer, and referred by the bidder on the Form of Bid except as provided for in ITB 16.2; or

17.8.2. In the case of a successful bidder, if the bidder fails:

17.8.2.1. to sign the contract in accordance with ITB 40; or

17.8.2.2. to furnish performance security (or guarantee) in accordance with ITB 41.

17.9. In case of Bid Security issued by the foreign bank is allowed by the Procuring agency/Employer, the same should be counter guaranteed by a corresponding bank in Pakistan. Furthermore, in case of joint venture, it should be in the name of Joint venture to ensure joint responsibility. In case the JV is not legally constituted at the time of bid submission, the bid security or bid securing declaration shall be in the names of all future members as named in the letter of bid.

18. **Withdrawal of Bids**

18.1. Before bid submission deadline, any bidder may withdraw, substitute, or modify its bid after it has been submitted by sending a written notice, duly signed by an authorized representative, and the corresponding must accompany the respective written notice.

19. **Format and Signing of Bid**

19.1. The Bidder shall prepare and submit Bids through EPADS with due diligence after carefully reading all the terms and condition before bid submission deadline.

# D. SUBMISSION OF BIDS

20. **Submission of Bids through EPADS v2.0**

20.1. All bids shall be submitted through EPADS v2.0.

21. **Deadline for Submission of Bids**

21.1. All bids shall be received through **EPADS v2.0** not later than bid submission deadline as specified in the **BDS**.

21.2. The Procuring agency/Employer may, under exceptional circumstances and at its discretion, extend the deadline for the submission of bids, pursuant to Rule 27 of the Public Procurement Rules, 2004. Extension of Time for submission of bid, by amending the Bidding Documents in accordance with ITB 7, in which case all rights and obligations of the Procuring agency/Employer and bidders previously subject to the deadline will thereafter be subject to the new deadline.

22. **Substitution and Modification of bids**

22.1. A bidder may substitute or modify his bid after it has been submitted, provided that written notice of the substitution or modification of the bid, is received by the Procuring agency/Employer prior to the deadline for submission of bids.

22.2. Revised bid may be submitted after the substitution or modification made in the original bid in accordance with the provisions referred in **ITB 18** .

# E. OPENING AND EVALUATION OF BIDS

23. **Opening of Bids**

23.1. The Procuring Agency will open bids in accordance with Rule 28 of the Public Procurement Rules, 2004 and as specified in the BDS.

24. **Confidentiality**

24.1. Information relating to the examination, clarification, evaluation and comparison of bids and recommendation of contract award shall not be disclosed to bidders or any other persons not officially concerned with such process until the time of the announcement of the respective evaluation report.

25. **Clarification of Bids**

25.1. Clarification of Bidding Documents shall be carried out in accordance with Rule 31 of the Public Procurement Rules, 2004.

25.2. The alteration or modification in the bid which in any case affect the following parameters will be considered as a change in the substance of a bid:

25.2.1. evaluation & qualification criteria;

25.2.2. required scope of work;

25.2.3. contract price;

25.2.4. all securities requirements;

25.2.5. tax requirements;

25.2.6. terms and conditions of bidding documents.

25.2.7. change in the ranking of the bidder

26. **Preliminary Examination of Bids**

26.1. Prior to the detailed evaluation of bids, the Procuring agency/Employer will determine whether each bid:

26.1.1. meets the eligibility criteria defined in **ITB 3** and **ITB 4**;

26.1.2. has been prepared as per the format and contents defined by the Procuring agency/Employer in the bidding documents;

26.1.3. has been properly signed;

26.1.4. is accompanied by the required securities; and

26.1.5. is substantially responsive to the requirements of the bidding documents.

The Procuring agency/Employer's determination of a bid's substantial responsiveness will be based on the contents of the bid itself.

26.2. A substantially responsive Bid is one which conforms to all the terms, conditions, and specifications of the Bidding Documents, without material deviation or reservation. A material deviation or reservation is one that: -

26.2.1. affects in any substantial way the scope, quality, or performance of the Works;

26.2.2. limits in any substantial way, inconsistent with the bidding documents, the Procuring agency/Employer's rights or the bidders' obligations under the Contract; or

26.2.3. if rectified, would affect unfairly the competitive position of other bidders presenting substantially responsive bids.

26.3. The Procuring agency/Employer will confirm that the documents and information specified under ITB 9, 10 and 11 have been provided in the bid. If any of these documents or information is missing, or is not provided in accordance with the Instructions to Bidders, the bid shall be rejected.

26.4. The Procuring agency/Employer may waive-off any minor informality, nonconformity, or irregularity in a bid which does not constitute a material deviation, provided such waiver does not prejudice or affect the relative ranking of any Bidder.

*Explanation: A minor informality, non-conformity or irregularity is one that is merely a matter of form and not of substance. It also pertains to some immaterial defect in a Bid or variation of a bid from the exact requirements of the invitation that can be corrected or waived without being prejudicial to other bidders. The defect or variation is immaterial when the effect on quantity, quality, or delivery is negligible when contrasted with the total cost or scope of the works. The Procuring agency/Employer either shall give the bidder an opportunity to cure any deficiency resulting from a minor*

*informality or irregularity in a bid or waive the deficiency, whichever is advantageous to the Procuring agency/Employer. Examples of minor informalities or irregularities include failure of a bidder to –*

26.4.1. *Submit the number of copies of signed bids required by the invitation;*

26.4.2. *Furnish required information concerning the number of its employees;*

26.4.3. *the firm submitting a bid has formally adopted or authorized, before the date set for opening of bids, the execution of documents by typewritten, printed, or stamped signature and submits evidence of such authorization and the bid carries such a signature.*

26.5. Provided that a Technical Bid is substantially responsive, the Procuring agency/Employer may request the bidder to submit the necessary information or documentation, within a reasonable period of time, to rectify nonmaterial nonconformities or omissions in the Technical Bid related to documentation requirements. Requesting information or documentation on such nonconformities shall not be related to any such aspect of the technical Proposal linked with the ranking of the bidders. Failure of the bidder to comply with the request may result in the rejection of its bid.

26.6. Provided that a Technical Bid is substantially responsive, the Procuring agency/Employer shall rectify quantifiable nonmaterial nonconformities or omissions related to the Financial Proposal. To this effect, the Bid Price shall be adjusted, for comparison purposes only, to reflect the price of the missing or nonconforming item or component.

26.7. If a bid is not substantially responsive, it will be rejected by the Procuring agency/Employer and may not subsequently be evaluated for complete technical responsiveness.

27. **Examination of Terms and Conditions; Technical Evaluation**

27.1. The Procuring agency/Employer shall examine the bid to confirm that all terms and conditions specified in the **GCC** and the **PCC** have been

accepted by the bidder without any material deviation or reservation.

For this purpose:

“Deviation” means departure from the requirements specified in the Bidding Document.

“Reservation” means setting of limiting conditions or withholding from complete acceptance of the requirements specified in the Bidding Document.

27.2. The Procuring agency/Employer shall evaluate the technical aspects of the bid submitted in accordance with ITB 30, to confirm that all requirements specified in Section VI – Works Requirement, Technical Specifications of the Bidding Documents have been met without material deviation or reservation.

27.3. If after the examination of the terms and conditions and the technical evaluation, the Procuring agency/Employer determines that the bid is not substantially responsive in accordance with ITB 27, it shall reject the bid.

28. **Correction of Arithmetic Errors**

28.1. Bids determined to be substantially responsive will be checked for any arithmetic errors. Errors will be corrected as follows: -

28.1.1. if there is a discrepancy between unit prices and the sub-total price that is obtained by multiplying the unit price and quantity, the unit price shall prevail, and the sub-total price shall be corrected, unless in the opinion of the Procuring agency/Employer there is an obvious misplacement of the decimal point in the unit price, in which the total price as quoted shall govern and the unit price shall be corrected;

28.1.2. if there is an error in a total corresponding to the addition or subtraction of sub-totals, the sub-totals shall prevail, and the total shall be corrected; and

28.1.3. where there is a discrepancy between the amounts in figures and in words, the amount in words will govern.

28.1.4. Where there is discrepancy between grand total of price schedule and amount mentioned on the Form of Bid, the amount referred in Price Schedule shall be treated as correct subject to elimination of other errors.

28.2. The amount stated in the Bid will, be rectified by the Procuring agency/Employer in accordance with the above procedure for the correction of errors and, with, the concurrence of the bidder, shall be considered as binding upon the bidder. If the bidder does not accept the corrected amount, its bid shall be rejected after forfeiture of Bid Security or execution of the Bid Securing Declaration, as the case may be, in accordance with **ITB 41.3**.

29. **Conversion to Single Currency**

29.1. The unit rates and the prices shall be quoted by the bidder entirely in Pak rupees. A bidder expecting to incur expenditures in other currencies for inputs to the Works from outside the Procuring agency/Employer's country (referred to as the "Foreign Currency Requirements") shall indicate the same in the letter of bid-financial proposal. The proportion of the Bid Price (excluding Provisional Sums) needed by him for the payment of such Foreign Currency Requirements either (i) entirely in the currency of the Bidder's home country or, (ii) at the bidder's option, entirely in Pak rupees provided always that a bidder expecting to incur expenditures in a currency or currencies other than those stated in (i) and (ii) above for a portion of the foreign currency requirements, and wishing to be paid accordingly, shall indicate the respective portions in his bid. Comparison of bids quoted in different currencies and conversion of bids into a single currency shall be carried out in accordance with Rule 30(2) of the Public Procurement Rules, 2004**.**

30. **Evaluation of Bids**

30.1. The Procuring agency/Employer shall evaluate and compare only the bids determined to be substantially responsive, pursuant to **ITB 27**.

30.2. In evaluating the Technical Proposal of each Bid, the Procuring agency/Employer shall use the criteria and methodologies listed in the BDS

and in terms of works requirement. No other evaluation criteria or methodologies shall be permitted.

30.3. The Procuring agency/Employer's evaluation of a bid will take into account:

30.3.1. the bid price, excluding provisional sums and the provision, if any, for contingencies in the summary bill of quantities, but including day work items, where priced competitively;

30.3.2. converting the amount resulting from applying above, if relevant, to a single currency in accordance with ITB 29;

30.4. The estimated effect of the price adjustment provisions of the Conditions of Contract, applied over the period of execution of the Contract, shall not be taken into account in bid evaluation.

30.5. If these bidding documents allow bidders to quote separate prices for different lots, and the award to a single bidder of multiple lots, the methodology of evaluation to determine the lowest evaluated lot combinations in the Form of Bid, is specified in the **BDS**.

30.6. If the bid, which results in the Evaluated Bid Price (Successful Bid), is seriously unbalanced or front loaded in the opinion of the Employer, the Employer may require the Bidder to produce detailed price analyses for any or all items of the Bill of Quantities, to demonstrate the internal consistency of those prices with the construction methods and schedule proposed. After evaluation of the price analyses, taking into consideration the schedule of estimated Contract payments, the Employer may require that the amount of the performance security be increased at the expense of the Bidder to a level sufficient to protect the Employer against financial loss in the event of default of the successful Bidder under the Contract.

Explanation:

*"Unbalanced" or "front-loaded" bids consist of deliberately submitting bids with artificially high prices or unit rates for the early stages of a construction project, offset by artificially low prices or unit rates for the later stages of the project, to improve the contractor's cash flow.*

31. **Domestic Preference**

31.1. If the **BDS** so specifies, the Procuring agency/Employer will grant a margin of preference to the domestic contractor in line with the rules, regulations, regulatory guides or instructions issued by the Authority from time to time.

## 32. **Determination of Successful Bid**

32.1. The Procuring agency/Employer shall compare the evaluated bids in accordance with the predefined bidding procedure, of all substantially responsive bids to determine the Successful bidder.

## 33. **Qualification of Bidder**

33.1. The Procuring agency/Employer shall determine to its satisfaction whether the bidder is substantially responsive and whose bid is declared as Successful bid either continues to meet (if prequalification applies) or meets (if post-qualification applies) the qualifying criteria specified in Evaluation and Qualification Criteria.
Note: In case of international bidding, the parameters for incorporation or licensing within Pakistan may be fulfilled as part of post qualification.

33.2. The determination shall be based upon an examination of the documentary evidence of the bidder’s qualifications submitted by the bidder, pursuant to **ITB 11**.

33.3. Prior to contract award, the Procuring agency/Employer will verify that the successful bidder (including each member of a JV) is not blacklisted/debarred. The Procuring agency/Employer will conduct the same verification for each sub-contractor proposed by the successful bidder.

## 34. **Sub-Contractors**

34.1. The bidder shall provide details regarding any specialized sub-contractor to the Procuring agency/Employer. In case change of sub-contractors, the bidder shall promptly notify the Procuring agency/Employer and obtain approval for replacement of sub-contractors.

34.2. Bidders may propose sub-contracting up to the percentage of total value of contracts or the volume of works as specified in the **BDS**.

35. **Abnormally Low Financial Bid**

35.1. A procuring Agency may reject abnormally low bids. The decision of the Procuring agency/Employer to reject a bid and reasons for the decision shall be recorded in the procurement proceedings and promptly communicated to the bidder concerned. Moreover, the Procuring agency/Employer shall not incur any liability solely by rejecting abnormally bid

Guidance for Procuring agency/Employer:

An abnormally low bid means, in the light of the Procuring agency/Employer's estimate and of all the bids submitted, the bid appears to be abnormally low by not providing a margin for normal levels of profit. In order to identify the Abnormally Low Bid (ALB) following approaches can be considered to minimize the scope of subjectivity:

35.1.1. Comparing the bid price with the cost estimate;

35.1.2. Comparing the bid price with the bids offered by other bidders submitting substantially responsive bids; and

35.1.3. Comparing the bid price with prices paid in similar contracts in the recent past either government- or development partner-funded.

35.2. The Procuring agency/Employer will determine to its satisfaction whether the bidder that is selected as having submitted the successful bid is qualified to perform the contract satisfactorily, in accordance with the criteria listed in **ITB 11**

35.3. The determination will take into account the bidder's financial and technical capabilities. It will be based upon an examination of the documentary evidence of the bidder's qualifications submitted by the bidder, pursuant to **ITB 11**, as well as such other information as the Procuring agency/Employer deems necessary and appropriate. Factors not included in these bidding documents shall not be used in the evaluation of the bidders' qualifications.

35.4. Procuring agency/Employer may seek “Certificate for Independent Price Determination” from the bidder and the results of reference checks may be used in determining award of contract.
*Explanation: The Certificate shall be furnished by the bidder. The bidder shall certify that the price is determined keeping in view of all the essential aspects such as raw material, its processing, value addition, optimization of resources due to economy of scale, transportation, insurance and margin of profit etc.*

35.5. An affirmative determination will be a prerequisite for award of the contract to the bidder. A negative determination will result in rejection of the bidder’s bid, in which event the Procuring agency/Employer will proceed to the next ranked bidder to make a similar determination of that bidder’s capabilities to perform satisfactorily.

# F. AWARD OF CONTRACT

## 36. **Criteria of Award**

36.1. Subject to **ITB 36 and 37**, the Procuring agency/Employer will award the Contract to the bidder whose bid has been determined to be substantially responsive to the bidding documents and who has been declared as Successful Bidder, provided that such bidder has been determined to be:

36.1.1. eligible in accordance with the provisions of **ITB 3**;

36.1.2. is determined to be qualified to perform the Contract satisfactorily; and

36.1.3. Successful negotiations have been concluded, if any.

## 37. **Negotiations**

37.1. The Committee of the Procuring agency/Employer may negotiate with the Most Advantageous Bidder relating to the following areas:

37.1.1. a minor alteration to the technical (drawings, design technical specifications) details of the statement of works;

37.1.2. Methodology, work plan, staffing in view to streamline the work;

37.1.3. a minor amendment to the Particular conditions of Contract;

37.1.4. finalizing payment arrangements;

37.1.5. clarifying details that were not apparent or could not be finalized at the time of Bidding;

37.2. Where negotiation fails to result into an agreement, the Procuring agency/Employer may invite the next ranked bidder for negotiations. Where negotiations are commenced with the next ranked bidder, the Procuring agency/Employer shall not reopen earlier negotiations.

38. **Procuring agency's Right to reject All Bids**

38.1. The procuring agency has the right to reject all bids in accordance with Rule 33 of the Public Procurement Rules, 2004. However, the Authority (i.e. **PPRA**) may call from the Procuring agency/Employer the justification of those grounds.

39. **Notification of Award**

39.1. The procuring agency shall announce and publish the evaluation result in accordance with Rule 35 of the Public Procurement Rules, 2004.

39.2. Where no complaints have been lodged, the bidder whose bid has been accepted will be notified of the award by the Procuring agency/Employer prior to expiration of the bid validity period through EPADS. However, the Procuring agency/Employer shall not award any procurement contract at least for five (05) days after the announcement of final evaluation report. The notification letter (herein after and in the condition of the contract and contract form called “Letter of Acceptance” will specify the sum that the Procuring agency/Employer will pay the successful bidder in consideration for the execution and completion of the

works as prescribed by the Contract (hereinafter and in the Contract called the "Contract Price).

39.3. The notification of award will constitute the formation of the Contract, subject to the bidder furnishing the Performance Security (or guarantee) in accordance with **ITB 41** and signing of the contract in accordance with **ITB 40**.

39.4. Upon the successful bidder’s furnishing of the performance security (or guarantee) pursuant to **ITB 41**, the Procuring agency/Employer will promptly notify each unsuccessful bidder, the name of the successful bidder and the Contract amount and will discharge the Bid Security or Bid Securing Declaration of the bidder(s) pursuant to **ITB 17**.

40. **Signing of Contract**

40.1. Promptly after notification of award, Procuring agency/Employer shall send the successful bidder the draft agreement, incorporating all terms and conditions as agreed by the parties to the contract.

40.2. Immediately after the Redressal of grievance by the **GRC**, and after fulfillment of all conditions precedent of the Contract Form, the successful bidder and the Procuring agency/Employer shall sign the contract.

40.3. Where no formal signing of a contract is required, work order issued to the bidder shall be construed to be the contract.

41. **Performance Security (or Guarantee)**

41.1. After the receipt of the Letter of Acceptance, the successful bidder, within the specified time, shall deliver to the Procuring agency/Employer a Performance Guarantee in the amount and in the form stipulated in the BDS and PCC, denominated in the type and proportions of currencies in the Letter of Acceptance and in accordance with the Conditions of Contract.

41.2. If the Performance Guarantee is provided by the successful bidder and it shall be in the form specified in the BDS which shall be in any of the following:

41.2.1. certified cheque, cashier's or manager's cheque, or bank draft;

41.2.2. irrevocable letter of credit issued by a scheduled bank of Pakistan or in the case of an irrevocable letter of credit issued by a foreign bank, the letter shall be confirmed or authenticated by a scheduled bank of Pakistan;

41.2.3. bank guarantee confirmed by a reputable local bank or, in the case of a successful foreign bidder, bonded by a foreign bank; or

41.2.4. surety bond callable upon demand issued by any reputable surety or insurance company.
Any Performance Guarantee submitted shall be enforceable in Pakistan.

41.3. Failure of the Most Advantageous Bidder to comply with the requirement of **ITB 40** shall constitute sufficient grounds for the annulment of the award and forfeiture of the Bid Security or declare blacklisted (in case bid securing declaration is submitted) in which event the Procuring agency/Employer may make the award to the next most advantageous bidder or reinitiate the procurement process afresh (as a case may be).

42. **Advance Payment**

42.1. Advance payment will be provided to the bidder in percentage and in the manner as agreed by the both parties in terms of Conditions of the Contract.

42.2. The Procuring agency/Employer will provide an advance payment as stipulated in the Conditions of Contract, subject to a maximum amount, as stated and/or Conditions of the Contract. The advance payment request shall be accompanied by an advance payment security (guarantee) in the form provided in Section X. For the purpose of receiving the advance payment, the bidder shall make and estimate of, and include in its bid, the expenses that will relate to the purchase of equipment, machinery, materials, and on the engagement of labor during the first month beginning with the date of the Procuring agency/Employer's "**Notice to Commence**" as specified in the **PCC**.

43. **General Performance of the Bidders**

43.1. The Procuring agency/Employer reserves the right to obtain information regarding performance of the bidders on their previously awarded contracts / works. The Procuring agency/Employer may seek information / report from the previous employer for consideration. However, the Procuring agency/Employer shall incorporate such parameters in the evaluation criteria and accordingly decide the fate of the bid submitted.

44. **Corrupt & Fraudulent Practices**

44.1. Procuring agencies (including beneficiaries of Government funded projects and procurement) as well as Bidders/Suppliers/Contractors under Government financed contracts, observe the highest standard of ethics during the procurement and execution of such contracts, and will avoid to engage in any corrupt and fraudulent practices.

# G. GRIEVANCE REDRESSAL & COMPLAINT REVIEW MECHANISM

45. **Grievance Redressal**

45.1. Grievance Redressal shall be carried out in accordance with Rule 48 of the Public Procurement Rules, 2004 i.e. Redressal of grievances by the procuring agency and “Redressal of Grievances Regulations 2021”.

# H. MECHANISM OF BLACKLISTING

46. **Mechanism of Blacklisting**

46.1. The Procuring agency/Employer shall proceed Blacklisting of Bidders/Contractors in accordance with Rule 19 of the Public Procurement Rules, 2004 i.e. Blacklisting and “Blacklisting and Debarment of Bidders or Contractors Regulations 2024.

# Bid Data Sheet

# Bids Data Sheet (BDS)

The following specific data for the procurement of Goods to be procured shall complement, supplement, or amend the provisions in the Instructions to Bidders (ITB). Whenever there is a conflict, the provisions herein shall prevail over those in ITB.

| BDS Clause Number | ITB Number | Amendments of, and Supplements to, Clauses in the Instruction to Bidders |
|---|---|---|
| A. Introduction | | |
| **1** | **1.1** | Name of Procuring Agency:**Attabad Lake Hydropower Project (Member (Water) WAPDA)**<br>The subject of procurement is:**Procurement of EPC Contractor for Package-III Electrical and Mechanical Works**<br>Expected commencement date: **Friday, January 1, 2027** |
| **2.** | **2.1** | Financial year for the operations of the Procuring Agency:**2025-26**<br>Name and identification number of the Contract: **P13301** |
| **3.** | **3.1** | JV/Consortium or AssociationAllowed: **Yes**<br>Number of JV/Consortium Members: **4** |
| B. Bidding Documents | | |

| | | |
|---|---|---|
| **4.** | **6.2 & 6.4** | The Bidders may seek clarifications through **EPADS v2.0**: Clarification Date: Friday, August 14, 2026<br>Pre-Bid Meeting: Tuesday, April 14, 2026 11:00 AM<br>Venue: Conference Hall / Committee room WAPDA House, Lahore. |
| **5.** | **7.2** | Any addendum, in case issued, shall be published on **Attabad Lake Hydropower Project (Member (Water) WAPDA)** website and on **EPADS v2.0**. |

## C. Preparation of Bids

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

| | | |
|---|---|---|
| **6.** | **8.1** | List of documents required along with the bid:<br><br>1. Application Submission Letter<br><br>2. Letter of Proposal – Technical Part (With Technical Bid)<br><br>3. Letter of Proposal – Financial Part (With Financial Bid)<br><br>4. Bid Security (Bank Guarantee): Scanned original bid security must be attached<br><br>5. Power of Attorney authorizing the signatory<br><br>6. JV Agreement / Letter of Intent to form JV (if applicable)<br><br>7. Completed Qualification Forms (ELI, CON, FIN Forms)<br><br>8. Technical Proposal including Methodology, Work Program, and Personnel<br><br>9. Manufacturer's/ Subcontractor Authorization (where applicable) as per attached annexure<br><br>10. Guarantees/Warranties: Any required performance guarantees or advance payment guarantees, as per instructions.<br><br>11. Certificate of Registration and Tax Documents: Copies of business licenses, registration certificates (e.g. PEC license), tax clearance certificates, etc., proving legal status.<br><br>12. The General Experience Form EXP 4.1 (as per attached EPC bidding document) submission is mandatory<br><br>13. The Specific Construction and Contract Management Experience Form EXP 4.2 (a) (as per attached EPC bidding document) submission is mandatory |

| | | |
|---|---|---|
| **7.** | **9.1** | The qualification criteria to establish the supply / production capability of the bidder.<br><br>*see Eligibility Criteria* |
| **8.** | **11.2** | **Works and Their relateddocuments:**<br>*See section Required Scope of Work* |
| **9.** | **11.1** | Price schedule will be provided according to the format defined and acquired.<br>*see section price schedule.* |
| **10.** | **11.4** | **Specifications:**<br><br>*see section of specifications.* |
| **11.** | **11.5 & 13.5** | The price shall be **Fixed**.<br>The bid price shall be adjusted in accordance with Appendix provided – Formula for Price Adjustment. |
| **12.** | **14.1** | Currency of the Bids shall be : **PKR** |
| **13.** | **16.1** | The Bids/Bid Validity period shall be: **180 Days** |
| **14.** | **17.1** | The amount of Bid Security shall be as defined in Bid Security Section for items and lots given in **BDS 6** |
| **15.** | **17.2** | The Bid Security shall be in the form of: **Bank Guarantee** |
| **16.** | **15.1** | Alternative Bids to the requirements of the bidding documents willnot be permitted. |

## D. Submission of Bids

| | | |
|---|---|---|
| **17.** | **18.1 & 21.1** | Bid shall be submitted online on EPADS v2.0 whereas hard copy of the bid security should be submitted to the following;<br><br>**Liaison Office: Office of Chief Engineer/ Project Director Attabad Lake Hydropower Project (ALHPP) WAPDA, Sunny View estate, Kashmir Road, Lahore, Pakistan**<br><br>Bids that are not submitted on EPADS v2.0 shall be disqualified.<br><br>The deadline for Bids submission is: **Thursday, August 20, 2026 11:00 AM** |

## E. Opening and Evaluation of Bids

| | | |
|---|---|---|
| **18.** | **24.1** | The Bids opening shall take place on **EPADS v2.0**.<br><br>Day *:* ***Thursday***<br><br>Date:***August 20, 2026***<br><br>Time *:* ***11:30 AM*** |
| **19.** | **30.2** | Selection technique adopted will be: **Quality Based Selection (QBS)**<br>*see Evaluation Criteria* |

## F. Award of Contract

| | | |
|---|---|---|
| **20.** | **41.1 & 41.2** | The Performance guarantee shall: **10.00%**.<br><br>The Performance Guarantee shall be acceptable in the form of:**Bank Guarantee** |
| **21.** | **45.1** | Arbitrator shall be appointed by mutual consent of the both parties. |

## G. Review of Procurement Decisions

| | | |
|---|---|---|
| **22.** | **37** | Grievance against this procurement shall be submitted online on EPADS v2.0. |

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

# Eligibility Criteria

| Bidder's Type | Required Registration |
|---|---|
| Partnership Firm<br>Company (Private Limited)<br>Company (Public Limited)<br>State Owned Enterprise (Private Limited)<br>State Owned Enterprise (Public Limited) | FBR (NTN)<br>FBR (GSTN)<br>PEC |

| Eligibility Criteria | Document |
|---|---|
| Nationality: The bidder shall have the nationality of an eligible country in accordance with the provisions of the attached EPC Bidding Document. Submission Requirement: The bidder shall provide the required information in Forms ELI-1.1 and ELI-1.2 of the attached EPC Bidding Document Volume 1 to demonstrate compliance with this eligibility requirements. Compliance Requirement: Single Entity must meet requirement, Each Member of JV must meet requirement | Yes |
| Conflict of Interest:The bidder shall not have a conflict of interest in accordance with the provisions of the attached EPC Bidding Document. Submission Requirement: The bidder shall provide confirmation through the Letter of Proposal – Technical Part of the attached EPC Bidding Document volume 1 demonstrating compliance with this requirement. Compliance Requirement: Single Entity must meet requirement, Each Member of JV must meet requirement | Yes |

| | |
|---|---|
| Eligibility: The bidder shall not have been declared ineligible by the Government of the Islamic Republic of Pakistan, as described in ITP 4.8 of the attached EPC Bidding Document Volume 1. Submission Requirement: The bidder shall provide the required information in Form ELI-1.1 of the EPC Bidding Document volume 1demonstrating compliance with this eligibility requirement. Compliance Requirement: Single Entity must meet requirement, Each Member of JV must meet requirement | Yes |
| State Owned Entity: If the bidder is a state-owned entity, it shall meet the conditions specified in ITP 4.6 of the attached EPC Bidding Document Volume 1.Submission Requirement: Forms ELI-1.1 and ELI-1.2 as per attached EPC bidding document volume 1 along with relevant supporting attachments. Compliance Requirement: Single Entity must meet requirement, Each Member of JV must meet requirement | Yes |
| United Nations Eligibility Requirement: The bidder shall not have been excluded from participation by any decision of the United Nations Security Council taken under Chapter VII of the Charter of the United Nations .Submission Requirement: The bidder shall provide the required information in Forms ELI-1.1 and ELI-1.2 in attached EPC Bidding Document Volume 1. Compliance Requirement: Single Entity must meet requirement, Each Member of JV must meet requirement | Yes |
| PEC: The Proposer shall be duly licensed by the Pakistan Engineering Council (PEC) for the year 2026 in Category CA. Submission Requirement: Provisional / standard PEC license. In case validity of License has expired, application for renewal of required category while other JV partners shall have a least category (as per requirement. Compliance Requirement: Single Entity must meet requirement, Each Member of JV must meet requirement according to share, Lead partner must meet C-A category. | Yes |
| Pakistani Firm Tax Registration: The bidder shall be registered with the Federal Board of Revenue (FBR) for taxation purposes in Pakistan in accordance with the applicable laws and regulations. Submission Requirement: Valid National Tax Number (NTN) and General Sales Tax Registration (GSTN) certificates issued by the Federal Board of Revenue. Compliance Requirement: Single Entity must meet requirement, Each Member of JV must meet requirement. | Yes |

| | |
|---|---|
| (ESHS) Past Performance Declaration: Declare any E&M work contracts that have been suspended or terminated and/or performance security called by an employer for reasons related to non-compliance with environmental, social, health or safety (including Sexual Exploitation and Abuse) contractual obligations during the past fifteen (15) years. Submission Requirement : Form CON-3 – ES Performance Declaration as per attached EPC bidding document. Each JV Member/ single entity must meet requireme | Yes |
| Employer’s SEA and/or SH Disqualification(i) At the time of Contract Award, the proposer shall not be subject to disqualification by the Employer for non-compliance with SEA/SH obligations. (ii) If previously disqualified, the proposer must demonstrate that appropriate measures have been taken to address the issue. Submission Requirement :Application Submission Letter and Form CON-4 as per attached EPC bidding document volume 1. Each JV member/ single entity must meet the requirement | Yes |
| Suspension Based on Execution of Bid/Proposal Securing Declaration by the Employer: Not under suspension based on execution of a Bid/Proposal Securing Declaration pursuant to ITP 19 of attached EPC document Volume 1. Submission Requirement: Letter of Proposal Technical Part . Each JV Member/ Single Entity/ All JV members combined Must meet requirement | Yes |
| General Experience: Experience in the role of Prime Contractor, JV Member, Sub-Contractor or Management Contractor of at least fifteen (15) years. Single Entity: Must Meet Requirement. Each Member: Must meet requirement. (For details see attached EPC bidding document volume 1 Eligibility and Qualification Criteria) Required document Form EXP 4.1 | Yes |
| Specific Construction & Contract Management Experience: For details see attached EPC bidding document volume 1 Eligibility and Qualification Criteria Required document Form EXP 4.2 (a) | Yes |
| Experience in Key Activities: For details see attached EPC bidding document volume 1 Eligibility and Qualification Criteria Required document Form EXP 4.2 (b) | Yes |
| Specific Experience in managing ESHS aspects: For details see attached EPC bidding document volume 1 Eligibility and Qualification Criteria Required document Form EXP 4.2 (c) | Yes |

| | |
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| Financial Capabilities: For details see attached EPC bidding document volume 1 Eligibility and Qualification Criteria Required documents: Form FIN 3.1, with attachments | Yes |
| Average Annual Construction Turnover: For details see attached EPC bidding document volume 1 Eligibility and Qualification Criteria Required documents: Form FIN 3.2 | Yes |
| History of Non- Performing Contracts: For details see attached EPC bidding document volume 1 Eligibility and Qualification Criteria Required documents: Form CON 2 | Yes |
| Pending Litigation: For details see attached EPC bidding document volume 1 Eligibility and Qualification Criteria Required documents: Form CON 2 | Yes |
| Litigation History: For details see attached EPC bidding document volume 1 Eligibility and Qualification Criteria Required documents: Form CON 2 | Yes |

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

# Evaluation Criteria

**Quality Based Selection (QBS)**

| | |
|---|---|
| **Technical Marks** | **100** |
| **Passing Marks** | **60** |
| Technical Evaluation Criteria | |
| Proposed Works: To what extent the Proposed Works (Proposed Generating Capacity) exceed the Employer's Requirements (Evaluation shall be based on the output at Step up Transformer Terminals) (Qualitative)(Doc Required)<br>Sufficient information that Significantly exceed the requirement/ Proposal contributes to significant value addition **(5)**<br>Sufficient information to demonstrate that the requirement will be marginally exceeded **(4)**<br>Sufficient information to demonstrate how the requirement will be met **(3)**<br>Required feature present with deficiencies such as insufficient or information that lacks clarity **(2)**<br>Required feature is absent; no relevant information to demonstrate how the requirement is met **(1)** | 5 |

| | |
|---|---|
| Technical Plant Data (E&M Works) for details see attached EPC bidding document Volume 1 (Qualitative)(Doc Required)<br><br>Sufficient information that Significantly exceed the requirement/ Proposal contributes to significant value addition **(20)**<br><br>Sufficient information to demonstrate that the requirement will be marginally exceeded **(18)**<br><br>Sufficient information to demonstrate how the requirement will be met **(16)**<br><br>Required feature present with deficiencies such as insufficient or information that lacks clarity **(10)**<br><br>Required feature is absent; no relevant information to demonstrate how the requirement is met **(1)** | 20 |
| Design Methodology for details see attached EPC bidding document Volume 1 (Qualitative)(Doc Required)<br><br>Sufficient information that Significantly exceed the requirement/ Proposal contributes to significant value addition **(10)**<br><br>Sufficient information to demonstrate that the requirement will be marginally exceeded **(9)**<br><br>Sufficient information to demonstrate how the requirement will be met **(8)**<br><br>Required feature present with deficiencies such as insufficient or information that lacks clarity **(5)**<br><br>Required feature is absent; no relevant information to demonstrate how the requirement is met **(1)** | 10 |

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| Testing and Commissioning Strategy for details see attached EPC bidding document Volume 1 (Qualitative)(Doc Required)<br><br>Sufficient information that Significantly exceed the requirement/ Proposal contributes to significant value addition **(10)**<br><br>Sufficient information to demonstrate that the requirement will be marginally exceeded **(9)**<br><br>Sufficient information to demonstrate how the requirement will be met **(8)**<br><br>Required feature present with deficiencies such as insufficient or information that lacks clarity **(5)**<br><br>Required feature is absent; no relevant information to demonstrate how the requirement is met **(1)** | 10 |
| Method Statement for key construction activities for critical equipment for details see attached EPC bidding document Volume 1 (Qualitative)(Doc Required)<br><br>Sufficient information that Significantly exceed the requirement/ Proposal contributes to significant value addition **(15)**<br><br>Sufficient information to demonstrate that the requirement will be marginally exceeded **(14)**<br><br>Sufficient information to demonstrate how the requirement will be met **(12)**<br><br>Required feature present with deficiencies such as insufficient or information that lacks clarity **(8)**<br><br>Required feature is absent; no relevant information to demonstrate how the requirement is met **(1)** | 15 |

| | |
|---|---|
| Optimization of Timelines for E&M Equipment for details see attached EPC bidding document Volume 1 (Qualitative) (Doc Required)<br><br>Sufficient information that Significantly exceed the requirement/ Proposal contributes to significant value addition **(10)**<br><br>Sufficient information to demonstrate that the requirement will be marginally exceeded **(9)**<br><br>Sufficient information to demonstrate how the requirement will be met **(8)**<br><br>Required feature present with deficiencies such as insufficient or information that lacks clarity **(5)**<br><br>Required feature is absent; no relevant information to demonstrate how the requirement is met **(1)** | 10 |
| Code of Conduct for details see attached EPC bidding document Volume 1 (Qualitative)(Doc Required)<br><br>Sufficient information that significantly exceed the requirement/ Proposal contributes to significant value addition **(5)**<br><br>Sufficient information to demonstrate that the requirement will be marginally exceeded **(4)**<br><br>Sufficient information to demonstrate how the requirement will be met **(3)**<br><br>Required feature present with deficiencies such as insufficient or information that lacks clarity **(2)**<br><br>Required feature is absent; no relevant information to demonstrate how the requirement is met **(1)** | 5 |

| | |
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| EPC/Turnkey Work Program for details see attached EPC bidding document Volume 1 (Qualitative)(Doc Required)<br>Sufficient information that significantly exceed the requirement/ Proposal contributes to significant value addition **(5)**<br>Sufficient information to demonstrate that the requirement will be marginally exceeded **(4)**<br>Sufficient information to demonstrate how the requirement will be met **(3)**<br>Required feature present with deficiencies such as insufficient or information that lacks clarity **(2)**<br>Required feature is absent; no relevant information to demonstrate how the requirement is met **(1)** | 5 |
| Key Personnel qualifications, Contract Personnel Organization, experience and resource schedule (The likely key specialists required to execute the contract are listed under Clause 1.3 (1A) (Qualitative)(Doc Required)<br>Excellent qualifications and experience **(10)**<br>Very Good **(9)**<br>Satisfactory **(8)**<br>Average **(5)**<br>Inadequate **(1)** | 10 |

| | |
|---|---|
| Risk Assessment and proposed management plan for details see attached EPC bidding document Volume 1 (Qualitative)(Doc Required)<br><br>Sufficient information that significantly exceed the requirement/ Proposal contributes to significant value addition **(5)**<br><br>Sufficient information to demonstrate that the requirement will be marginally exceeded **(4)**<br><br>Sufficient information to demonstrate how the requirement will be met **(3)**<br><br>Required feature present with deficiencies such as insufficient or information that lacks clarity **(2)**<br><br>Required feature is absent; no relevant information to demonstrate how the requirement is met **(1)** | 5 |
| Environmental, Social, Health and Safety (ESHS) for details see attached EPC bidding document Volume 1 (Qualitative) (Doc Required)<br><br>Sufficient information that significantly exceed the requirement/ Proposal contributes to significant value addition **(5)**<br><br>Sufficient information to demonstrate that the requirement will be marginally exceeded **(4)**<br><br>Sufficient information to demonstrate how the requirement will be met **(3)**<br><br>Required feature present with deficiencies such as insufficient or information that lacks clarity **(2)**<br><br>Required feature is absent; no relevant information to demonstrate how the requirement is met **(1)** | 5 |
| **Financial Marks** | **100** |
| Financial Evaluation Criteria | |

| | |
|---|---|
| Evaluated Financial Bid as per formula 'B=Clow/C' where where 'Clow' is the Lowest Evaluated Bid Price as per ITP 40.1(f) and 'C' is the Evaluated Bid Price of the Proposal under consideration. (Combine Evaluation Formula as per attached EPC bidding document) (Qualitative)<br><br>Financial Score of First Lowest Evaluated bid price **(100)**<br><br>Financial Score of Second Lowest Evaluated Bid Price (Score will be as per actual according to evaluation of financial bid formula) **(90)**<br><br>Financial Score of Third Lowest Evaluated Bid Price (Score will be as per actual according to evaluation of financial bid formula) **(80)**<br><br>Financial Score of Fourth Lowest Evaluated Bid Price (Score will be as per actual according to evaluation of financial bid formula) **(70)**<br><br>Financial Score of Fifth Lowest Evaluated Bid Price (Score will be as per actual according to evaluation of financial bid formula) **(60)**<br><br>Others Evaluated Bids (Score will be as per actual according to evaluation of financial bid formula) **(50)**<br><br>Others Evaluated Bids (Score will be as per actual according to evaluation of financial bid formula) **(1)** | 100 |

# Jobs/Lots

**Lot Title :** Procurement of EPC Contractor for Package III Electro Mechanical Works

**Bid Security :** 120000000 PKR

| Job | Delivery Schedule | Quantity |
|---|---|---|
| Price Schedule No. 01: Supply of Plant from Abroad (Pre-Engineered Structures) including Fixtures and other Materials, Goods and Spare Parts (if any) (Schedule of Price basis) | **Address:** Dour Khan, Aliabad, Hunza., Aliabad Tehsil, Hunza District (District), Gilgit Division (Division), Gilgit-Baltistan (GB) (Province). **Schedule:** As per attached EPC bidding document Volume 1 **Quantity:** 1/job | 1/job |
| Price Schedule No. 02: Supply of Plant from within the Employer’s Country (Pre-Engineered Structures) including Fixtures and other Materials, Goods and Spare Parts (if any) (Schedule of Price basis) | **Address:** Dour Khan, Aliabad, Hunza., Aliabad Tehsil, Hunza District (District), Gilgit Division (Division), Gilgit-Baltistan (GB) (Province). **Schedule:** As per attached EPC bidding document Volume 1 **Quantity:** 1/job | 1/job |
| Price Schedule No. 03: Design Services | **Address:** Dour Khan, Aliabad, Hunza., Aliabad Tehsil, Hunza District (District), Gilgit Division (Division), Gilgit-Baltistan (GB) (Province). **Schedule:** As per attached EPC bidding document Volume 1 **Quantity:** 1/job | 1/job |
| Price Schedule No. 04: Installation and All other Services | **Address:** Dour Khan, Aliabad, Hunza., Aliabad Tehsil, Hunza District (District), Gilgit Division (Division), Gilgit-Baltistan (GB) (Province). **Schedule:** As per attached EPC bidding document Volume 1 **Quantity:** 1/job | 1/job |
| Provisional Sum and Contingencies | **Address:** Dour Khan, Aliabad, Hunza., Aliabad Tehsil, Hunza District (District), Gilgit Division (Division), Gilgit-Baltistan (GB) (Province). **Schedule:** As per attached EPC bidding document Volume 1 **Quantity:** 1/job | 1/job |

| Job | Delivery Schedule | Quantity |
|---|---|---|
| Daywork (Labor, material and EPC Contractor Equipment) | **Address:** Dour Khan, Aliabad, Hunza., Aliabad Tehsil, Hunza District (District), Gilgit Division (Division), Gilgit-Baltistan (GB) (Province). **Schedule:** As per attached EPC bidding document Volume 1 **Quantity:** 1/job | 1/job |

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

# Related Services :

No

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# Work Specifications and Market Rates

**Lot Title:** Procurement of EPC Contractor for Package III Electro Mechanical Works

**Specifications / Requirements:**

| Sr. No | Ref | Description | Unit | Qty | Rate | Amount (Million PKR) |
|---|---|---|---|---|---|---|
| 1 | 1 | Design, Supply, Installation, Testing & Commissioning of Electro-Mechanical Equipment including Supply of Plant from Abroad, Supply of Plant from within Pakistan, Installation & Erection, Testing, Commissioning, Training, Dayworks, Provisional Sums and Contingencies complete in all respects as per Contract Documents | Job | 1 | LS | 12,688,010,000.00 |
| | | | | | GRAND TOTAL: | Rs12,688,010,000.00 |

# Scope of Work

The scope of work under this Contract comprises the Engineering, Procurement and Construction (EPC) of the Electro-Mechanical Works for Package-III of the Attabad Lake Hydropower Project, including all activities necessary for the complete and satisfactory design, manufacture, supply, delivery, installation, testing, commissioning and successful operation of the electro-mechanical equipment and associated systems.

The Contractor shall be fully responsible for the complete detailed engineering design, preparation and submission of drawings, design calculations, technical documentation, procurement and manufacturing of all electro-mechanical equipment, auxiliaries, accessories and associated systems, as well as the transportation, insurance, handling, storage, erection, installation, testing and commissioning of all equipment required for the proper functioning of the hydropower plant.

The Contractor’s responsibilities shall include, but shall not be limited to, turbines, generators, control and protection systems, instrumentation, mechanical auxiliaries, electrical systems, associated balance-of-plant equipment, and all other components necessary for the safe, reliable and efficient operation of the generating units and related facilities.

Notwithstanding any omission or discrepancy in the bidding documents, the Contractor shall be deemed to have included in the Contract Price all works, equipment, materials, services and facilities necessary for the complete and functional operation of the Electro-Mechanical Works in accordance with the Employer’s Requirements. The Contractor shall ensure that the installed equipment and systems meet the specified performance guarantees, reliability requirements and operational standards.

The scope further includes performance testing, preparation of operation and maintenance manuals, provision of special tools and recommended spare parts, training of the Employer’s personnel, and completion of all services required for safe, reliable and continuous operation of the hydropower facility.

The procurement and execution of the works shall be carried out in accordance with the EPC Bidding Documents for Package-III (Electro-Mechanical Works), comprising Volume-I to Volume-VIII, which are attached with this procurement and shall form an

integral part of the Contract and govern the rights, obligations, technical requirements and contractual conditions of the works.

All works shall be executed in accordance with the EPC Contract, Employer’s Requirements, applicable international standards, and relevant statutory and regulatory requirements.

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# Price Schedule

### For Individual Jobs

| # | Job Title | Quantity | Unit Price (PKR) | Total Price (PKR) | Delivery Location | Delivery Period / Year | Country of Origin |
|---|---|---|---|---|---|---|---|
| 1 | | | | | | | |
| 2 | | | | | | | |

### For Lots

| # | Lot Title | Total Lot Price (PKR) | Country of Origin |
|---|---|---|---|
| 1 | [Lot 1 Title] | | |

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# General Conditions of Contract

# A. General

1. **Definitions**

1.1. Unless the context otherwise requires, the following terms whenever used in this Contract shall have the same meaning and shall be interpreted as indicated

1.1.1. “Applicable Law” means the laws and any other instruments having the force of law in the Government’s Country, or in such other country as may be specified in the Special Conditions of the Contract (SC), as they may be issued and in force from time to time;

1.1.2. “The Contract” means an agreement enforceable by law;

1.1.3. “The Contract Price” means the price payable to the Contractor under the Contract for the full and proper performance of its contractual obligations;

1.1.4. “The Services” means the work to be performed by the Contractor pursuant to this Contract and as prescribed in the Specifications and Schedule of Activities included in the Contractor’s Bid;

1.1.5. “Ancillary Services” means those services ancillary to the provision of Services, such as transportation and insurance, and any other incidental services, such as installation, commissioning, provision of technical assistance, training, and other such obligations of the Contractor covered under the Contract;

1.1.6. “GCC” means the General Conditions of Contract contained in this section;

1.1.7. “SCC” means the Special Conditions of Contract by which the GCC may be amended or supplemented;

1.1.8. **“**Day” means calendar day unless indicated otherwise;

1.1.9. “Effective Date” means the date on which this Contract comes into force and effect;

1.1.10. “The Contractor” means the individual or corporate body whose Bids to provide the Services has been accepted by the Procuring Agency;

1.1.11. “The Project Site,” where applicable, means the place or places named in Bid Data Sheet and technical Specifications;

1.1.12. “Government” means the Government of Pakistan;

1.1.13. “Local Currency” means the currency of Pakistan;

1.1.14. “In Writing” means communicated in written form with proof of receipt;

1.1.15. “Completion Date” means the date of completion of the Services by the Contractor as certified by the Procuring Agency;

1.1.16. “Foreign Currency” means any currency other than the currency of the country of the Procuring Agency;

1.1.17. “Party” means the Procuring Agency or the Contractor, as the case may be, and “Parties” means both of them;

1.1.18. "Service" means any object of procurement other than goods or works;

1.1.19. “Subcontractor” means any entity to which the Bidder subcontracts any part of the Services.

2. **Applicable Law**

2.1. The contract shall be governed and interpreted in accordance with the laws of Pakistan, unless otherwise specified in SCC.

3. **Language**

3.1. The Contract as well as all correspondence and documents relating to the Contract exchanged between the Contractorand the Procuring Agency, shall be written in the **English language** unless otherwise stated in the **SCC** . Supporting documents and printed literature that are part of the Contract may be in another language provided these are accompanied by an accurate translation of the relevant passages in English, in which case, for purposes of interpretation of the Contract, this translation shall govern.

4. **Notices**

4.1. Any notice, request, or consent made pursuant to this Contract shall be in writing and shall be deemed to have been made when delivered in person to an authorized representative of the Party to whom the communication is addressed, or when sent by registered mail, telex, telegram, or facsimile to such Party at the address specified in the **SCC**.

5. **Location**

5.1. The Services shall be performed at such locations as the Procuring Agency may approve and as specified in **SCC.**

5.2. A {DOCUMENTS}

6. **Authorized Representatives / Authority of Member in charge**

6.1. Any action required or permitted to be taken, and any document required or permitted to be executed, under this Contract by the Procuring Agency or the Contractor may be taken or executed by the officials specified in the **SCC**.

## B. Commencement, Completion, Modification, and Termination of Contract

7. **Effectiveness of Contract**

7.1. This Contract shall come into effect on the date the Contract is signed by both parties and such other later date as may be stated in the **SCC.**

8. **Commencement of Services**

8.1. The Contractor shall confirm availability of Key Experts and begin carrying out the Services not later than the number of days after the Effective Date specified in the **SCC.**

9. **Program schedule**

9.1. Before commencement of the Services, the Contractor shall submit to the Procuring Agency for approval a Program showing the general methods, arrangements, order and timing for all activities. The Services shall be carried out in accordance with the approved Program as updated.

10. **Starting Date/Expiration Date**

10.1. The Contractor shall start carrying out the Services Five (05) days after the date the Contract becomes effective, or at such other date as may be specified in the **SCC.**

10.2. Unless terminated earlier pursuant to Clause **GCC 14** hereof, this Contract shall expire at the end of such time period after the Effective Date as specified in the **SCC.**

11. **Entire Agreement**

11.1. This Contract contains all covenants, stipulations and provisions agreed by the Parties. No agent or representative of either Party has authority to make, and the Parties shall not be bound by or be liable for, any statement, representation, promise or agreement not set forth herein.

12. **Modification**

12.1. Any modification or variation of the terms and conditions of this Contract, including any modification or variation of the scope of the Services, may only be made by written agreement between the Parties. However, each Party shall give due consideration to any modification(s) or variation(s) made by the other Party.

12.2. In cases of any modification(s) or variation(s), the prior written consent of the Procuring Agency is required.

13. **Force Majeure**

13.1. **Definition**
For the purposes of this Contract, “Force Majeure” means an event which is beyond the reasonable control of a Contractor and which makes a Contractor’s performance of its obligations under the Contract impossible or so impractical as to be considered impossible under the circumstances.

13.2. **No Breach of Contract**
The failure of a Party to fulfill any of its obligations under the contract shall not be considered to be a breach of, or default under, this Contract in so far as such inability arises from an event of Force Majeure, provided that the Party affected by such an event (a) has taken all reasonable precautions, due care and reasonable alternative

measures in order to carry out the terms and conditions of this Contract, and (b) has informed the other Party as soon as possible about the occurrence of such an event.

13.3. **Extension of Time**
Any period within which a Contractor shall, pursuant to this Contract, complete any action or task, shall be extended for a period equal to the time during which such Party was unable to perform such action as a result of Force Majeure.

13.4. **Payments**
During the period of their inability to perform the Services as a result of an event of Force Majeure, the Contractor shall be entitled to continue to be paid under the terms of this Contract, as well as to be reimbursed for additional costs reasonably and necessarily incurred by them during such period for the purposes of the Services and in reactivating the Service after the end of such period.

14. **Termination**

14.1. **By the Procuring Agency**
The Procuring Agency may terminate this Contract in case of the occurrence of any of the events specified in paragraphs (a) through (e) of this Clause. In such an occurrence the Procuring Agency shall give at least thirty (30) calendar days' written notice of termination to the Contractor in case of the events referred to in (a) through (d); at least sixty (60) calendar days' written notice in case of the event referred to in (e);

14.1.1. If the Contractor fails to remedy a failure in the performance of its obligations hereunder, as specified in a notice of suspension;

14.1.2. If the Contractor becomes (or, if the Contractor consists of more than one entity, if any of its members becomes) insolvent or bankrupt or enter into any agreements with their creditors for relief of debt or take advantage of any law for the benefit of debtors or go into liquidation or receivership whether compulsory or voluntary;

14.1.3. If the Contractor fails to comply with any final decision reached as a result of arbitration proceedings;

14.1.4. If, as the result of Force Majeure, the Contractor is unable to perform a material portion of the Services for a period of not less than sixty (60) calendar days;

14.1.5. If the Procuring Agency, in its sole discretion and for any reason whatsoever, decides to terminate this Contract;

14.2. **By the Contractor**
The Contractor may terminate this Contract, by not less than thirty (30) calendar days' written notice to the Procuring Agency, in case of the occurrence of any of the events specified in paragraphs (a) through (d) of this Clause.

14.2.1. If the Procuring Agency fails to pay any money due to the Contractor pursuant to this Contract and not subject to dispute within forty-five (45) calendar days after receiving written notice from the Contractor that such payment is overdue;

14.2.2. If, as the result of Force Majeure, the Contractor is unable to perform a material portion of the Services for a period of not less than sixty (60) calendar days;

14.2.3. If the Procuring Agency fails to comply with any final decision reached as a result of arbitration;

14.2.4. If the Procuring Agency is in material breach of its obligations pursuant to this Contract and has not remedied the same within forty-five (45) days (or such longer period as the Bidder may have subsequently approved in writing) following the receipt by the Procuring Agency of the Contractor's notice specifying such breach.

# C. Obligations of the Contractor

15. **General**

15.1. **Standard of Performance**

15.1.1. The Contractor shall perform the Services and carry out the Services with all due diligence, efficiency and economy, in accordance with generally accepted professional standards and practices, and shall observe sound management practices, and employ appropriate technology and safe and effective equipment, machinery, materials and methods. The Contractor shall always act, in respect of any matter relating to this Contract or to the Services, as a faithful adviser to the Procuring Agency, and shall at all times support and safeguard the Procuring Agency's legitimate interests in any dealings with the third parties;

15.1.2. The Contractor shall employ and provide such qualified and experienced Experts and Sub-Contractors as are required to carry out the Services.

15.2. **Law Applicable to Services**

The Contractor shall perform the Services in accordance with the Contract and in accordance with the Law of Pakistan and shall take all practicable steps to ensure that any of its Experts and Sub-Bidders, comply with the Applicable Law.

16. **Conflict of Interests**

16.1. **Contractor Not to Benefit from Commissions and Discounts**

The remuneration of the Contractor shall constitute the Contractor's sole remuneration in connection with this Contract or the Services, and the Contractor shall not accept for their own benefit any trade commission, discount, or similar payment in connection with activities pursuant to this Contract or to the Services or in the discharge of their obligations under the Contract, and the Contractor shall use their best efforts to ensure that the Personnel, any Subcontractors, and agents of either of them similarly shall not receive any such additional remuneration.

16.2. **Contractor and Affiliates Not to be Otherwise Interested in Project**

The Contractor agree that, during the term of this Contract and after its termination, the Contractor and its affiliates, as well as any Subcontractor and any of its affiliates, shall be disqualified from providing Services (other than the Services and any continuation thereof) for any project resulting from or closely related to the Services.

16.3. **Prohibition of Conflicting Activities**
Neither the Bidder nor its Subcontractors nor the Personnel shall engage, either directly or indirectly, in any of the following activities:

16.3.1. during the term of this Contract, any business or professional activities in the Government's country which would conflict with the activities assigned to them under this Contract;

16.3.2. during the term of this Contract, neither the Contractor nor their Subcontractors shall hire public employees in active duty or on any type of leave, to perform any activity under this Contract;

16.3.3. after the termination of this Contract, such other activities as may be specified in the **SCC.**

17. **Insurance to be Taken Out by the Contractor**

17.1. The Contractor(a) shall take out and maintain, and shall cause any Subcontractors to take out and maintain, at its (or the Sub-contractors', as the case may be) own cost but on terms and conditions approved by the Procuring Agency, insurance against the risks, and for the coverage, as shall be specified in the **SCC**; and (b) at the Procuring Agency's request, shall provide evidence to the Procuring Agency showing that such insurance has been taken out and maintained and that the current premiums have been paid.

18. **Contractor's Actions Requiring Procuring Agency's Prior Approval**

18.1. The Contractor shall obtain the Procuring Agency's prior approval in writing before taking any of the following actions:

18.1.1. appointing such members of the Personnel not provided by the Contractor;

18.1.2. changing the Program of activities; and

18.1.3. any other action that may be specified in the **SCC.**

19. **Reporting Obligations**

19.1. The Contractor shall submit to the Procuring Agency the reports and documents in the numbers, and within the periods as prescribed by the Procuring Agency.

20. **Liquidated Damages**

20.1. **Payments of Liquidated Damages**
The Contractor shall pay liquidated damages to the Procuring Agency at the rate per day stated in the **SCC** for each day that the Completion Date is later than the Intended Completion Date. The total amount of liquidated damages shall not exceed the amount defined in the **SCC**. The Procuring Agency may deduct liquidated damages from payments due to the Contractor. Payment of liquidated damages shall not affect the Contractor's liabilities.

20.2. **Correction for Over-payment**
If the Intended Completion Date is extended after liquidated damages have been paid, the Procuring Agency shall correct any overpayment of liquidated damages by the Contractor by adjusting the next payment certificate. The

Contractor shall be paid interest on the overpayment, calculated from the date of payment to the date of repayment, at the rates specified in **SCC.**

20.3. **Lack of performance penalty**
If the Contractor has not corrected a Defect within the time specified in the Procuring Agency's notice, a penalty for Lack of performance will be paid by the Contractor. The amount to be paid will be calculated as a percentage of the cost of having the Defect corrected, assessed as specified in the Contractor

21. **Performance Guarantee**

21.1. Within the time stipulated in the acceptance letter from the Procuring Agency, the successful Bidder shall furnish the Performance Guarantee in shape and amount **specified in SCC.**

21.2. The proceeds of the Performance Guarantee shall be payable to the Procuring agency as compensation for any loss resulting from the Supplier's failure to complete its obligations under the Contract.

21.3. The Performance Guarantee shall be denominated in the currency of the Contract, or in a freely convertible currency acceptable to the Procuring agency and shall be in the acceptable form as specified in **SCC**.

21.4. The Performance Guarantee will be discharged by the Procuring agency and returned to the Supplier not later than thirty (30) days following the date of completion of the Supplier's performance obligations under the Contract, including any warranty obligations, unless otherwise **specified in SCC.**

22. **Sustainable Procurement**

22.1. The Contractor shall conform to the sustainable procurement contractual provisions, if and as specified in the **SCC.**

# D. Contractor's Personnel

23. **Description of Personnel**

23.1. The titles, agreed job descriptions, minimum qualifications, and estimated periods of engagement in the carrying out of the Services of the Contractor's Key Personnel. The Key Personnel listed by title as well as by name are hereby approved by the Procuring Agency.

24. **Removal and / or Replacement of Personnel**

24.1. Except as the Procuring Agency may otherwise agree, no changes shall be made in the Key Personnel. If, for any reason beyond the reasonable control of the Contractor, it becomes necessary to replace any of the Key Personnel, the Contractor shall provide as a replacement a person of equivalent or better qualifications.

24.2. If the Procuring Agency finds that any of the Personnel have (i) committed serious misconduct or have been charged with having committed a criminal action, or (ii) have reasonable cause to be dissatisfied with the performance of any of the Personnel, then the Contractor shall, at the Procuring Agency's written request specifying the grounds thereof, provide as a replacement a person with qualifications and experience acceptable to the Procuring Agency.

24.3. The Contractor shall have no claim for additional costs arising out of or incidental to any removal and/or replacement of Personnel.

## E. Obligations of the Procuring Agency

25. **Change in the Applicable Law**

25.1. If, after the date of this Contract, there is any change in the Applicable Law with respect to taxes and duties which increases or decreases the cost of the Services rendered by the Contractor, then the remuneration and reimbursable expenses otherwise payable to the Contractor under this Contract shall be increased or decreased accordingly by agreement between the Parties, and corresponding adjustments shall be made to the amounts referred in the **SCC.**

26. **Services and Facilities**

26.1. The Procuring Agency shall make available to the Contractor and the Experts, for the purposes of the Services and free of any charge, the services, facilities and property described in the Terms of Reference, at the times and in the manner specified in the Terms of Reference.

26.2. In case that such services, facilities and property shall not be made available to the Contractor, the Parties shall agree on (i) any time extension that it may be appropriate to grant to the Contractor for the performance of the Services, (ii) the manner in which the Contractor shall procure any such services, facilities and property from other sources, and (iii) the additional payments, if any, to be made to the Contractor as a result thereof.

## F. Payments to the Contractor

27. **Contract Price**

27.1. The price payable shall be in Pakistani Rupees unless otherwise specified in the **SCC**.

28. **Terms and Conditions of Payment**

28.1. Payments will be made to the Contractor according to the payment schedule stated in the **SCC** and as per actual invoice submitted by the Contractor.

28.2. Unless otherwise stated in the **SCC**, the advance payment shall be made against the provision by the Contractor of a bank guarantee for the same amount, and shall be valid for the period stated in the **SCC.** Any other payment shall be made after the conditions listed in the **SCC** for such payment have been met, and the Contractor have submitted an invoice to the Procuring Agency specifying the amount due.

29. **Quality Control Identifying Defects**

29.1. The principle and modalities of Inspection of the Services by the Procuring Agency shall be as indicated in the **SCC.** The Procuring Agency shall check the Contractor’s performance and notify him of any Defects that are

found. Such checking shall not affect the Contractor's responsibilities. The Procuring Agency may instruct the Contractor to search for a Defect and to uncover and test any service that the Procuring Agency considers may have a Defect. Defect Liability Period is as defined in the **SCC**.

29.2. A {INSPECTION}

30. **Correction of Defects, and Lack of Performance Penalty**

30.1. The Procuring Agency shall give notice to the contractor of any Defects before the end of the Contract. The Defects liability period shall be extended for as long as Defects remain to be corrected.

30.2. Every time notice a Defect is given; the contractor shall correct the notified Defect within the length of time specified by the Procuring Agency's notice.

30.3. If the contractor has not corrected a Defect within the time specified in the Procuring Agency's notice, the Procuring Agency will assess the cost of having the Defect corrected, the contractor will pay this amount, and a Penalty for Lack of Performance.

31. **Settlement of Disputes Amicable Settlement**

31.1. The Parties shall use their best efforts to settle amicably all disputes arising out of or in connection with this Contract or its interpretation.

32. **Dispute Settlement**

32.1. **Arbitration**

If any dispute of any kind whatsoever shall arise between the procuring agency and the contractor in connection with or arising out of the Contract, including without prejudice to the generality of the foregoing, any question regarding its existence, validity or termination, or the execution of the contract, the parties shall seek to resolve any such dispute or difference by mutual consultation. If the parties fail to resolve such a dispute or difference even after negotiations or mediation, then the dispute shall be referred within fourteen (14) days in writing by either party to the Arbitrator, with a copy to the other party.

Any dispute in respect of which a notice of intention to commence arbitration has been given, in accordance with **GCC sub-clause 32.1**, shall be finally settled by arbitration. Arbitration may be commenced prior to or after completion of the Contract. Arbitration proceedings shall be conducted in accordance with Arbitration Act 1940. Notwithstanding any reference to arbitration herein, the parties shall continue to perform their respective obligations under the Contract unless otherwise agreed. The Procuring Agency shall continue to pay the Contractor any undisputed amounts due under the Contract during the resolution of any dispute.

# Special Conditions of Contract

# *SECTION VIII. SPECIAL CONDITIONS OF CONTRACT*

The following Special Conditions of Contract shall supplement the General Conditions of Contract. Whenever there is a conflict, the provisions herein shall prevail over those in the Conditions of Contract. The corresponding clause number of the GCC is indicated in parentheses.

***Number of GC Clause***

***Amendments of, and Supplements to, Clauses in the General Conditions of Contract***

**Number of GC Clause 1**

**Definitions**

**The Procuring Agency is:** Attabad Lake Hydropower Project (Member (Water) WAPDA), Chief Engineer/ PD Liaison Office: Office of Chief Engineer/ Project Director Attabad Lake Hydropower Project (ALHPP) WAPDA, Sunny View estate, Kashmir Road, Lahore, Pakistan

**The Supplier is:**

**The title of the subject procurement is: Procurement of EPC Contractor for Package-III Electrical and Mechanical Works**

**Number of GC Clause 2**

**Applicable/Governing Law:**

The Contract shall be interpreted in accordance with the laws of Islamic Republic of Pakistan

**Number of GC Clause 3**

**Language:**

The language of the Contract, all correspondence and communications to be given, and all other documentation to be prepared and supplied under the Contract shall be in **English.**

**Number of GC Clause 4**

**Notices:**

**The addresses for the notices are:**

Procuring Agency:

Attabad Lake Hydropower Project (Member (Water) WAPDA), Chief Engineer/ PD
Liaison Office: Office of Chief Engineer/ Project Director Attabad Lake Hydropower Project (ALHPP) WAPDA, Sunny View estate, Kashmir Road, Lahore, Pakistan
+92-333-448-1116
pdalhpp@gmail.com

Contractor/ Bidder:

[Name, address and telephone number]

The Contractor/ Bidder's Representative(s)

[Name, address, telephone number and e-mail address]

**Number of GC Clause 6.1**

**The Authorized Representatives are:**

**For the Procuring Agency:**

Attabad Lake Hydropower Project (Member (Water) WAPDA), Chief Engineer/ PD
Liaison Office: Office of Chief Engineer/ Project Director Attabad Lake Hydropower Project (ALHPP) WAPDA, Sunny View estate, Kashmir Road, Lahore, Pakistan
+92-333-448-1116
pdalhpp@gmail.com

**For the Bidder:**

**Name: ……**

**Designation: ……..**

**Address: ……..**

**Number of GC Clause 7**

**Effectiveness of the contract**

The Contractor/Bidder shall be effective within ….. days from the date of signature of the Contract by both parties

**Number of GC Clause 8**

**Commencement of Contract:**

The Contractor/Bidder shall provide Non-Consultancy Services from the effective date of contract.

**Number of GC Clause 10.2**

**Expiration of Contract:**

The time period shall be ……

**Number of GC Clause 14**

**Termination**

In the event of termination of the contract due to any reason as already defined in the General Conditions of Contract, the Bidder shall be responsible for providing to the Authority the Goods till the time of alternate arrangements.

**Number of GC Clause 16**

**Conflict of Interest:**

The Procuring Agency reserves the right to determine on a case-by-case basis whether the Bidder should be disqualified from providing goods or services due to a conflict of a nature described in Clause GCC 17.

**Number of GC Clause 20**

**Liquidated Damages**

If the Bidder fails to provide services as required under the contract or in case of any data loss/data breach or any incident compromising the data security or other such failures related to any services, the Bidder shall pay to the Procuring Agency as Liquidated Damages at a rate of **0.38%** to **10.00%** of the Contract value, in accordance with the extent of performance failure & the cost of investigating such incidents as judged by the Authority.

**Number of GC Clause 21**

**Performance Guarantee:**

The amount of performance guarantee shall be **10.00%** of the contract price in acceptable form of **Bank Guarantee**

**Number of GC Clause 27**

**Currency of Payment:**

All the payment to be released to the contractor/Bidder shall be in Pakistani Rupees.

**Number of GC Clause 28**

**Payment terms:**

Payment will be made to the Bidder against the procured Goods and services according to the actual invoice or running bills submitted by the Bidder against the services provided within the time given in the conditions of the contract.

**Number of GC Clause 29**

**Identifying Defects:**

The Authority reserves the right at any time to inspect the premises of the provider to inspect the goods and monitor the goods being provided.

## Inspections & Tests Requirements

Brand New Equipment Certificate: The supplier shall provide a certificate confirming that all equipment is brand new, unused, and bears clearly identifiable reference numbers consistent with the bid and manufacturer’s documentation

Physical Fitness Certificate: A certificate from the supplier must confirm that the equipment is physically intact, free from damage, and suitable for installation and operation.

Country of Origin Certificate: A certificate issued by the original manufacturer verifying the country of origin of the equipment, consistent with the quoted origin in the proposal.

Factory Acceptance Test (FAT) and Site Acceptance Test (SAT): FAT shall be conducted at the manufacturer's facility (where applicable) and SAT at the project site, witnessed by the Employer's Engineer. Both shall be performed in accordance with Volume II – Technical Provisions

Type Test Certificates: Type test certificates for each major equipment/system shall be submitted, as per requirements specified in the technical evaluation criteria of the bidding documents

Testing & Commissioning Strategy: The Contractor shall submit a comprehensive Testing & Commissioning Plan detailing methodology, sequence, safety measures, and expected performance benchmarks

QA/QC Documentation: Complete traceability records, quality assurance reports, and control documents from the manufacturer shall be provided for all major systems and components.

Successful Operation Certificate: Upon completion of installation, testing, and commissioning of the equipment, a certificate of successful operation shall be issued by the Employer confirming that the equipment has been installed in accordance with contract specifications, has undergone full commissioning, and is operating satisfactorily under site conditions

## Delivery & Documents

Copies of the Supplier's invoice showing Goods' description, quantity, unit price, and total amount;

Original and two copies of the usual transport document (for example, a negotiable bill of lading, a nonnegotiable sea waybill, an inland waterway document, an air waybill, a railway consignment note, a road consignment note, or a multimodal transport document) which the buyer may require to take the goods;

Copies of the packing list identifying contents of each package;

Insurance Certificate;

Manufacturer's or Supplier's Valid Warranty Certificate;

Inspection Certificate issued by the Nominated Inspection Agency (if any), and the Supplier's Factory Inspection Report;

Certificate of Origin.

The above documents would be required even if the equipment has already been imported and is available with the supplier ex-stock

O&M Manuals: Comprehensive Operation and Maintenance Manuals for all major equipment and systems, submitted in both soft and hard copy formats.

As-Built Drawings: Final as-built drawings and relevant technical documentation for the supplied and installed equipment.

List of Spare Parts & Tools: Detailed list of spare parts and maintenance tools supplied under the contract, along with associated delivery schedule

Training Certificate: Certificate confirming successful completion of training sessions for the Employer's personnel, if training was included in the scope of supply.

**Number of GC Clause 31**

**Following is the guidance for Dispute Resolution**

i. If any dispute of any kind whatsoever shall arise between the Authority and the Bidder in connection with or arising out of the Contract... (full clause unchanged)

ii. At future of negotiation the dispute shall be resolved through mediation...

iii. At failure of mediation, arbitration under Arbitration Act 1940...

iv. Cost sharing equally...

v. Proceedings may commence before/after completion...

Notwithstanding any reference to the arbitration herein, the parties shall continue to perform their respective obligations under the Contract.

**Rules of procedure for arbitration proceedings:**

Any dispute between the Authority and a Bidder shall be referred to arbitration under the laws of Pakistan including Arbitration Act 1940.

**Place of Arbitration and Award:**

The arbitration shall be conducted in English language and place shall be Islamabad. The award shall be final and binding.

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

# Bid Securing Declaration

# Form 9: Bid Securing Declaration

Date: *[insert date (as day, month and year)]*

Bid No.:***P13301***

To: **Attabad Lake Hydropower Project (Member (Water) WAPDA), Chief Engineer/ PD Liaison Office: Office of Chief Engineer/ Project Director Attabad Lake Hydropower Project (ALHPP) WAPDA, Sunny View estate, Kashmir Road, Lahore, Pakistan**

We, the undersigned, declare that:

We understand that, according to your conditions, Bids must be supported by a Bid Securing Declaration.

We accept that we will be blacklisted and henceforth cross debarred for participating in respective category of public procurement proceedings for a period of (not more than) six months, if fail to abide with a bid securing declaration, however without indulging in corrupt and fraudulent practices, if we are in breach of our obligation(s) under the Bid conditions, because we:

1. have withdrawn or modified our Bid during the period of Bid Validity specified in the Form of Bid;

2. Disagreement to arithmetical correction made to the Bid price; or

3. having been notified of the acceptance of our Bid by the Procuring Agency during the period of Bid Validity, (i) failure to sign the contract if required by Procuring Agency to do so or (ii) fail or refuse to furnish the Performance Security or to comply with any other condition precedent to signing the contract specified in the Bidding Documents.

We understand this Bid Securing Declaration shall expire if we are not the successful

Bidder, upon the earlier of (i) our receipt of your notification to us of the name of the successful Bidder; or (ii) twenty-eight (28) days after the expiration of our Bid.

# Contract Form

# *SECTION IX: CONTRACT FORMS*

THIS AGREEMENT made the _____ day of _____ 20_____ between **Attabad Lake Hydropower Project (Member (Water) WAPDA), Chief Engineer/ PD Liaison Office: Office of Chief Engineer/ Project Director Attabad Lake Hydropower Project (ALHPP) WAPDA, Sunny View estate, Kashmir Road, Lahore, Pakistan**

(hereinafter called "the Procuring Agency") of the one part and *[name of Bidder]* of *[city and country of Bidder]* (hereinafter called "the Bidder") of the other part:

WHEREAS the Procuring Agency invited Bids for provision of goods, viz., **Procurement of EPC Contractor for Package-III Electrical and Mechanical Works (*P13301*)** and has accepted a Bids by the Bidder for the provision of Goods in the sum of *[contract price in words and figures]* (hereinafter called "the Contract Price").

**NOW THIS CONTRACT WITNESSETH AS FOLLOWS:**

1. In this Contract words and expressions shall have the same meanings as are respectively assigned to them in the Conditions of Contract referred to.

2. The following documents shall be deemed to form and be read and construed as part of this Contract, In the event of any ambiguity or conflict between the Contract Documents listed below, the order of precedence shall be the order in which the Contract Documents are listed below:-

1. This form of Contract;
2. the Form of Bids and the Price Schedule submitted by the Bidder;
3. the Schedule of Requirements;
4. the Technical Specifications;
5. the Special Conditions of Contract;
6. the General Conditions of the Contract;
7. the Procuring Agency's Letter of Acceptance; and
8. [*add here: any other documents*]

3. In consideration of the payments to be made by the Procuring Agency to the Bidder as hereinafter mentioned, the Bidder hereby covenants with the Procuring Agency to provide the Goods related services and to remedy defects therein in conformity in all respects with the provisions of the Contract.

4. The Procuring Agency hereby covenants to pay the Bidder in consideration of the provision of Goods and the remedying of defects therein, the Contract Price or such other sum as may become payable under the provisions of the contract at the times and in the manner prescribed by the contract.

IN WITNESS whereof the parties hereto have caused this Contract to be executed in accordance with their respective laws the day and year first above written.

Signed, sealed, delivered by _____the _____ (for the Procuring Agency)

Witness to the signatures of the Procuring Agency:

……

Signed, sealed, delivered by _____the _____ (for the Procuring Agency)

Witness to the signatures of the Bidder: ……

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

# Integrity Pact

# Integrity Pact

## DECLARATION OF FEES, COMMISSION AND BROKERAGE ETC. PAYABLE BYTHE SUPPLIERS OF GOODS, SERVICES & WORKS IN CONTRACTS WORTH RS.10.00 MILLION OR MORE

**Contract** Number: Contract Value: Contract Title:

Dated:

[Name of Supplier] hereby declares that it has not obtained or induced the procurement of any contract, right, interest, privilege or other obligation or benefit from Government of Pakistan or any administrative subdivision or agency thereof or any other entity owned or controlled by it (GoP) through any corrupt business practice.

Without limiting the generality of the foregoing [Name of Supplier] represents and warrants that it has fully declared the brokerage, commission, fee etc. paid or payable to anyone and not given or agreed to give and shall not give or agree to give to anyone within or outside Pakistan either directly or indirectly through any natural or juridical person, including its affiliate, agent, associate, broker, consultant, director, promoter, shareholder, sponsor or subsidiary, any commission, gratification, bribe, finder's fee or kickback, whether described as consultations fee or otherwise, with the object of obtaining or inducing the procurement of a contract, right, interest, privilege or other obligation or benefit in whatsoever form from GoP, except that which has been expressly declared pursuant hereto.

[Name of Supplier] certifies that it has made and will make full disclosure of all agreements and arrangements with all persons in respect of or related to the transaction with GoP and has not taken any action or will not take any action to circumvent the above declaration, representative or warranty.

[Name of Supplier] accepts full responsibility and strict liability for making and false declaration, not making full disclosure, misrepresenting fact or taking any action likely to defeat the purpose of this declaration, representation and warranty. It agrees that any contract, right interest, privilege or other obligation or benefit obtained or procured as aforesaid shall, without prejudice to any other right and remedies available to GoP under any law, contract or other instrument, be voidable at the option of GoP.

Notwithstanding any rights and remedies exercised by GoP in this regard, [Name of Supplier] agrees to indemnify GoP for any loss or damage incurred by it on account of its corrupt business practices and further pay compensation to GoP in an amount equivalent to ten time the sum of any commission, gratification, bribe, finder's fee or kickback given by [Name of Supplier] as aforesaid for the purpose of obtaining or inducing the procurement of any contract, right, interest, privilege or other obligation or benefit in whatsoever form from GoP.

# Performance Guarantee Form

# Performance Guarantee Form

To: **Attabad Lake Hydropower Project (Member (Water) WAPDA), Chief Engineer/ PD Liaison Office: Office of Chief Engineer/ Project Director Attabad Lake Hydropower Project (ALHPP) WAPDA, Sunny View estate, Kashmir Road, Lahore, Pakistan**

WHEREAS *[name of Bidder]* (hereinafter called "the Bidder") has undertaken, in pursuance of Contract No. *[reference number of the contract]* dated *[insert date]* for provision of Goods*(*hereinafter called "the Contract").

AND WHEREAS it has been stipulated by you in the said Contract that the Bidder shall furnish you with a Bank Guarantee by a reputable bank for the sum specified therein as security for compliance with the Bidder's performance obligations in accordance with the Contract.

AND WHEREAS we have agreed to give the Bidders guarantee:

THEREFORE, WE hereby affirm that we are Guarantors and responsible to you, on behalf of the Bidder, up to a total of *[amount of the guarantee in words and figures]*, and we undertake to pay you, upon your first written demand declaring the Bidder to be in default under the Contract and without cavil or argument, any sum or sums within the limits of *[amount of guarantee]* as aforesaid, without your needing to prove or to show grounds or reasons for your demand or the sum specified therein.

This guarantee is valid until the: *[insert date]*

Signature and seal of the Guarantors

_____

*[name of bank or financial institution]*

_____

*[address]*

_____

*[date}*

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

# Annexure

# Cover Annexure – Supersession of PPRA SBD Sections by Project Specific EPC Bidding Documents Volume-I Bidding Procedures and Conditions of Contract

**Description**

This is to certify that the following sections of the EPC Bidding Documents for Attabad Lake Hydropower Project (54 MW) – Package-III: Electro-Mechanical Works shall take precedence over the corresponding sections of the PPRA Standard Bidding Documents (SBD – Works) wherever applicable

| PPRA SBD Section | Superseded By Sections from attached EPC Bidding Document |
|---|---|
| Section II – Instructions to Bidders (ITB) | Volume I – Section I: Instructions to Proposers (ITP) |
| Section III – Bid Data Sheet (BDS) | Volume I – Section II: Proposal Data Sheet (PDS) |
| Section IV – Eligible Countries | Volume I – Section V: Eligible Countries |
| Section V – Evaluation and Qualification Criteria | Volume I – Section III: Evaluation & Qualification Criteria |
| Not Applicable in PPRA SBD | Volume I – Section VI: Fraud and Corruption (including Integrity Pact) |
| Section VI – Works Requirements | Volume II – Employer's Requirements (Parts I, II & III) |
| Section VII – Standard Bidding Forms | Volume I – Section IV: Proposal Forms |
| Section VIII – General Conditions of Contract (GCC) | Volume I – Section VII: General Conditions (FIDIC 2017 – EPC/Turnkey) |
| Section IX – Particular Conditions of Contract (PCC) | Volume I – Section VIII: Particular Conditions (Contract Data + SP) |
| Section X – Contract Forms | Volume I – Section X: Contract Forms |

The attached EPC Bidding Documents (Volumes I to VIII) shall govern the procurement process, bid evaluation, contract award, execution, and all related obligations, in accordance with PPRA Rules.

All the form that are neccessary for submission of Bids may also be filled and submitted on EPADs along with forms of attached EPC document.

Google Drive Link of complete EPC bidding document is https://drive.google.com/drive/folders/1RknEK1kV-aTcgheKRxyhjlJpXCjiHxWE?usp=sharing

Technical Submission (Vendor)

See Form Under Additional Forms and Documents: **Cover Annexure – Supersession of PPRA SBD Sections by Project Specific EPC Bidding Documents Volume-I Bidding Procedures and Conditions of Contract** (page number: 116)

## EPC Bidding Document Volume II Employer's Requirement Part 1 Specific Provisions

Technical Submission (Vendor)

See Form Under Additional Forms and Documents: **EPC Bidding Document Volume II Employer's Requirement Part 1 Specific Provisions** (page number: 329)

## EPC Bidding Document Volume II Employer's Requirement Part 2 Technical Provisions

Technical Submission (Vendor)

See Form Under Additional Forms and Documents: **EPC Bidding Document Volume II Employer's Requirement Part 2 Technical Provisions** (page number: 500)

## EPC Bidding Document Volume II Employer's Requirement Part 3(1) Drawings

Technical Submission (Vendor)

See Form Under Additional Forms and Documents: **EPC Bidding Document Volume II Employer's Requirement Part 3(1) Drawings** (page number: 1070)

# EPC Bidding Document Volume II Employer's Requirement Part 3(2) Drawings

Technical Submission (Vendor)

See Form Under Additional Forms and Documents: **EPC Bidding Document Volume II Employer's Requirement Part 3(2) Drawings** (page number: 1096)

# EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume 1 Part 1

Technical Submission (Vendor)

See Form Under Additional Forms and Documents: **EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume 1 Part 1** (page number: 1120)

# EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume 1 Part 2

Technical Submission (Vendor)

See Form Under Additional Forms and Documents: **EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume 1 Part 2** (page number: 1313)

# EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume II Part 1

Technical Submission (Vendor)

See Form Under Additional Forms and Documents: **EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume II Part 1** (page number: 1607)

# EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume II Part 2

Technical Submission (Vendor)

See Form Under Additional Forms and Documents: **EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume II Part 2** (page number: 1627)

## EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume II Part 3

Technical Submission (Vendor)

See Form Under Additional Forms and Documents: **EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume II Part 3** (page number: 1658)

## EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume II Part 4

Technical Submission (Vendor)

See Form Under Additional Forms and Documents: **EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume II Part 4** (page number: 1683)

## EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume II Part 5

Technical Submission (Vendor)

See Form Under Additional Forms and Documents: **EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume II Part 5** (page number: 1696)

## EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume II Part 6

Technical Submission (Vendor)

See Form Under Additional Forms and Documents: **EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume II Part 6** (page number: 1708)

## EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume II Part 7

Technical Submission (Vendor)

See Form Under Additional Forms and Documents: **EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume II Part 7** (page number: 1748)

## EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume III

Technical Submission (Vendor)

See Form Under Additional Forms and Documents: **EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume III** (page number: 1759)

## EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume IV

Technical Submission (Vendor)

See Form Under Additional Forms and Documents: **EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume IV** (page number: 1844)

## EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume V

Technical Submission (Vendor)

See Form Under Additional Forms and Documents: **EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume V** (page number: 1963)

## EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume VI

Technical Submission (Vendor)

See Form Under Additional Forms and Documents: **EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume VI** (page number: 2027)

# EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume VII

Technical Submission (Vendor)

See Form Under Additional Forms and Documents: **EPC Bidding Document Volume III Additional Information Part 1 Feasibility Study Volume VII** (page number: 2172)

# EPC Bidding Document Volume III Additional Information Part 2 Feasibility Review Report Part 1

Technical Submission (Vendor)

See Form Under Additional Forms and Documents: **EPC Bidding Document Volume III Additional Information Part 2 Feasibility Review Report Part 1** (page number: 2378)

# EPC Bidding Document Volume III Additional Information Part 2 Feasibility Review Report Part 2

Technical Submission (Vendor)

See Form Under Additional Forms and Documents: **EPC Bidding Document Volume III Additional Information Part 2 Feasibility Review Report Part 2** (page number: 2486)

# EPC Bidding Document Volume III Additional Information Part 3 Topographic Mapping Part 1

Technical Submission (Vendor)

See Form Under Additional Forms and Documents: **EPC Bidding Document Volume III Additional Information Part 3 Topographic Mapping Part 1** (page number: 2593)

# EPC Bidding Document Volume III Additional Information Part 3 Topographic Mapping Part 2

Technical Submission (Vendor)

See Form Under Additional Forms and Documents: **EPC Bidding Document Volume III Additional Information Part 3 Topographic Mapping Part 2** (page number: 2636)

## EPC Bidding Document Volume III Additional Information Part 4 EIA Report

Technical Submission (Vendor)

See Form Under Additional Forms and Documents: **EPC Bidding Document Volume III Additional Information Part 4 EIA Report** (page number: 2681)

## Addendum No. 1

Please upload signed letter acknowledging receipt and acceptance of Addendum No. 01 in response to this Addendum Annexure.

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Addendum No. 1** (page number: 2976)

## Technical Bid Submission Part 1 Form of Proposal / Bid Security

Please upload Bid Security as per Bidding Document requirements.

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Technical Bid Submission Part 1 Form of Proposal / Bid Security** (page number: 3022)

## Technical Bid Submission Part 2: Application Submission Letter – Employer’s SEA and/or SH Disqualification

Please upload duly signed Application Submission Letter.

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Technical Bid Submission Part 2: Application Submission Letter – Employer's SEA and/or SH Disqualification** (page number: 3023)

## Technical Bid Submission Part 3: ELI 1.1 with Attachments – Nationality, Eligibility, State owned Entity of the Employer's Country, United Nations resolution or Employer's Country Law

Please upload ELI 1.1 with all required attachments regarding nationality and eligibility requirements.

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Technical Bid Submission Part 3: ELI 1.1 with Attachments – Nationality, Eligibility, State owned Entity of the Employer's Country, United Nations resolution or Employer's Country Law** (page number: 3024)

## Technical Bid Submission Part 4: ELI 1.2 with Attachments – Nationality, State owned Entity of the Employer's Country, United Nations resolution or Employer's Country Law

Please upload ELI 1.2 with all required attachments regarding nationality and eligibility requirements.

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Technical Bid Submission Part 4: ELI 1.2 with Attachments – Nationality, State owned Entity of the Employer's Country, United Nations resolution or Employer's Country Law** (page number: 3025)

## Technical Bid Submission Part 5: Letter of Proposal – Technical Part – Conflict of Interest, Suspension Based on Execution of Bid / Proposal Securing Declaration by the Employer, Potential DAAB Members

Please upload duly signed Letter of Proposal – Technical Part.

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Technical Bid Submission Part 5: Letter of Proposal – Technical Part – Conflict of Interest, Suspension Based on Execution of Bid / Proposal Securing Declaration by the Employer, Potential DAAB Members** (page number: 3026)

# Technical Bid Submission Part 6: PEC Standard License – PEC Licensing (Category C-A)

Please upload valid PEC License.

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Technical Bid Submission Part 6: PEC Standard License – PEC Licensing (Category C-A)** (page number: 3027)

# Technical Bid Submission Part 7: Income Tax Certificate (ATL) – Pakistani Firm Tax Registration

Please upload Income Tax Certificate / ATL evidence.

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Technical Bid Submission Part 7: Income Tax Certificate (ATL) – Pakistani Firm Tax Registration** (page number: 3028)

# Technical Bid Submission Part 8: Form CON-2 – History of Non-Performing Contracts, Pending Litigations, Litigation History

Please upload Form CON-2 with supporting documents.

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Technical Bid Submission Part 8: Form CON-2 – History of Non-Performing Contracts, Pending Litigations, Litigation History** (page number: 3029)

# Technical Bid Submission Part 9: Form CON-3 ES Performance Declaration – Environmental, Social, Health and Safety (ESHS) past performance

Please upload duly filled Form CON-3 ES Performance Declaration.

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Technical Bid Submission Part 9: Form CON-3 ES Performance Declaration – Environmental, Social, Health and Safety (ESHS) past performance** (page number: 3030)

# Technical Bid Submission Part 10 Form CON-4 – Employer's SEA and/or SH Disqualification

Please upload duly filled Form CON-4.

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Technical Bid Submission Part 10 Form CON-4 – Employer's SEA and/or SH Disqualification** (page number: 3031)

# Technical Bid Submission Part 11 Form CCC – Current Contract Commitments / Work Progress

Please upload Current Contract Commitments / Work Progress details

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Technical Bid Submission Part 11 Form CCC – Current Contract Commitments / Work Progress** (page number: 3032)

# Technical Bid Submission Part 12 Form FIN-3.1 with Attachments – Financial Capabilities

Please upload Form FIN-3.1 along with all attachments.

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Technical Bid Submission Part 12 Form FIN-3.1 with Attachments – Financial Capabilities** (page number: 3033)

## Technical Bid Submission Part 13: Form FIN-3.2 – Average Annual Construction Turnover

Please upload Form FIN-3.2 regarding Average Annual Construction Turnover.

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Technical Bid Submission Part 13: Form FIN-3.2 – Average Annual Construction Turnover** (page number: 3034)

## Technical Bid Submission Part 14: Form FIN-3.3 – Current Contract Commitments / Work Progress

Please upload Form FIN-3.3 regarding Current Contract Commitments.

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Technical Bid Submission Part 14: Form FIN-3.3 – Current Contract Commitments / Work Progress** (page number: 3035)

## Technical Bid Submission Part 15: Form EXP-4.1 with Attachments – General Experience

Please upload Form EXP-4.1 with supporting documents.

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Technical Bid Submission Part 15: Form EXP-4.1 with Attachments – General Experience** (page number: 3036)

# Technical Bid Submission Part 16 Form EXP-4.2(a) with Attachments – Specific Construction & Contract Management Experience

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Technical Bid Submission Part 16 Form EXP-4.2(a) with Attachments – Specific Construction & Contract Management Experience** (page number: 3037)

# Technical Bid Submission Part 17: Form EXP-4.2(b) with Attachments – Experience in Key Activities

Please upload Form EXP-4.2(b) with supporting documents.

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Technical Bid Submission Part 17: Form EXP-4.2(b) with Attachments – Experience in Key Activities** (page number: 3038)

# Technical Bid Submission Part 18 Form EXP-4.2(c) with Attachments – Specific Experience in managing ESHS aspects

Please upload Form EXP-4.2(c) with supporting documents.

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Technical Bid Submission Part 18 Form EXP-4.2(c) with Attachments – Specific Experience in managing ESHS aspects** (page number: 3039)

# Technical Bid Submission Part 19 Design Methodology

Please upload complete Design Proposal.

Evaluation shall be based on the following requirements: H. The Design Proposal shall demonstrate the Proposer9s understanding of the Project and present a comprehensive technical solution for the Electro-Mechanical works, including Francis Turbine, Governor, Main Inlet Valve, Synchronous Generator, Power Transformer, 132 kV Switchgear and Hydraulic Gates. The Proposal shall clearly describe the design philosophy, compliance with applicable standards, interface with Civil Works, and long-term operational

reliability of the plant.

a) Overview

b) References

c) Design criteria and basis

d) Technical narrative

e) Process flow diagram

f) Process design and calculation of components (including structural modelling and Load application)

g) Layout arrangement, component plans and spot details in A3

h) Proposed design deliverables for Contract execution

i) Site Investigation Reports (optional)

The Works shall be designed to withstand all description in accordance with the Employer9s Requirements, and the appropriate codes and standards.

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Technical Bid Submission Part 19 Design Methodology** (page number: 3040)

# Technical Bid Submission Part 20: Method Statement for Key Construction Activities

Please upload Method Statement for Key Construction Activities.

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Technical Bid Submission Part 20: Method Statement for Key Construction Activities** (page number: 3041)

# Technical Bid Submission Part 20: Testing and Commissioning Strategy

**Testing and Commissioning Strategy**

The Contractor shall submit a comprehensive Testing and Commissioning Strategy covering factory tests, site installation verification, pre-commissioning, commissioning, performance and reliability tests for all Electro-Mechanical equipment.

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Technical Bid Submission Part 20: Testing and Commissioning Strategy** (page number: 3042)

# Technical Bid Submission Part 21:: Optimization of Timelines for E&M Equipment

**Optimization of Timelines for E&M Equipment**

The Proposer may propose optimization of timelines for Electro-Mechanical works within the overall completion period defined by the Employer. The Proposal shall clearly identify areas of schedule optimization, interface with Civil Works, associated risks and mitigation measures, and resource deployment. The optimized schedule shall be supported by a detailed program and shall not compromise safety, quality, testing requirements, or performance guarantees.

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Technical Bid Submission Part 21:: Optimization of Timelines for E&M Equipment** (page number: 3043)

# Technical Bid Submission Part 22: Code of Conduct

Please upload duly signed Code of Conduct Form along with Attachments

**Code of Conduct**

The Proposer shall submit a project-specific Code of Conduct, based on the template provided in the Bidding Documents, signed by an authorized representative. The submission shall include an implementation and monitoring plan describing how the Code will be communicated, enforced, monitored, and how breaches will be addressed. The Code of Conduct, once accepted, shall be part of the Contract and enforceable. See specific requirements for code of conduct under Section IV Proposal Forms.

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Technical Bid Submission Part 22: Code of Conduct** (page number: 3044)

# Technical Bid Submission Part 23: EPC/Turnkey Work Program

Please upload detailed Work Program

**EPC/Turnkey Work Program**

The Proposer shall set out a work program for design and construction of the Works as per attached Proposal Forms. See specific requirements for work program under Section IV Proposal Forms.

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Technical Bid Submission Part 23: EPC/Turnkey Work Program** (page number: 3045)

# Technical Bid Submission Part 24: Proposer's Personnel Organization Chart

Please upload Personnel Organization Chart.

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Technical Bid Submission Part 24: Proposer's Personnel Organization Chart** (page number: 3046)

# Technical Bid Submission Part 25: Risk Assessment and proposed management plan

Please upload Risk Assessment and Proposed Management Plan.

**Risk Assessment and proposed management plan**

The Proposer is required to access the Project risks and suggest the proposed remedial measures, for various stages during the execution of the project. The Proposer should be able to list any risks and constraints involved that could affectthe sequence / progress of works. See specific requirements for Risk Assessment under Section IV Proposal Forms.

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Technical Bid Submission Part 25: Risk Assessment and proposed management plan** (page number: 3047)

# Technical Bid Submission Part 26: Form EQU – Proposer's Equipment

Please upload Form EQU regarding Proposer's Equipment.

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Technical Bid Submission Part 26: Form EQU – Proposer's Equipment** (page number: 3048)

# Technical Bid Submission Part 27: Form PER-1 – Key Personnel Qualification and Resource Schedule

Please upload Form PER-1 regarding Key Personnel Qualification and Resource Schedule.

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Technical Bid Submission Part 27: Form PER-1 – Key Personnel Qualification and Resource Schedule** (page number: 3049)

# Technical Bid Submission Part 28 Form PER-2 – Resume and Declaration EPC Contractor's and Key Personnel

Please upload Form PER-2 including resumes and declarations of key personnel.

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Technical Bid Submission Part 28 Form PER-2 – Resume and Declaration EPC Contractor's and Key Personnel** (page number: 3050)

# Technical Bid Submission Part 29: Sub-Contractors (if Applicable) – Proposed Sub-contractors and/or Manufacturers

Please provide details of the proposed Sub-Contractors and/or Manufacturers, including their name, country of origin, scope of work/supply, and relevant experience. If the supporting documents exceed the upload limit, the complete documents may be provided through a Google Drive link with view-only access.

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Technical Bid Submission Part 29: Sub-Contractors (if Applicable) – Proposed Sub-contractors and/or Manufacturers** (page number: 3051)

## Technical Bid Submission Part 30:Sub-Contractor’s Authorization

Please upload Sub-contractor’s Authorization documents.

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Technical Bid Submission Part 30:Sub-Contractor’s Authorization** (page number: 3052)

## Technical Bid Submission Part 31: Integrity Pact – Fraud and Corruption

Please upload duly signed Integrity Pact.

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Technical Bid Submission Part 31: Integrity Pact – Fraud and Corruption** (page number: 3053)

## Technical Bid Submission Part 32: Summary of Procedure for Delay Damages for Interface Milestones (Table-1 and Table-2)

Please upload signed acceptance of delay damages procedure (Table-1 and Table-2).

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Technical Bid Submission Part 32: Summary of Procedure for Delay Damages for Interface Milestones (Table-1 and Table-2)** (page number: 3054)

## Technical Bid Submission Part 33: Appendix-A Performance Guarantees

Please upload duly signed Appendix-A Performance Guarantees.

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Technical Bid Submission Part 33: Appendix-A Performance Guarantees** (page number: 3055)

## Technical Bid Submission Part 34: Environmental and Social (ES) Metrics for Progress Reports

Please upload Environmental and Social Metrics for Progress Reports.

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Technical Bid Submission Part 34: Environmental and Social (ES) Metrics for Progress Reports** (page number: 3056)

## Technical Bid Submission Part 35: Declaration of Ultimate Beneficial Owners Information for Public Procurement Contracts

Please upload Declaration of Ultimate Beneficial Owners Information for Public Procurement Contracts.

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Technical Bid Submission Part 35: Declaration of Ultimate Beneficial Owners Information for Public Procurement Contracts** (page number: 3057)

## Technical Bid Submission Part 36: any other Miscellaneous document

any other misc documents proposer wants to submit that are not covered in technical bid submission (They can be mandatory or optional as per attached EPC document)

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Technical Bid Submission Part 36: any other Miscellaneous document** (page number: 3058)

## Financial Bid Submission Part 1 Letter of Proposal – Financial Part

Please upload duly signed Letter of Proposal – Financial Part.

Financial Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Financial Bid Submission Part 1 Letter of Proposal – Financial Part** (page number: 3059)

## Financial Bid Submission Part 2 : Table of Adjustment Data – Table A: Local Currency

Please upload Table of Adjustment Data for Local Currency.

Financial Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Financial Bid Submission Part 2 : Table of Adjustment Data – Table A: Local Currency** (page number: 3060)

## Financial Bid Submission Part 3: Table B Foreign Currency

Please upload Table of Adjustment Data for Foreign Currency.

Financial Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Financial Bid Submission Part 3: Table B Foreign Currency** (page number: 3061)

## Financial Bid Submission Part 4: Table C: Summary of Payment Currencies

Please upload Summary of Payment Currencies.

Financial Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Financial Bid Submission Part 4: Table C: Summary of Payment Currencies** (page number: 3062)

## Financial Bid Submission Part 5: Price Schedule No. 01 – Supply of Plant from Abroad (Pre-Engineered Structures) including Fixtures and other Materials, Goods and Spare Parts (if any)

Please upload duly filled and signed Price Schedule No. 01.

Financial Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Financial Bid Submission Part 5: Price Schedule No. 01 – Supply of Plant from Abroad (Pre-Engineered Structures) including Fixtures and other Materials, Goods and Spare Parts (if any)** (page number: 3063)

## Financial Bid Submission Part 6: Price Schedule No. 02 – Supply of Plant from within the Employer's Country (Pre-Engineered Structures) including Fixtures and other Materials, Goods and Spare Parts (if any)

Please upload duly filled and signed Price Schedule No. 02.

Financial Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Financial Bid Submission Part 6: Price Schedule No. 02 – Supply of Plant from within the Employer's Country (Pre-Engineered Structures) including Fixtures and other Materials, Goods and Spare Parts (if any)** (page number: 3064)

## Financial Bid Submission Part 7: Price Schedule No. 03 – Design Services

Please upload duly filled and signed Price Schedule No. 03 for Design Services.

Financial Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Financial Bid Submission Part 7: Price Schedule No. 03 – Design Services** (page number: 3065)

## Financial Bid Submission Part 8: Price Schedule No. 04 – Installation and All other Services

Please upload duly filled and signed Price Schedule No. 04.

Financial Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Financial Bid Submission Part 8: Price Schedule No. 04 – Installation and All other Services** (page number: 3066)

## Financial Bid Submission Part 9: Price Schedule No. 05 – Summary

Please upload duly filled and signed Price Schedule No. 05 Summary.

Financial Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Financial Bid Submission Part 9: Price Schedule No. 05 – Summary** (page number: 3067)

## Financial Bid Submission Part 10: Price Schedule No. 06 – Recommended Spare Parts

Please upload duly filled and signed Price Schedule No. 06 for Recommended Spare Parts.

Financial Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Financial Bid Submission Part 10: Price Schedule No. 06 – Recommended Spare Parts** (page number: 3068)

## Financial Bid Submission Part 11 Priced Sub-Activity Schedule for E&M Works – Breakdown of Prices

Please upload Currency Wise Break-Up of Priced Sub-Activity Schedule.

Financial Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Financial Bid Submission Part 11 Priced Sub-Activity Schedule for E&M Works – Breakdown of Prices** (page number: 3069)

## Financial Bid Submission Part 12: Schedule of Payments for E&M Works – Currency Wise Break-Up of Priced Sub-Activity Schedule

Please upload Currency Wise Break-Up of Priced Sub-Activity Schedule.

Financial Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Financial Bid Submission Part 12: Schedule of Payments for E&M Works – Currency Wise Break-Up of Priced Sub-Activity Schedule** (page number: 3070)

## Financial Bid Submission Part 13: Schedule of Payments for E&M Works – Apportionment of Contract Price According to Activity

Please upload Apportionment of Contract Price According to Activity.

Financial Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Financial Bid Submission Part 13: Schedule of Payments for E&M Works – Apportionment of Contract Price According to Activity** (page number: 3071)

## Financial Bid Submission Part 14: Schedule of Daywork Rates – Labour

Please upload Schedule of Daywork Rates for Labour.

Financial Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Financial Bid Submission Part 14: Schedule of Daywork Rates – Labour** (page number: 3072)

## Financial Bid Submission Part 15: Schedule of Daywork Rates – Materials

Please upload Schedule of Daywork Rates for Materials.

Financial Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Financial Bid Submission Part 15: Schedule of Daywork Rates – Materials** (page number: 3073)

## Financial Bid Submission Part 16: Schedule of Daywork Rates – EPC Contractor's Equipment

Please upload Schedule of Daywork Rates for EPC Contractor's Equipment.

Financial Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Financial Bid Submission Part 16: Schedule of Daywork Rates – EPC Contractor's Equipment** (page number: 3074)

## Financial Bid Submission Part 17: Daywork Summary

Please upload duly filled Daywork Summary.

Financial Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Financial Bid Submission Part 17: Daywork Summary** (page number: 3075)

## Financial Bid Submission Part 18: Specified Provisional Sums

Specified Provisional Sum should be same as in bidding documents

Financial Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Financial Bid Submission Part 18: Specified Provisional Sums** (page number: 3076)

## Financial Bid Submission Part 19: Grand Summary

Please upload duly filled and signed Grand Summary.

Financial Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Financial Bid Submission Part 19: Grand Summary** (page number: 3077)

## Financial Bid Submission Part 20: Miscellaneous

Any other document proposer want to submit with finanical proposal or any mandatory submission not covered above.

Financial Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Financial Bid Submission Part 20: Miscellaneous** (page number: 3078)

## Addendum No. 02

Please upload a duly signed letter acknowledging receipt and acceptance of Addendum No. 02 and confirming that all provisions of the Addendum have been duly incorporated into the submitted Bid/Proposal

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Addendum No. 02** (page number: 3079)

## Addendum No. 03

Please upload a duly signed letter acknowledging receipt and acceptance of Addendum No. 03 and confirming that all provisions of the Addendum have been duly incorporated into the submitted Bid/Proposal

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Addendum No. 03** (page number: 3081)

# Addendum No. 04

Please upload a duly signed letter acknowledging receipt and acceptance of Addendum No. 04and confirming that all provisions of the Addendum have been duly incorporated into the submitted Bid/Proposal

Technical Submission (Vendor)

Document Required

See Form Under Additional Forms and Documents: **Addendum No. 04** (page number: 3084)

# Pre-Proposal Clarifications from Potential Proposers

Information (Read-Only)

See Form Under Additional Forms and Documents: **Pre-Proposal Clarifications from Potential Proposers** (page number: 3092)

# Adjustment Data

SBD Document (Read-Only)

Invalid schema or demoList

PUBLIC PROCUREMENT REGULATORY AUTHORITY
(PPRA)
EPADS

# Procurement Forms

# Past Experience and Completed Contracts

The bidder must meet the expeirence requirement in Section III Qualification and Evaluation Criteria ( D. Experience ) of attached EPC bidding document Volume 1

See Form Under Additional Forms and Documents: **Past Experience and Completed Contracts** (page number: 3153)

# Historical Contract Non-Performance, and Pending Litigation and Litigation History

**Qualifciation Requirement**

Non-performance of a contractdid not occur as a result of EPC Contractor’s default since 1st January 2010.

Compliance Requirement: Single Entiry Must Meet Requirement

All JV Member Combined: Must Meet Requirement

Each JV Member:Must Meet Requirement

Submission Requiement: Form CON-2 as per attached EPC bidding document volume 1

See Form Under Additional Forms and Documents: **Historical Contract Non-Performance, and Pending Litigation and Litigation History** (page number: 3154)

# Current Contracts and Their Progress

The requirements for disclosure of current contract commitments and works in progress shall be governed by the attached EPC Bidding Document. Bidders shall submit the required information in accordance with Form FIN-3.3 (Current Contract Commitments / Works in Progress) of the EPC Bidding Document Volume 1.

See Form Under Additional Forms and Documents: **Current Contracts and Their Progress** (page number: 3156)

# Financial Capacity and Net Worth Evaluation Form

The financial capability requirements shall be governed by the attached EPC Bidding Document Volume 1. Bidders shall submit the required financial information in accordance with Form FIN-3.1 (Financial Data) of the EPC Bidding Document, including audited financial statements for the previous three (03) years

See Form Under Additional Forms and Documents: **Financial Capacity and Net Worth Evaluation Form** (page number: 3157)

# Average Annual Turnover

The requirements for submission of Average Annual Construction Turnover shall be governed by the attached EPC Bidding Document. Bidders shall submit the required information in accordance with Form FIN-3.2 (Average Annual Construction Turnover) of the EPC Bidding Document Volume 1.

See Form Under Additional Forms and Documents: **Average Annual Turnover** (page number: 3159)

# Past Construction Experiences

The bidder must meet the expeirence requirement in Section III Qualification and Evaluation Criteria ( D. Experience ) of attached EPC bidding document Volume 1

See Form Under Additional Forms and Documents: **Past Construction Experiences** (page number: 3160)

# Contractor's Key Personnel Representative and Their Schedules

See Form Under Additional Forms and Documents: **Contractor's Key Personnel Representative and Their Schedules** (page number: 3166)

# Financial Resources

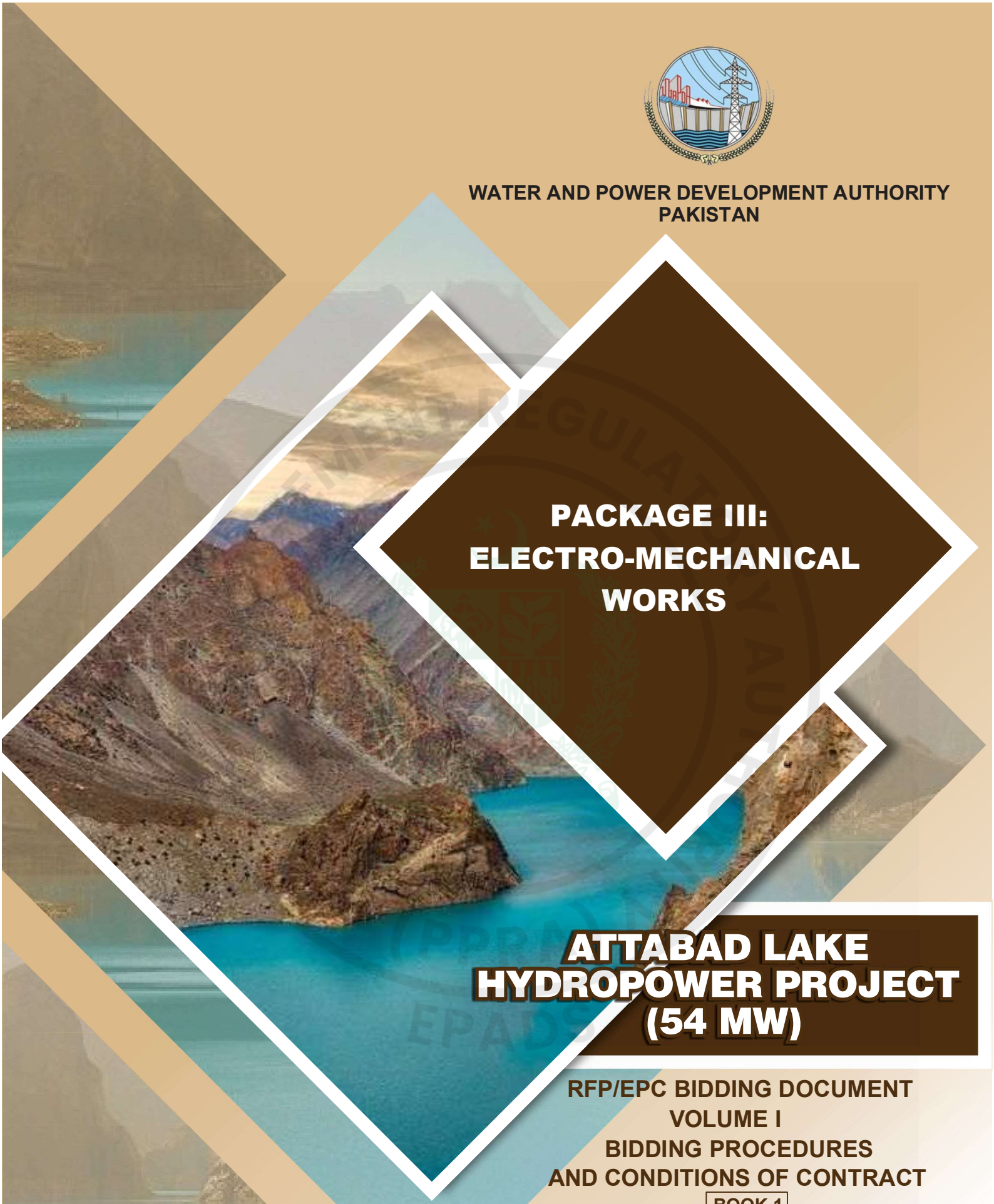
The financial capability requirements shall be governed by the attached EPC Bidding Document Volume 1. Bidders shall submit the required financial information in accordance with Form FIN-3.1 (Financial Data) of the EPC Bidding Document, including audited financial statements for the previous three (03) years

See Form Under Additional Forms and Documents: **Financial Resources** (page number: 3170)

PUBLIC PROCUREMENT REGULATORY AUTHORITY
(PPRA)
EPADS

# Additional Forms and Documents

WATER AND POWER DEVELOPMENT AUTHORITY
PAKISTAN



# PACKAGE III: ELECTRO-MECHANICAL WORKS

# ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

## RFP/EPC BIDDING DOCUMENT
## VOLUME I
## BIDDING PROCEDURES AND CONDITIONS OF CONTRACT
BOOK 1

August 2026

AHMC ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

NESPAK · MCE · PES · DOLSAR ENGINEERING

**DOCUMENT NO:**
**BD-ALHPP-03 (V1)**

e-Pak Acquisition and Disposal System (EPADS) generated document | © 2026

**RFP No.:** BD/ICB-ALHPP-03

## INVITATION TO BID/PROPOSAL

1. Water and Power Development Authority, invites electronic Bids / Proposals through PPRA EPADs from the Contractors for Engineering, Procurement and Construction (EPC) of **Package-III: Electro-Mechanical Works, of Attabad Lake Hydropower Project (54 MW).** The Bidding process will be conducted through ICB, following the Bidding Procedures of Single Stage Two Envelope, as specified in Public Procurement Regulation Authority (PPRA)'s Rules-2004 (updated) and Pakistan Engineering Council (PEC)'s By-laws. The Foreign Bidders/ Proposers (from Countries having diplomatic relations with Islamic Republic of Pakistan) are entitled to participate in the Bidding process only in Joint Venture with Pakistani Contractors who are registered with Income Tax and Sales Tax Departments and are on Active Taxpayers List of the Federal Board of Revenue (FBR) and registered with Pakistan Engineering Council (PEC) (In the case of a Joint Venture (JV), it is required that only the Lead Partner in the Joint Venture shall hold a valid C-A category License, while the other JV member(s) shall meet the specified requirements corresponding to their respective share(s) in the Joint Venture).
2. All Bids / Proposals must be accompanied by a scanned copy of Bid / Proposal Security of **PKR 120 Million** or equivalent amount in freely convertible currencies**.** Source of exchange rate shall be State Bank of Pakistan. The date for the exchange rate shall be the deadline for submission of Proposals
3. E-Proposals / Bidding Documents, containing detailed Terms and Conditions, Method of Procurement, Procedure for submission of Bids / Proposals, Bid / Proposal security, Bids / Proposals validity, Opening of Bids / Proposals, Evaluation Criteria, Clarification / Rejection of Bids / Proposals, Performance Guarantee etc. are available on for registered Bidders / Proposers on EPADs v2.0 at **(www.vendors.epads.gov.pk)**
4. The electronic Bids / Proposals, prepared in accordance with the instructions provided in the Proposal / Bidding Document, shall be submitted using EPADs on or before **August 20, 2026 at 1100 hrs**. The Technical Part of Electronic Bids / Proposals on EAPDS shall be opened the same day **at 1130 hrs in WAPDA Auditorium, WAPDA House, Sharah-e-Quaid-e-Azam Lahore, Punjab.** This advertisement is also available on PPRA website at **(www.ppra.org.pk).**

   Note: Notification of the GRC (Grievance Redressal Committee) constituted in terms of Rule-48 of PPRA rules, is provided on EPADS at **(www.ppra.org.pk)** and on PPRA's website (if any).

Chief Engineer / PD
Attabad Lake Hydropower Project
Liaison office, Sunny View Estate, Kashmir Road, Lahore Pakistan
Telephone: 0092-42-99204981 0092-42-3334481116
e-mail address: gmpna01@gmail.com , pdalhpp@gmail.com

**RFP/EPC BIDDING DOCUMENTS OF**
**ATTABAD LAKE HYDROPOWER PROJECT (54 MW)**

**PACKAGE-III: ELECTRO-MECHANICAL WORKS**

**INDEX TO BIDDING DOCUMENTS**

**VOLUME-I: BIDDING PROCEDURES AND CONDITIONS OF CONTRACT**

**Part-I: Bidding Procedures**

**Part-II: Conditions of Contract and Standard Forms**

**VOLUME-II: EMPLOYER'S REQUIREMENTS**

**Part-I: Specific Provisions**

**Part-II: Technical Provisions**

**Part-III: Conceptual Drawings**

**VOLUME-III: ADDITIONAL INFORMATION**

**Part-I: Feasibility Study Report (2021)**

**Part-II: Feasibility Review Report (2022)**

**Part-III: Topographic Survey Map Book (2025)**

**Part-IV: Updated Environmental Impact Assessment (EIA) Report**

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**EPC BIDDING DOCUMENTS OF**
**ATTABAD LAKE HYDROPOWER PROJECT (54 MW)**

**PACKAGE-III: ELECTRO-MECHANICAL WORKS**

**VOLUME-I: BIDDING PROCEDURES AND CONDITIONS OF CONTRACT**

**TABLE OF CLAUSES**

**LIST OF ABBRIVIATIONS ..... V**

**PART-I: BIDDING PROCEDURES ..... 1-1**

**SECTION I - INSTRUCTIONS TO PROPOSERS (ITP) ..... 1-1**
A. General ..... 1-1
B. Contents of RFP Document ..... 1-5
C. Preparation of Proposals ..... 1-7
D. Submission of Proposals ..... 1-14
E. Opening of Technical Parts of Proposals ..... 1-16
F. Evaluation of Proposals - General Provisions ..... 1-17
G. Evaluation of Technical Parts of Proposals ..... 1-18
H. Opening of Financial Parts ..... 1-20
I. Evaluation of Financial Part ..... 1-21
J. Evaluation of Combined Technical and Financial Part ..... 1-24
K. Award of Contract ..... 1-25

**SECTION II - PROPOSAL DATA SHEET (PDS) ..... 2-1**
A. General ..... 2-1
B. Contents of RFP/EPC Bidding Document ..... 2-2
C. Preparation of Proposals ..... 2-3
D. Submission of Proposals ..... 2-4
E. Opening of Technical Parts of Proposals ..... 2-5
G. Evaluation of Technical Parts of Proposals ..... 2-5
J. Evaluation of Combined Technical and Financial Parts ..... 2-9
K. Award of Contract ..... 2-9

**SECTION III - EVALUATION AND QUALIFICATION CRITERIA ..... 3-1**
A. Technical Part ..... 3-1
B. Financial Part ..... 3-29
C. Combined Evaluation ..... 3-30

**SECTION IV - PROPOSAL FORMS ..... 4-1**
Proposal Forms ..... 4-1
Appendix to Proposal ..... 4-5
Technical Proposal Forms ..... 4-28



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Personnel ..... 4-41
Sub-Contractors ..... 4-45
Qualification Forms ..... 4-47
Form of Proposal Security ..... 4-68

**SECTION V - ELIGIBLE COUNTRIES ..... 5-1**

**SECTION VI - FRAUD AND CORRUPTION ..... 6-1**
Integrity Pact ..... 6-3

**PART-II: CONDITIONS OF CONTRACT AND STANDARD FORMS ..... 7-1**

**SECTION VII - GENERAL CONDITIONS (GC) ..... 7-1**

**SECTION VIII - PARTICULAR CONDITIONS ..... 8-1**
Part A - Contract Data ..... 8-1
Part B - Special Provisions ..... 8-13

**SECTION IX - ENVIRONMENTAL AND SOCIAL (ES) METRICS FOR PROGRESS REPORTS ..... 9-1**

**SECTION X - CONTRACT FORMS ..... 10-1**
Declaration of Ultimate Beneficial Owners Information for Public Procurement Contracts 10-1
Letter of Acceptance ..... 10-3
Contract Agreement ..... 10-4
Schedule 1 - Schedule of Payments ..... 10-6
DAAB Agreement ..... 10-7
Performance Security ..... 10-9
Form of Mobilization Advance Guarantee / Bond ..... 10-11



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## LIST OF ABBRIVIATIONS

| | |
|---|---|
| ALHPP | Attabad Lake Hydropower Project |
| BAFO | Best and Final Offer |
| CESMP | Construction Environmental & Social Management Plan |
| CIP | Carriage and Insurance Paid |
| COPA | Conditions of Particular Application |
| COVID-19 | Corona virus Disease 2019 |
| CPM | Critical Path Method |
| DAAB | Dispute Avoidance and Adjudication Board |
| DCS | Distributed Control System |
| DNP | Defects Notification Period |
| E&M | Electrical and Mechanical |
| EOT | Extension of time |
| EPC | Engineering, Procurement and Construction |
| ES | Environmental and Social |
| EXW | Ex Works |
| FED | Federal Excise Duty |
| FIDIC | Federation Internationale Des Ingenieurs Conseils |
| FOB | Freight on Board |
| FPC | Final Payment Certificate |
| GC | General Condition |
| HIV | Human immunodeficiency virus |
| ICB | International Competitive Bidding |
| ICC | International Chamber of Commerce |
| IEC | International Electrotechnical Commission |
| ISBN | International Standard Book Number |
| ITP | Instructions to Proposers |
| JV | Joint Venture |
| MSIP | Management. Strategies And Implementation Plan |
| MW | Megawatt |
| NOC | No Objection Certificate |
| PCC | Particular Conditions of Contract |
| PDS | Proposal Data Sheet |
| PEC | Pakistan Engineering Council |
| PPRA | Public Procurement Regulatory Authority |
| PKR | Pakistani Rupees |



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| RFP | Request for Proposals |
| SCADA | Supervisory Control and Data Acquisition System |
| SEA | Sexual Exploitation and Abuse |
| SH | Sexual Harassment |
| STD | Sexually Transmitted Disease |
| TOC | Taking Over Certificate |
| URDG | Uniform Rules for Demand Guarantees |
| WAPDA | Water and Power Development Authority |
| WHT | Withholding Taxes |

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## PART-I: BIDDING PROCEDURES

## SECTION I - INSTRUCTIONS TO PROPOSERS (ITP)

### A. General

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| **1. Scope of Proposal** | 1.1 The Employer, as specified in the **PDS**, issues, this Request for Proposals (RFP) Document for the execution of the Works on EPC/Turnkey and Construction basis as specified in Volume-II (Employer's Requirements). The name, identification and number of lots (Contracts) of this RFP are specified in the **PDS**.<br>1.2 Unless otherwise stated, throughout this RFP Document definitions and interpretations shall be as prescribed in the **Section VII (General Conditions).**<br>1.3 Throughout this RFP Document:<br>(a) the term "**in writing**" means communicated in written form (e.g., by mail, e-mail, fax, including if specified **in the PDS**, distributed or received through the electronic-procurement system used by the Employer) with proof of receipt;<br>(b) if the context so requires, "**singular**" means "**plural**" and vice versa;<br>(c) "**Day**" means calendar day, unless otherwise specified as "**Business Day**". A Business Day is any day that is an official working day of the Employer. It excludes the Employer's official public holidays;<br>(d) "**Works**" refers to Works, subject of this Request For Proposals document, to be executed on EPC/Turnkey contracting arrangement;<br>(e) "**ES**" means environmental and social (including Sexual Exploitation and Abuse (SEA) and Sexual Harassment (SH));<br>(f) "**Sexual Exploitation and Abuse**" "**(SEA)**" means the following:<br>**Sexual Exploitation** is defined as any actual or attempted abuse of position of vulnerability, differential power or trust, for sexual purposes, including, but not limited to, profiting monetarily, socially or politically from the sexual exploitation of another.<br>**Sexual Abuse** is defined as the actual or threatened physical intrusion of a sexual nature, whether by force or under unequal or coercive conditions;<br>(g) "**Sexual Harassment**" "**(SH)**" is defined as unwelcome sexual advances, requests for sexual favors, and other verbal or physical conduct of a sexual nature by the EPC |



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| | Contractor's Personnel with other EPC Contractor's or Employer's Personnel;<br><br>(h) "**EPC Contractor's Personnel**" is as defined in Sub-Clause 1.1.14 of the General Conditions; and<br><br>(i) "**Employer's Personnel**" is as defined in Sub-Clause 1.1.29 of the General Conditions.<br><br>A non-exhaustive list of (i) behaviors which constitute SEA and (ii) behaviors which constitute SH is attached to the Code of Conduct form in **Section IV (Proposal Forms)**. |
| **2. Source of Funds** | 2.1 The Employer has received funds from Government of Pakistan towards the cost of the project named **in the PDS**. The Employer intends to apply a portion of the funds to eligible payments under the Contract for which this RFP Document is issued. |
| **3. Fraud and Corruption** | 3.1 The Employer requires, Proposers shall observe the highest standards of ethics during the procurement and execution of such contracts. In pursuance of this policy, the Employer:<br><br>(a) defines for the purpose of this provision, the terms set forth below as follows:<br>i. "corrupt practice" means the offering, giving, receiving or soliciting of anything of value to influence the action of a public official in the procurement process or in contract execution; and<br>ii. "fraudulent practice" means any act or omission, including misrepresentation of facts in order to influence a procurement process or the execution of a contract to the detriment of the Employer, and includes collusive practice among Proposers (prior to or after Proposal submission) designed to establish Proposal prices at artificial non-competitive levels and to deprive the Employer to the benefits of free and open competition;<br>(b) will reject a Proposal for award if it determines that the Proposer recommended for award has engaged in corrupt or fraudulent practices in competing for the contract in question<br>(c) will declare a firm ineligible, either indefinitely or for a stated period of time, to be awarded a contract if it at any time determines that the firm has engaged in corrupt or fraudulent practices in competing for or executing a contract.<br><br>3.2 The Proposer shall sign and stamp the Integrity Pact provided in **Section VI** (**Fraud and Corruption)** of the RFP Documents for all Federal Government procurement contracts exceeding Rupees ten million. Failure to provide such Integrity Pact shall make the Proposer non-responsive. |

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| **4. Eligible Proposers** | 4.1 A Proposer may be a firm that is a private entity, a state-owned enterprise or institution subject to **ITP 4.6** or any combination of such entities in the form of a joint venture (JV) under an existing agreement or with the intent to enter into such an agreement supported by a letter of intent. In the case of a joint venture, all members shall be jointly and severally liable for the execution of the Contract in accordance with the Contract terms. The JV shall nominate a Representative who shall have the authority to conduct all business for and on behalf of any and all the members of the JV during the RFP process and, in the event the JV is awarded the Contract, during contract execution. Unless specified **in the PDS**, there is no limit on the number of members in a JV.<br><br>4.2 A Proposer shall not have a conflict of interest. Any Proposer found to have a conflict of interest shall be disqualified. A Proposer may be considered to have a conflict of interest for the purpose of this RFP process, if the Proposer:<br><br>(a) directly or indirectly controls, is controlled by or is under common control with another Proposer; or<br><br>(b) receives or has received any direct or indirect subsidy from another Proposer; or<br><br>(c) has the same legal representative as another Proposer; or<br><br>(d) has a relationship with another Proposer, directly or through common third parties, that puts it in a position to influence the Proposal of another Proposer, or influence the decisions of the Employer regarding this RFP process; or<br><br>(e) any of its affiliates participates as a consultant in the preparation of the Employer's Requirements for the Works that are the subject of the Proposal; or<br><br>(f) or any of its affiliates has been hired (or is proposed to be hired) by the Employer or Borrower as the Employer's Representative for the Contract implementation; or<br><br>(g) would be providing goods, works, or non-consulting services resulting from or directly related to consulting services for the preparation or implementation of the project specified in the **PDS ITP 2.1** that it provided or were provided by any affiliate that directly or indirectly controls, is controlled by, or is under common control with that firm; or<br><br>(h) has a close business or family relationship with a professional staff of the Borrower (or of the project implementing agency, or of a recipient of a part of the loan) who: (i) are directly or indirectly involved in the preparation of the RFP Document or Employer's requirements of the Contract, and/or the Proposal evaluation process of such |



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| | Contract; or (ii) would be involved in the implementation or supervision of such Contract unless the conflict stemming from such relationship has been resolved in a manner acceptable to the Employer throughout the RFP process and execution of the Contract.<br><br>4.3 A firm that is a Proposer (either individually or as a JV member) shall not participate in more than one Proposal, except for permitted alternative Proposals. This includes participation as a subcontractor in other Proposals. Such participation shall result in the disqualification of all Proposals in which the firm is involved. A firm that is not an individual Proposer or a JV member in a Proposal may participate as a subcontractor in more than one Proposal.<br><br>4.4 A Proposer may have the nationality of any country, subject to the restrictions pursuant to **ITP 4.8.** A Proposer shall be deemed to have the nationality of a country if the Proposer is constituted, incorporated or registered in and operates in conformity with the provisions of the laws of that country, as evidenced by its articles of incorporation (or equivalent documents of constitution or association) and its registration documents, as the case may be. This criterion also shall apply to the determination of the nationality of proposed sub-contractors or sub-consultants for any part of the Contract including related Services.<br><br>4.5 A Proposer that has been sanctioned by the Employer, pursuant to the PPRA's Guidelines, and in accordance with its prevailing sanctions policies and procedures as set forth in **Section VI (Fraud and Corruption)** paragraph 2.2 d., shall be ineligible to Bid, submit Proposal for, or to be awarded a Government of Pakistan financed contract, financially or otherwise, during such period of time as the Employer shall have determined. The list of debarred firms and individuals is available at the electronic address specified **in the PDS**.<br><br>4.6 Proposers that are state-owned enterprises or institutions in the Employer's Country may be eligible to compete and be awarded a Contract(s) only if they can establish, in a manner acceptable to the Employer, that they (i) are legally and financially autonomous (ii) operate under commercial law, and (iii) are not under supervision of the Employer.<br><br>4.7 A Proposer shall not be under suspension from submitting Proposals by the Employer as the result of the operation of a Proposal Securing Declaration or Proposal-Securing Declaration.<br><br>4.8 Firms and individuals may be ineligible if so indicated in **Section V (Eligible Countries)** and (a) as a matter of law or official regulations, the Employer's country prohibits commercial relations with that country, or (b) by an act of compliance with a decision of the United Nations Security Council taken under Chapter VII of the Charter of the United Nations, the Employer's |



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| | country prohibits any import of goods or contracting of works or services from that country, or any payments to any country, person, or entity in that country.<br><br>4.9 A Proposer shall provide such documentary evidence of eligibility satisfactory to the Employer, as the Employer shall reasonably request.<br><br>4.10 A firm that is under a sanction of debarment by the Employer's Country from being awarded a contract is eligible to participate in this procurement. |
| **5. Eligible Materials, Equipment, and Services** | 5.1 The materials, equipment and services to be supplied under the Contract may have their origin in any country subject to the restrictions specified in **Section V (Eligible Countries)** and all expenditures under the Contract will not contravene such restrictions. At the Employer's request, Proposers may be required to provide evidence of the origin of materials, equipment and services. |

## B. Contents of RFP Document

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| **6. Sections of RFP Document** | 6.1 The RFP Document consists of Parts 1, 2, and 3, which include all the sections indicated below, and should be read in conjunction with any Addenda issued in accordance with **ITP 8**:<br><br>**PART 1 Request for Proposal Procedures**<br><br>Section I - Instructions to Proposers (ITP)<br>Section II - Proposal Data Sheet (PDS)<br>Section III - Evaluation and Qualification Criteria<br>Section IV - Proposal Forms<br>Section V - Eligible Countries<br>Section VI - Fraud and Corruption<br><br>**PART 2 Employer's Requirements**<br><br>Section VII - Employer's Requirements<br><br>**PART 3 Conditions of Contract and Contract Forms**<br><br>Section VIII - General Conditions<br>Section IX - Particular Conditions<br>Section X - Contract Forms<br><br>6.2 The Specific Procurement Notice, Notice of Request for Proposals (RFP) issued by the Employer, is not part of this RFP Document.<br><br>6.3 Unless obtained directly from the Employer, the Employer is not responsible for the completeness of the document, responses to requests for clarification, the Minutes of the pre-Proposal meeting (if any), or Addenda to the RFP Document in accordance with **ITP 8**. In case of any contradiction, documents obtained directly from the Employer shall prevail. |



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| | 6.4 | The Proposer is expected to examine all instructions, forms, terms, and Employer's requirements in the RFP Document and to furnish with its Proposal all information or documentation as is required by the RFP Document. |
| **7. Clarification of RFP Document, Site Visit, Pre-Proposal Meeting** | 7.1 | A Proposer requiring any clarification of the RFP Document shall contact the Employer in writing at the Employer's address specified **in the PDS** or raise its enquiries during the pre-Proposal meeting if provided for in accordance with **ITP 7.4**. The Employer will respond to any request for clarification, provided that such request is received prior to the deadline for submission of Proposals within a period specified **in the PDS.** The Employer shall forward copies of its response to all Proposers who have acquired the RFP Document in accordance with **ITP 6.3**, including a description of the inquiry but without identifying its source. If so, specified **in the PDS**, the Employer shall also promptly publish its response at the web page identified **in the PDS**. Should the Employer deem it necessary to amend the RFP Document as a result of a request for clarification, it shall do so following the procedure under **ITP 8.** |
| | 7.2 | The Proposer is advised to visit and examine the Site of the Works and its surroundings and obtain for itself on its own responsibility all information that may be necessary for preparing the Proposal and entering into a contract. The costs of visiting the site shall be at the Proposer's own expense. |
| | 7.3 | The Proposer and any of its personnel or agents will be granted permission by the Employer to enter upon its premises and lands for the purpose of such visit, but only upon the express condition that the Proposer, its personnel, and agents will release and indemnify the Employer and its personnel and agents from and against all liability in respect thereof, and will be responsible for death or personal injury, loss of or damage to property, and any other loss, damage, costs, and expenses incurred as a result of the inspection. |
| | 7.4 | The Proposer's designated representative is invited to attend a pre-Proposal meeting and/or a site visit, if provided for **in the PDS**. The purpose of the meeting will be to clarify issues and to answer questions on any matter that may be raised at that stage. Nonattendance at the pre-Proposal meeting will not be a cause for disqualification of a Proposer. |
| | 7.5 | The Proposer is requested to submit any questions in writing, to reach the Employer not later than one week before the meeting. |
| | 7.6 | Minutes of the pre-Proposal meeting, including the text of the questions raised without identifying the source, and the responses given, together with any responses prepared after the meeting, will be transmitted promptly to all Proposers who have acquired the RFP Document in accordance with **ITP 6.3**. Any modification to the RFP Document that may become necessary as a result of the pre-Proposal meeting shall be made by the Employer exclusively |

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| | through the issue of an Addendum pursuant to **ITP 8** and not through the minutes of the pre-Proposal meeting. |
| **8. Amendment of RFP Document** | 8.1 At any time prior to the deadline for submission of Proposals, the Employer may amend the RFP Document by issuing addenda.<br><br>8.2 Any addendum issued shall be part of the RFP Document and shall be communicated in writing to all who have obtained the RFP Document from the Employer in accordance with **ITP 6.3.** The Employer shall also promptly publish the addendum on the Employer's web page in accordance with **ITP 7.1.**<br><br>8.3 To give prospective Proposers reasonable time in which to take an addendum into account in preparing their Proposals, the Employer may, at its discretion, extend the deadline for the submission of Proposals, pursuant to **ITP 23.2.** |
| **9. Cost of Proposals** | 9.1 The Proposer shall bear all costs associated with the preparation and submission of its Proposal, and the Employer will in no case be responsible or liable for those costs. |
| **10. Contacting the Employer** | 10.1 From the time of Proposal opening to the time of Contract award, if any Proposer wishes to contact the Employer on any matter related to the Proposal, it should do so in writing.<br><br>10.2 If a Proposer tries to directly influence the Employer or otherwise interfere in the Proposal evaluation process and the Contract award decision, its Proposal may be rejected. |
| **11. Language of Proposals** | 11.1 Unless otherwise specified **in the PDS**, the Proposal prepared by the Proposer and all correspondence and documents related to the Proposal exchanged by the Proposer and the Employer shall be written in the English Language, or, **if the PDS** so provides, in either one of two languages specified there. Any printed literature furnished by the Proposer as part of its Proposal may be in a language not specified **in the PDS,** as long as such literature is accompanied by a translation of its pertinent passages into the language of the Proposal, in which case, for purposes of interpretation of the Proposal, the translation shall govern. |

## C. Preparation of Proposals

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| **12. Documents Comprising the Proposal** | 12.1 The Proposal shall comprise two Parts, namely the Technical Part and the Financial Part. These two Parts shall be submitted simultaneously in two (02) separate sealed envelopes (single-stage, two-envelope RFP process). One envelope shall contain only information relating to the Technical Part and the other, only information relating to the Financial Part. These two envelopes shall be enclosed in a separate sealed outer envelope marked "ORIGINAL PROPOSAL". |



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| | 12.2 The Technical Part submitted by the Proposer shall comprise the following:<br><br>(a) **Letter of Proposal** - Technical Part, prepared in accordance with **ITP 13**;<br><br>(b) **Security**: Proposal Security or Proposal-Securing declaration, in accordance with **ITP 19**;<br><br>(c) **Alternative Proposal** - Technical Part, if permissible in accordance with **ITP 14**;<br><br>(d) written confirmation authorizing the signatory of the Proposal to commit the Proposer, in accordance with **ITP 21.1;**<br><br>(e) documentary evidence that the Proposer continues to be eligible and qualified to perform the contract if its Proposal is accepted;<br><br>(f) documentary evidence in accordance with **ITP 18** that the Works offered by the Proposer conform to the RFP Document;<br><br>(g) Proposers shall give details of all departures in their Technical - Proposal with respect to the contractual terms and conditions and/or to the required technical features specified in the performance and/or functional requirements, that they would like the Employer to consider during the evaluation of the Technical Proposals;<br><br>(h) in the case of a Technical Part submitted by a JV, JV agreement, or letter of intent to enter into a JV including a draft agreement, indicating at least the parts of the Works to be executed by the respective partners;<br><br>(i) list of subcontractors, in accordance with **ITP 18.3**;<br><br>(j) any other document required **in the PDS**.<br><br>12.3 The Financial Part submitted by the Proposer shall comprise the following:<br><br>(a) **Letter of Proposal - Financial Part:** prepared in accordance with **ITP 13**;<br><br>(b) **Schedule of Rates and Prices (if any):** completed in accordance with **ITP 15** and **ITP 16**;<br><br>(c) **Alternative Proposal - Financial Part:** if permissible in accordance with **ITP 14**;<br><br>(d) **Financial Disclosure:** The Proposer shall furnish in the Letter of Proposal information on commissions and |



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| | gratuities, if any, paid or to be paid to agents or any other party relating to this Proposal; and<br><br>(e) **Other:** any other document required **in the PDS**.<br><br>12.4 The Technical Part shall not include any financial information related to the Proposal price. Where material financial information related to the Proposal price is contained in the Technical Part, the Proposal shall be declared non-responsive.<br><br>12.5 The Proposer shall furnish in the Letter of Proposal-Technical Part three names of the potential DAAB members and attach their curriculum vitae. |
| **13. Letter of Proposal, and Schedules** | 13.1 The Proposer shall complete the Letter of Proposal - Technical Part and Letter of Proposal - Financial Part using the relevant forms furnished in **Section IV (Proposal Forms)**. The forms must be completed without any alterations to the text, and no substitutes shall be accepted except as provided under **ITP 21.3**. All blank spaces shall be filled in with the information requested. |
| **14. Alternative Technical Proposals** | 14.1 Proposers shall note that they are permitted to propose technical alternatives with their proposals in addition to the requirements specified in the RFP Documents. Any technical alternatives received in lieu of the requirements specified in the RFP Documents shall be rejected and shall not be considered by the Employer. The Alternative Technical Proposal shall comprise two Parts, namely Alternative Proposal - Technical Part and Alternative Proposal - Financial Part.<br><br>14.2 Alternative Proposal - Technical Part: the Proposer wishing to offer alternative technical Proposal shall (i) document that the proposed technical alternatives are to the benefit of the Employer, that they fulfill the principal objectives of the contract, and that they meet the basic performance and technical criteria specified in the RFP Documents; and (ii) further provide all information necessary for a complete technical evaluation of the alternative by the Employer, including as relevant drawings, design calculations, technical specifications, and proposed construction methodology and other relevant details.<br><br>14.3 Alternative Proposal - Financial Part: The Proposer submitting alternative technical Proposal shall provide all information necessary for a complete financial evaluation of the alternative by the Employer, including breakdown of prices relevant to the offered technical alternative and in the manner and detail called for in the Schedule of Rates and Prices (if any) included in **Section IV (Proposal Forms).**<br><br>14.4 Only the technical alternatives, if any, of the Proposer with the Most Advantageous Proposal conforming to the basic performance and technical criteria specified in the RFP Documents shall be considered by the Employer. |



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| **15. Proposal Prices** | 15.1 Unless otherwise specified **in the PDS,** Proposers shall quote for the entire Works on a "single responsibility" basis such that the lump sum Proposal Price, subject to any adjustments, in accordance with the Contract, covers all the EPC Contractor's obligations under the Contract. The Works shall include any work which is necessary to satisfy the Employer's Requirements and Schedules, or is implied by the Contract, and all works which (although not mentioned in the Contract) are necessary for stability or for the completion, or safe and proper operation, of the Works.<br><br>15.2 Proposers shall give a breakdown of the prices in the manner and detail called for in the Schedule of Rates and Prices (if any) included in **Section IV (Proposal Forms)**. These will not in any way limit the Proposer's "single responsibility" as stated in **ITP 15.1**. The cost of any items that the Proposer may have omitted is deemed to be included in the total lump sum Proposal price and will not be paid for separately by the Employer.<br><br>15.3 The prices shall be either fixed or adjustable as specified **in the PDS**.<br><br>15.4 In the case of **Fixed Price**, prices quoted by the Proposer shall be fixed during the Proposer's performance of the contract and not subject to variation on any account. A Proposal submitted with an adjustable price quotation will be treated as non-responsive and rejected.<br><br>15.5 In the case of **Adjustable Price**, prices quoted by the Proposer shall be subject to adjustment during performance of the contract to reflect changes in the cost elements in accordance with the procedures specified in the corresponding Appendix to the Contract Agreement. A Proposal submitted with a fixed price quotation will not be rejected, but the price adjustment will be treated as zero. Proposers are required to indicate the source of labour and material indices in the corresponding Form in **Section IV (Proposal Forms).**<br><br>15.6 If so, indicated in **ITP 1.1**, Proposals are being invited for individual lots (contracts) or for any combination of lots (packages). Proposers wishing to offer any price reduction (discount) for the award of more than one Contract shall specify in their Letter of Proposal the price reductions applicable to each package, or alternatively, to individual Contracts within the package, and the manner in which the price reductions will apply. **However, discounts for the award of more than one contract will not be considered for proposal evaluation purpose.**<br><br>15.7 Proposers wishing to offer any unconditional discount shall specify in their Letter of Proposal the offered discounts and the manner in which price discounts will apply.<br><br>15.8 All duties, taxes, and other levies payable by the EPC Contractor under the Contract, or for any other cause, as of the date 28 days |



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| | | prior to the deadline for submission of Proposals, shall be included in the Proposal price submitted by the Proposer. |
| **16. Proposal Currencies** | 16.1 | The currency (ies) of the Proposal and the currency (ies) of payments shall be the same and shall be as specified **in the PDS**. |
| | 16.2 | Proposers may be required by the Employer to justify, to the Employer's satisfaction, their local and foreign currency requirements, and to substantiate that the amounts included in the Schedule of Rates and Prices (if any) and shown in the Table of Adjustment Data in the Appendix to the Proposal are reasonable, in which case a detailed breakdown of the foreign currency requirements shall be provided by Proposers. |
| **17. Documents Establishing the Qualification of the Proposer** | 17.1 | In accordance with **Section III (Evaluation and Qualification Criteria),** to establish that the Proposer meets the qualification criteria, the Proposer shall provide updated information on all assessed aspect. |
| | 17.2 | If a margin of preference applies in accordance with **ITP 39.1**, domestic Proposers, individually or in joint ventures, applying for eligibility for domestic preference shall supply all information required to satisfy the criteria for eligibility specified in accordance with **ITP 39.1**. |
| **18. Documents Establishing Conformity of the Works** | 18.1 | Pursuant to **ITP 12.2(f),** the Proposer shall furnish, as part of its Proposal documents establishing the conformity to the RFP Documents of the Works that the Proposer proposes to execute on EPC/Turnkey basis under the Contract. |
| | 18.2 | The documentary evidence of the conformity of the Works with the RFP documents may be in the form of literature, drawings and data, and shall include:<br>(a) the documents specified in **Section-IV (Proposal Forms) - Technical Proposal.**<br>(b) detailed description of the essential technical and functional/performance characteristics of the proposed Works, in response to the Employer's Requirements.<br>(c) adequate evidence demonstrating the substantial responsiveness of the Works to the Employer's Requirements. |
| | 18.3 | The Proposer shall be responsible for ensuring that any proposed subcontractor complies with the requirements of **ITP 4**, and that any Works to be provided by the subcontractor comply with the requirements of **ITP 5** and **ITP 18.1.** The Proposer shall submit its Code of Conduct that meets the requirements set-out in **Section IV (Proposal Forms).** |
| **19. Securing the Proposal** | 19.1 | The Proposer shall furnish as part of its Proposal, either a Proposal-Securing Declaration or a Proposal Security as specified |



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| | **in the PDS**, in original form and, in the case of a Proposal Security, in the amount and currency specified **in the PDS**.<br><br>19.2 A Proposal-Securing Declaration shall use the form included in **Section IV (Proposal Forms).**<br><br>19.3 If a Proposal Security is specified pursuant to **ITP 19.1**, the Proposal security shall be a demand guarantee in any of the following forms at the Proposer's option:<br><br>(a) an unconditional guarantee issued by a bank<br>(b) an irrevocable letter of credit;<br>(c) a cashier's or certified check; or<br>(d) another security indicated **in the PDS**,<br><br>from a reputable source from an eligible country. If an unconditional guarantee is issued by a non-bank financial institution located outside the Employer's Country the issuing non-bank financial institution shall have a correspondent financial institution located in the Employer's Country to make it enforceable unless the Employer has agreed in writing, prior to Proposal submission, that a correspondent financial institution is not required.<br><br>19.4 The Proposal security shall be in the form of an unconditional bank guarantee issued by a Scheduled Bank of Pakistan or a foreign bank duly counter guaranteed by a Scheduled Bank of Pakistan. The Bid security shall be submitted using the Proposal Security Form included in the Bidding Documents. The form must include the complete name of the Proposer. The Proposal Security shall be submitted either using the Proposal Security Form included in **Section IV (Proposal Forms)** or in another substantially similar format approved by the Employer prior to Proposal submission. In either case, the form must include the complete name of the Proposer. The Proposal Security shall be valid for twenty-eight days (28) beyond the original date of expiry of the Proposal validity, or beyond any extended date if requested under **ITP 20.2.**<br><br>19.5 If a Proposal Security or a Proposal-Securing Declaration is specified pursuant to **ITP 19.1**, any Proposal not accompanied by a substantially responsive Proposal Security or Proposal-Securing Declaration shall be rejected by the Employer as non-responsive.<br><br>19.6 If a Proposal Security is specified in accordance with **ITP 19.1**, the Proposal Security of the Proposers shall be returned as promptly as possible once the successful Proposer has signed the Contract, furnished the required Performance Security, and if required **in the PDS**, the Environmental and Social (ES) Performance Security.<br><br>19.7 The Proposal Security may be forfeited:<br><br>(a) if a Proposer withdraws its Proposal prior to the expiry date of the Proposal validity specified by the Proposer on |



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| | the Letter of Proposal or any extended date provided by the Proposer; or<br><br>(b) if the successful Proposer fails to:<br><br>(i) sign the Contract in accordance with **ITP 53**; or<br><br>(ii) furnish a Performance Security and if required **in the PDS**, the Environmental and Social (ES) Performance Security, in accordance with **ITP 54**.<br><br>19.8 The Proposal Security or the Proposal-Securing Declaration of a JV shall be in the name of the JV that submits the Proposal. If the JV has not been legally constituted into a legally enforceable JV at the time of submission of Proposals, the Proposal Security or the Proposal-Securing Declaration shall be in the names of all future members as named in the letter of intent referred to in **ITP 4.1.**<br><br>19.9 If a Proposal Security is not required **in the PDS**, and:<br><br>(a) if a Proposer withdraws its Proposal prior to the expiry date of the Proposal validity specified by the Proposer on the Letter of Proposal or any extended date provided by the Proposer; or<br><br>(b) if the successful Proposer fails to:<br><br>(i) sign the Contract in accordance with **ITP 53**; or<br><br>(ii) furnish a performance security and if required **in the PDS**, the Environmental and Social (ES) Performance Security, in accordance with **ITP 54**,<br><br>the Employer may, if provided for **in the PDS**, declare the Proposer disqualified to be awarded a contract by the Employer for a period of time as stated **in the PDS**. |
| **20. Period of Validity of Proposals** | 20.1 Proposals shall remain valid until the date specified **in the PDS** or any extended date if amended by the Employer in accordance with **ITP 8**. A Proposal that is not valid until the date specified **in the PDS,** or any extended date if amended by the Employer in accordance with **ITP 8**, shall be rejected by the Employer as non-responsive.<br><br>20.2 In exceptional circumstances, prior to the date of expiry of the Proposal validity, the Employer may request that the Proposers extend the date of validity until a specified date. The request and the responses to the request shall be made in writing. A Proposer may refuse the request without risking execution of the Proposal-Securing Declaration or forfeiting the Proposal Security. Except as provided in **ITP 20.3**, a Proposer agreeing to the request will not be required or permitted to modify its Proposal, but will be required to ensure that the Proposal Security is extended for a correspondingly longer period, pursuant to **ITP 19.4**. |

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| | 20.3 | In the case of fixed price contracts, if the award is delayed by a period exceeding fifty-six (56) days beyond the date of expiry of the Proposal validity specified in accordance with **ITP 20.1**, the contract price will be adjusted as specified **in the PDS**. Proposal evaluation will be based on the Proposal prices without taking into consideration the above correction. |
| **21. Format and Signing of Proposal** | 21.1 | The original and all copies of the Proposal, each consisting of the documents listed in **ITP 12**, shall be typed or written in indelible ink and shall be signed by a person or persons duly authorized to sign on behalf of the Proposer. The authorization must be in writing as specified **in the PDS**, and included in the Proposal pursuant to **ITP 12.2(d).** The name and position held by each person signing the authorization must be typed or printed below the signature. All pages of the Proposal where entries or amendments have been made shall be signed or initialed by the person signing the Proposal. |
| | 21.2 | In case the Proposer is a JV, the Proposal shall be signed by an authorized representative of the JV on behalf of the JV, and so as to be legally binding on all the members as evidenced by a power of attorney signed by their legally authorized representatives. |
| | 21.3 | The Proposal shall contain no interlineations, erasures, or overwriting, except to correct errors made by the Proposer, in which case such corrections shall be initialed by the person or persons signing the Proposal. |
| | 21.4 | The Proposer shall furnish in the **Proposal Submission Form (Section IV)** information regarding commissions or gratuities, if any, paid or to be paid to agents relating to this procurement and to the execution of the Contract should the Proposer be successful. |

## D. Submission of Proposals

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| **22. Submission, Sealing and Marking of Proposals** | 22.1 | Unless the **PDS** states that Proposals are to be submitted electronically the following procedures shall apply.<br>(a) The Proposer shall deliver the Proposal in two separate, sealed envelopes. One envelope containing the Technical Part and the other the Financial Part. These two envelopes shall be enclosed in a sealed outer envelope and clearly marked "Proposal - Original".<br>(b) In addition, the Proposer shall prepare copies of the Proposal, in the number specified **in the PDS**. Copies of the Technical Part shall be placed in a separate sealed envelope marked "Copies: Technical Part". Copies of the Financial Part shall be placed in a separate sealed envelope marked "Copies: Financial Part". The Proposer shall place both of these envelopes in a separate, sealed outer envelope marked |

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| | "Proposal - Copies". In the event of any discrepancy between the original and the copies, the original shall prevail.<br><br>(c) If alternative Proposals are permitted in accordance with **ITP 14**, the alternative Proposals shall be submitted as follows: the original of the alternative Proposal Technical Part shall be placed in a sealed envelope marked "Alternative Proposal – Technical Part" and the Financial Part shall be placed in a sealed envelope marked "Alternative Proposal – Financial Part" and these two separate sealed envelopes then enclosed within a sealed outer envelope marked "Alternative Proposal – Original", the copies of the alternative Proposal will be placed in separate sealed envelopes marked "Alternative Proposal – Copies Of Technical Part", and "Alternative Proposal – Copies Of Financial Part" and enclosed in a separate sealed outer envelope marked "Alternative Proposal - Copies"<br><br>22.2 The inner and outer envelopes shall:<br><br>(a) bear the name and address of the Proposer;<br><br>(b) be addressed to the Employer, at the address given **in the PDS** for **ITP 23.1**; and<br><br>(c) bear the Contract(s) name, the Invitation for Proposals (RFP) title and number, as specified **in the PDS** for **ITP 1.1**, and the statement "Do Not Open Before [time and date]," to be completed with the time and date specified **in the PDS** for **ITP 23.1**.<br><br>22.3 If the outer envelope is not sealed and marked as required by **ITP 22.1** and **ITP 22.2,** the Employer will assume no responsibility for the Proposal's misplacement or premature opening. |
| **23. Deadline for Submission of Proposals** | 23.1 Proposals must be received by the Employer at the address specified, and no later than the time and date specified, **in the PDS**. Proposers have the option of submitting their Proposals electronically if specified **in the PDS**.<br><br>23.2 The Employer may, at its discretion, extend this deadline for submission of Proposals by amending the RFP Documents in accordance with **ITP 8.3**, in which case all rights and obligations of the Employer and Proposers will thereafter be subject to the deadline as extended. |
| **24. Late Proposals** | 24.1 The Employer shall not consider any Proposal that arrives after the deadline for submission of Proposals, in accordance with **ITP 23.** Any Proposal received by the Employer after the deadline for submission of Proposals shall be declared late, rejected, and returned unopened to the Proposer. |
| **25. Withdrawal, Substitution, and** | 25.1 A Proposer may withdraw, substitute, or modify its Proposal after it has been submitted, and before the deadline for submission of proposals, by sending a written notice, duly signed by an authorized |



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| **Modification of Proposals** | representative, including a copy of the authorization in accordance with **ITP 21.1,** (except that withdrawal notices do not require copies). The corresponding substitution or modification of the Proposal must accompany the respective written notice. All notices must be:<br><br>(a) prepared and submitted in accordance with **ITP 21** and **ITP 22** (except that withdrawals notices do not require copies), and in addition, the respective envelopes shall be clearly marked "Withdrawal," "Substitution, ("Technical Part" and/or "Financial Part")" "Modification ("Technical Part" and/or "Financial Part");" and<br><br>(b) received by the Employer prior to the deadline prescribed for submission of Proposals, in accordance with **ITP 23**. |

## E. Opening of Technical Parts of Proposals

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| **26. Opening of Technical Part by Employer** | 26.1 Except as in the cases specified in **ITP 24** and **ITP 25**, the Employer shall conduct the Technical part opening in public, in the presence of Proposers` designated representatives and anyone who chooses to attend, and at the address, date and time specified **in the PDS**. Any specific electronic Proposal opening procedures, if permitted, shall be as specified **in the PDS**.<br><br>26.2 First, the written notice of withdrawal in the envelopes marked "Withdrawal" shall be opened and read out and the envelope with the corresponding Proposal shall not be opened, but returned to the Proposer. No Proposal withdrawal shall be permitted unless the corresponding withdrawal notice contains a valid authorization to request the withdrawal and is read out at Proposal opening.<br><br>26.3 Next, envelopes marked "Substitution" shall be opened and read out and exchanged with the corresponding Technical Part being substituted, and the substituted Proposal shall not be opened, but returned to the Proposer. No Proposal substitution shall be permitted unless the corresponding substitution notice contains a valid authorization to request the substitution and is read out at Proposal opening.<br><br>26.4 Next, envelopes marked "Modification" shall be opened and read out with the corresponding Proposal. No Proposal modification shall be permitted unless the corresponding modification notice contains a valid authorization to request the modification and is read out at Proposal opening.<br><br>26.5 Next, all other envelopes marked "Technical Part" shall be opened one at a time. All envelopes marked "Financial Part" shall remain sealed, and kept by the Employer in safe custody until they are opened, at a later public opening, following the evaluation of the Technical Part of the Proposals. On opening the Technical Part envelopes, the Employer shall read out: the name of the Proposer and whether there is a modification; the presence or absence of a |



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| | Proposal security or a Proposal-Securing Declaration; and other details as the Employer, at its discretion, may consider appropriate.<br><br>26.6 Only Technical Parts of Proposals and Alternative Proposal - Technical Parts that are opened and read out at Proposal opening shall be considered further. At the Proposal opening the Employer shall neither discuss the merits of any Proposal nor reject any Proposal (except for late Proposals, in accordance with **ITP 24.1**).<br><br>26.7 The Employer shall prepare a record of the Technical Parts of public opening that shall include, as a minimum: the name of the Proposer and whether there is a withdrawal, substitution, or modification. The Proposers' representatives who are present shall be requested to sign the record. The omission of a Proposer's signature on the record shall not invalidate the contents and effect of the record. A copy of the record shall be distributed to all Proposers who submitted Proposals in time, and posted online when electronic procurement is permitted. |

## F. Evaluation of Proposals - General Provisions

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| **27. Confidentiality** | 27.1 Information relating to the evaluation of the Technical Part shall not be disclosed to Proposers or any other persons not officially concerned with the RFP process until the notification of evaluation of the Technical Part in accordance with **ITP 33**.<br><br>27.2 Information relating to the evaluation of the Financial Part and recommendation of contract award, shall not be disclosed to Proposers or any other persons not officially concerned with the RFP process until the Notification of Intention to Award the Contract is transmitted to all Proposers in accordance with **ITP 49**.<br><br>27.3 Any effort by a Proposer to influence the Employer in the evaluation of the Proposals may result in the rejection of its Proposal.<br><br>27.4 Notwithstanding **ITP 27.1 and ITP 27.2**, from the time of Proposal opening to the time of Contract award, if any Proposer wishes to contact the Employer on any matter related to the RFP process, it should do so in writing. |
| **28. Clarification of Proposals** | 28.1 To assist in the examination, evaluation, and comparison of the Proposals, and qualification of the Proposers, the Employer may, at its discretion, ask any Proposer for a clarification of its Proposal. Any clarification submitted by a Proposer that is not in response to a request by the Employer shall not be considered. The Employer's request for clarification and the response shall be in writing.<br><br>28.2 If a Proposer does not provide clarifications of its Proposal by the date and time set in the Employer's request for clarification, its Proposal may be rejected. |



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| **29. Deviations, Reservations, and Omission** | 29.1 During the evaluation of Proposals, the following definitions apply:<br>(a) "Deviation" is a departure from the requirements specified in the RFP document;<br>(b) "Reservation" is the setting of limiting conditions or withholding from complete acceptance of the requirements specified in the RFP document; and<br>(c) "Omission" is the failure to submit part or all of the information or documentation required in the RFP document. |

## G. Evaluation of Technical Parts of Proposals

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| **30. Determination of Responsiveness of Technical Parts** | 30.1 The Employer will examine the Technical Parts, including any alternatives submitted by Proposers, to determine whether they are complete, have been properly signed, and are generally in order.<br>30.2 The Employer's determination of a Technical Part's substantial responsiveness is to be based on the contents of the Proposal itself. For purposes of this determination, a substantially responsive Proposal is one that materially conforms to the requirements of the RFP Document without material deviation, reservation, or omission. A material deviation, reservation, or omission is one that:<br>(a) if accepted, would:<br>(i) affect in any substantial way the scope, quality, or performance of the Works specified in the Contract; or<br>(ii) limit in any substantial way, inconsistent with the RFP Document, the Employer's rights or the Proposer's obligations under the proposed Contract; or<br>(b) if rectified, would unfairly affect the competitive position of other Proposers presenting substantially responsive Proposals.<br>30.3 Provided that a Technical Part is substantially responsive, the Employer may waive any nonmaterial nonconformity in the Proposal.<br>30.4 Provided that a Proposal is substantially responsive, the Employer may request that the Proposer submit the necessary information or documentation, within a reasonable period of time, to rectify nonmaterial nonconformities in the Proposal related to documentation requirements.<br>30.5 The Employer will also determine if the Proposals contain departures from the requirements of the RFP Documents (e.g., documentary evidence, responsiveness of the technical proposal, etc.) in such numbers or of such nature that the Proposal cannot reasonably be expected to become responsive within the framework of the single-stage process. In this case, the proposal shall be rejected by the Employer and may not subsequently be made |



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| | responsive by correction of the material deviation, reservation, or omission. |
| **31. Evaluation of Technical Proposals** | 31.1 The Employer's evaluation of technical proposals will be carried out as specified in **Section III (Evaluation and Qualification Criteria).**<br><br>31.2 The Employer will carry out a detailed technical evaluation of each Technical Proposal that was determined to be substantially responsive in accordance with **ITP 30**, in order to determine whether the technical aspects of the Proposal are responsive to the requirements set forth in the RFP Documents.<br><br>31.3 The Employer will also review alternative technical Proposals, if any, offered by the Proposer, pursuant to **ITP 14**, and evaluate them to determine their acceptability.<br><br>31.4 The scores to be given to technical factors and sub factors are specified **in the PDS**. |
| **32. Evaluation of Proposers Qualification** | 32.1 The Employer shall ascertain to its satisfaction that, on the basis of updated documentary evidence submitted in accordance with **ITP 12.2 (e),** and **Section III (Evaluation and Qualification Criteria)** the Proposer continues to be qualified to satisfactorily perform the Contract.<br><br>32.2 Only Proposals that are both substantially responsive to the RFP document and are qualified shall have their envelopes marked "FINANCIAL PART" opened at the second public opening. |
| **33. Notification of evaluation of Technical Parts** | 33.1 Following the completion of the evaluation of the Technical Parts of Proposals, the Employer shall make the following notifications:<br><br>(a) Notify in writing those Proposers whose Proposals were considered substantially non-responsive to the requirements in the RFP, advising them of the following information:<br><br>(i) the grounds on which their Technical Part has been considered to be non-responsive;<br><br>(ii) their envelope marked "Financial Part" will be returned to them unopened after the completion of the Proposal evaluation process and the signing of the Contract;<br><br>(b) simultaneously, notify in writing those Proposers whose Proposals were considered substantially responsive to the requirements in the RFP, advising them that their Proposal has been evaluated as substantially responsive to the RFP; and<br><br>(c) notify all Proposers in accordance with the one of following two options: |

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| | (i) Option 1: when **BAFO or Negotiations is not to be applied,** the date, time and location of the public opening of the envelopes marked 'Financial Part", or;<br><br>(ii) Option 2: when BAFO or Negotiations apply as specified in the **PDS ITP 44** and **ITP 46** respectively, that: (i) the envelopes marked 'Financial Part' will not be opened in public, but in the presence of a Probity Assurance Provider (Probity Auditor) appointed by the Employer, and that (ii) the announcement of the names of the Proposers whose Financial Parts will be opened and the Proposal Price will be deferred to the time that the Notification of Intention to Award the contract is issued. |

## H. Opening of Financial Parts

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| **34. Public Opening of Financial Parts when BAFO or negotiations do not apply** | 34.1 When BAFO or negotiations do not apply as specified **in the PDS**, the Financial Parts will be opened in public by the Employer in the presence of Proposers, or their designated representatives, and anyone else who chooses to attend. Each envelope marked "Financial Part" shall be inspected to confirm that it has remained sealed and unopened. These envelopes shall then be opened by the Employer. The Employer shall read out the names of each Proposer, the technical score, the Proposal Price, per lot (contract) if applicable, including any discounts, the presence or absence of a Proposal Security or Proposal-Securing Declaration, if required and any other details as the Employer may consider appropriate. Only discounts read out at the public opening shall be considered for evaluation. The Letter of Proposal - Financial Part and the Schedule of Rates and Prices (if any) are to be initialed by representatives of the Employer attending the public opening in the manner specified **in the PDS**.<br>34.2 The Employer shall prepare a record of the Financial Part of the Proposal opening that shall include, as a minimum:<br>(a) the name of the Proposers whose Financial Part was opened;<br>(b) the Proposal prices, per lot (contract) if applicable, including any discounts.<br>34.3 The Proposers whose envelopes marked "Financial Part" have been opened, or their representatives who are present, shall be requested to sign the record. The omission of a Proposer's signature on the record shall not invalidate the contents and effect of the record. A copy of the record shall be distributed to all Proposers. |
| **35. Opening of Financial Parts when BAFO or negotiations apply** | 35.1 When, as specified **in the PDS**, BAFO or negotiations apply the Financial Parts will not be opened in public, and will be opened in the presence of a Probity Assurance Provider appointed by the Employer. |

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| | 35.2 At the opening each of the envelopes marked "Financial Part" shall be inspected to confirm that they have remained sealed and unopened. These envelopes shall then be opened by the Employer. The Employer shall record the names of each Proposer, and the Proposal Price and any other details as the Employer may consider appropriate. The Letter of Proposal - Financial Part and the Schedule of Rates and Prices (if any) are to be initialed by representatives of the Employer attending the public opening and by the Consultant's Representatives.<br>35.3 The Employer shall prepare a record of the opening of the Financial Part envelopes that shall include, as a minimum:<br>(a) the name of the Proposers whose Financial Part was opened;<br>(b) the Proposal prices including any discounts; and<br>(c) the Consultant's Representative's report of the opening of the Financial Part.<br>35.4 The Probity Assurance Provider shall sign the record. The contents of the envelopes marked 'Financial Part' and the record of the opening shall be kept in safe custody by the Employer and not disclosed to anyone until the time of the transmission of the Notification of Intention to Award the contract. |

## I. Evaluation of Financial Part

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| **36. Nonmaterial Nonconformities** | 36.1 Provided that a Proposal is substantially responsive, and Proposals have been invited on single responsibility basis in accordance with **ITP 15**, the Employer:<br>(a) may waive any nonconformities in the Proposal; or<br>(b) may request that the Proposer to submit the necessary information or documentation, within a reasonable period of time, to rectify nonmaterial nonconformities in the Proposal.<br>36.2 Provided that a Proposal is substantially responsive, and Proposals have been invited to include any part of the Works to be paid according to quantity supplied or work done in accordance with **ITP 15**, the Employer shall rectify quantifiable nonmaterial nonconformities related to the Proposal Price. To this effect, the Proposal Price shall be adjusted, for comparison purposes only, to reflect the price of a missing or non-conforming item or component by adding the average price of the item or component quoted by substantially responsive Proposers. If the price of the item or component cannot be derived from the price of other substantially responsive Proposers, the Employer shall use its best estimate. |
| **37. Arithmetic Correction** | 37.1 If Proposals have been invited on single responsibility basis in accordance with **ITP 15**, the Proposer is deemed to have included all prices in the (lump sum) Total Proposal Price. Arithmetical corrections shall therefore not be made, except that where there is |

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| | a discrepancy between the amount in words and the amount figures, the amount in words shall prevail.<br><br>37.2 If Proposals have been invited to include any part of the Works to be paid according to quantity supplied or work done in accordance with **ITP 15**, the Employer shall correct arithmetical errors only for the price for such part of the Works on the following basis:<br><br>(a) where there are errors between the total of the amounts given under the column for the price breakdown and the amount given under the Proposal Price, the former shall prevail and the latter will be corrected accordingly;<br><br>(b) if there is a discrepancy between words and figures, the amount in words shall prevail, unless the amount expressed in words is related to an arithmetic error, in which case the amount in figures shall prevail subject to (a) above.<br><br>37.3 A Proposer shall be requested to accept the correction of arithmetical errors. Failure to accept the correction in accordance with **ITP 37.1** and **ITP 37.2** shall result in the rejection of the Proposal. |
| **38. Conversion to Single Currency** | 38.1 For evaluation and comparison purposes, the currency (ies) of the Proposal shall be converted into a single currency as specified **in the PDS.** |
| **39. Margin of Preference** | 39.1 Unless otherwise specified **in the PDS,** a margin of preference for domestic Proposers[1] shall not apply. |
| **40. Evaluation Process Financial Parts** | 40.1 To evaluate each Proposal's Financial Part, the Employer shall consider the following:<br><br>(a) the Proposal price, excluding provisional sums and the provision, if any, for contingencies in the Schedule of Rates and Prices (if any), but including Daywork items, where priced competitively;<br><br>(b) price adjustment for correction of arithmetic errors in accordance with **ITP 37**;<br><br>(c) price adjustment due to discounts offered in accordance with **ITP 15.7**;<br><br>(d) price adjustment due to quantifiable nonmaterial nonconformities in accordance with **ITP 36.2**; |

[1] An individual firm is considered a domestic Proposer for purposes of the margin of preference if it is registered in the country of the Employer, has more than 50 percent ownership by nationals of the country of the Employer, and if it does not subcontract more than 10 percent of the contract price, excluding provisional sums, to foreign contractors. JVs are considered as domestic Proposer and eligible for domestic preference only if the individual member firms are registered in the country of the Employer or have more than 50 percent ownership by nationals of the country of the Employer, and the JV shall be registered in the country of the Borrower. The JV shall not subcontract more than 10 percent of the contract price, excluding provisional sums, to foreign firms. JVs between foreign and national firms will not be eligible for domestic preference.

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| | (e) converting the amount resulting from applying (a) to (c) above, if relevant, to a single currency in accordance with **ITP 38.1**; and<br><br>(f) any additional evaluation factors indicated **in the PDS** and detailed in **Section III (Evaluation and Qualification Criteria)**.<br><br>40.2 If price adjustment is allowed in accordance with **ITP 15.5**, the estimated effect of the price adjustment provisions of the Conditions of Contract, applied over the period of execution of the Contract, shall not be taken to account in Proposal evaluation.<br><br>40.3 If this RFP allows Proposers to quote separate prices for different lots (contracts), each lot will be evaluated separately to determine the most advantageous Proposal using the methodology specified in **Section III (Evaluation and Qualification Criteria)**. **Discounts that are conditional on the award of more than one lot, or slice shall not be considered for Proposal evaluation.** |
| **41. Abnormally Low Proposals** | 41.1 An Abnormally Low Proposal is one where the Proposal price, in combination with other elements of the Proposal, appears so low that it raises material concerns as to the capability of the Proposer to perform the Contract for the offered Proposal Price.<br><br>41.2 In the event of identification of a potentially Abnormally Low Proposal, the Employer shall seek written clarifications from the Proposer, including detailed price analyses of its Proposal price in relation to the subject matter of the contract, scope, proposed methodology, schedule, allocation of risks and responsibilities and any other requirements of the RFP Document.<br><br>41.3 After evaluation of the price analyses, in the event that the Employer determines that the Proposer has failed to demonstrate its capability to perform the Contract for the offered Proposal Price, the Employer shall reject the Proposal. |
| **42. Unbalanced or Front-Loaded Proposals** | 42.1 If the Proposal that is evaluated as the lowest evaluated cost is, in the Employer's opinion, seriously unbalanced or front loaded the Employer may require the Proposer to provide written clarifications. Clarifications may include price analyses to demonstrate the consistency of the Proposal prices with the scope of the Works, proposed methodology, schedule and any other requirements of the RFP Document.<br><br>42.2 After the evaluation of the information and price analyses presented by the Proposer, the Employer may:<br><br>(a) accept the Proposal, or<br><br>(b) if appropriate, require that the total amount of the Performance Security be increased, at the expense of the Proposer, to a level not exceeding twenty percent (20%) of the Contract Price; or<br><br>(c) reject the Proposal. |



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## J. Evaluation of Combined Technical and Financial Part

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| **43. Evaluation of Combined Technical and Financial Proposals** | 43.1 | The Employer's evaluation of responsive Proposals will take to account technical factors, in addition to cost factors in accordance with **Section III (Evaluation and Qualification Criteria)**. The weight to be assigned for the Technical factors and cost is specified **in the PDS**. The Employer will rank the Proposals based on the evaluated Proposal score (B). |
| **44. Best and Final Offer (BAFO)** | 44.1 | After completion of the combined technical and financial evaluation of Proposals, if specified **in the PDS**, the Employer may invite those Proposers to submit their BAFOs. The procedure for submitting BAFOs will be specified **in the PDS**. BAFO is a final opportunity for Proposers to improve their Proposals without changing the specified business function and performance requirements in accordance with the RFP Document. Proposers are not obliged to submit a BAFO. Where BAFO is used there will be no negotiation after BAFO. |
| | 44.2 | BAFO will apply a two-envelope procurement process. The submission of BAFOs, opening of the Technical Parts and Financial Parts and the evaluation of Proposals will follow the procedures described for the Technical, Financial and Combined evaluation above, as appropriate. |
| **45. Most Advantageous Proposal (MAP)** | 45.1 | The Most Advantageous Proposal is the Proposal of the Proposer that meets the Qualification Criteria, and whose Proposal has been determined to be:<br>(a) substantially responsive to the RFP; and<br>(b) the best evaluated Proposal i.e., the highest scoring Proposal, in the combined technical and financial evaluation. |
| **46. Negotiations** | 46.1 | If specified **in the PDS**, the Employer may conduct negotiations following the evaluation of Proposals and before the final contract award. The procedure of the negotiations will be specified **in the PDS**. |
| | 46.2 | Negotiations shall be held in the presence of Probity Assurance Provider appointed by the Employer. |
| | 46.3 | Negotiations may address any aspect of the contract so long as they do not change the specified business function and performance requirements. |
| | 46.4 | The Employer may negotiate first with the Proposer that has the Most Advantageous Proposal. If the negotiations are unsuccessful the Employer may negotiate with the Proposer that has the next best Most Advantageous Proposal, and so on down the list until a successful negotiated outcome is achieved. |
| **47. Employer's Right to Accept Any Proposal, and to Reject** | 47.1 | The Employer reserves the right to accept or reject any Proposal, and to annul the RFP process and reject all Proposals at any time prior to contract award, without thereby incurring any liability to Proposers. In |



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| **Any or All Proposals** | | case of annulment, all Proposals submitted and specifically, Proposal securities shall be promptly returned to the Proposers. |
| **48. Standstill Period** | 48.1 | The Contract shall not be awarded earlier than the expiry of the Standstill Period. The Standstill Period shall be ten (10) Business Days unless extended in accordance with **ITP 52**. The Standstill Period commences the day after the date the Employer has announced the evaluation report in accordance with PPRA Rule-35. |
| **49. Notification of Intention to Award** | 49.1 | The Employer shall send to each Proposer (that has not already been notified that it has been unsuccessful) the Notification of Intention to Award the Contract to the successful Proposer. The Notification of Intention to Award shall contain, at a minimum, the following information:<br>(a) the name and address of the Proposer submitting the successful Proposal;<br>(b) the Contract price of the successful Proposal;<br>(c) the total combined score of the successful Proposal;<br>(d) the names of all Proposers who submitted Proposals, and their Proposal prices as readout and as evaluated prices and technical score;<br>(e) a statement of the reason(s) the Proposal (of the unsuccessful Proposer to whom the notice is addressed) was unsuccessful;<br>(f) the expiry date of the Standstill Period; and<br>(g) instructions on how to request a debriefing or submit a complaint during the standstill period. |

## K. Award of Contract

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| **50. Award Criteria** | 50.1 | Subject to **ITP 47.1**, the Employer shall award the Contract to the Proposer with the Most Advantageous Proposal, provided that the Proposer is determined to be eligible and qualified to perform the Contract satisfactorily. |
| **51. Notification of Award** | 51.1 | Prior to the date of expiry of the Proposal validity and upon expiry of the Standstill Period, specified in **ITP 48.1** or any extension thereof, and upon satisfactorily addressing any complaint that has been filed within the Standstill Period, the Employer shall notify the successful Proposer, in writing, that its Proposal has been accepted. The notification of award (hereinafter and in the Conditions of Contract and Contract Forms called the "Letter of Acceptance") shall specify the sum that the Employer will pay the EPC Contractor in consideration of the execution of the Contract (hereinafter and in the Conditions of Contract and Contract Forms called "the Contract Price").<br>51.2 Until a formal contract is prepared and executed, the Letter of Acceptance shall constitute a binding Contract. |

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| **52. Debriefing by the Employer** | 52.1 | On receipt of the Borrower's Notification of Intention to Award referred to in **ITP 49**, an unsuccessful Proposer has three (3) Business Days to make a written request to the Employer for a debriefing. The Employer shall provide a debriefing to all unsuccessful Proposers whose request is received within this deadline. |
| | 52.2 | Where a request for debriefing is received within the deadline, the Employer shall provide a debriefing within five (5) Business Days, unless the Employer decides, for justifiable reasons, to provide the debriefing outside this timeframe. In that case, the standstill period shall automatically be extended until five (5) Business Days after such debriefing is provided. If more than one debriefing is so delayed, the standstill period shall not end earlier than five (5) Business Days after the last debriefing takes place. The Employer shall promptly inform, by the quickest means available, all Proposers of the extended standstill period. |
| | 52.3 | Where a request for debriefing is received by the Employer later than the three (3)-Business Day deadline, the Employer should provide the debriefing as soon as practicable, and normally no later than fifteen (15) Business Days from the date of publication of Public Notice of Award of contract. Requests for debriefing received outside the three (3)-day deadline shall not lead to extension of the standstill period. |
| | 52.4 | Debriefings of unsuccessful Proposers may be done in writing or verbally. The Proposer shall bear its own costs of attending such a debriefing meeting. |
| **53. Signing of Contract** | 53.1 | The Employer shall send to the successful Proposer the Letter of Acceptance including the Contract Agreement and a request to submit the Beneficial Ownership Disclosure Form providing additional information on its beneficial ownership. The Beneficial Ownership Disclosure Form shall be submitted within eight (8) Business Days of receiving this request. |
| | 53.2 | The successful Proposer shall sign, date and return to the Employer, the Contract Agreement within twenty-eight (28) days of its receipt. |
| **54. Performance Security** | 54.1 | Within twenty-eight (28) days of the receipt of the Letter of Acceptance from the Employer, the successful Proposer shall furnish the Performance Security and if required **in the PDS**, the Environmental and Social (ES) Performance Security, in accordance with the General Conditions, subject to **ITP 42.2 (b)**, using the Performance Security and ES Performance Security Forms included in **Section X (Contract Forms)** or another form acceptable to the Employer. Failure of the successful Proposer to submit the above-mentioned Performance Security and if required **in the PDS**, the Environmental and Social (ES) Performance Security, or sign the Contract shall constitute sufficient grounds for the annulment of the award and forfeiture of the Proposal security. In that event the Employer may award the Contract to the next lowest evaluated Proposer–whose offer is substantially responsive and is determined by the Employer to be qualified to perform the Contract satisfactorily. |



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| **55. Procurement Related Complaint** | 55.1 The procedures for making a Procurement-related Complaint are as specified **in the PDS**. |



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## SECTION II - PROPOSAL DATA SHEET (PDS)

### A. General

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| **ITP 1.1** | The Employer is: **Water and Power Development Authority (WAPDA)**,<br><br>Represented by Chief Engineer/PD ALHPP<br>**Liaison Office:** Office of Chief Engineer/PD ALHPP, Sunny View Estate, Kashmir Road, Lahore, Pakistan.<br>**Site Office:** Office of Chief Engineer / PD Attabad Lake HPP, Dour Khan, Aliabad, Hunza.<br><br>The name of the RFP is<br><br>**EPC Bidding Documents of**<br>**Attabad Lake Hydropower Project (54 MW)**<br>**Package-III: Electro-Mechanical Works**<br><br>Mode of Procurement: Single-Stage two Envelope.<br><br>Technical and Financial Proposal shall be submitted in separate envelopes marking as “Technical Proposal” and “Financial Proposal”. |
| **ITP 1.3 (a)** | The Proposal/ Bids shall be submitted/uploaded through EPADs v2.0 on **(www.vendors.epads.gov.pk)**. The Proposal/ Bids not submitted/ uploaded on EPADs v2.0 shall not be accepted. |
| **ITP 2.1** | The name of the Project is **Attabad Lake Hydropower Project (54 MW).** |
| **ITP 4.1** | Maximum number of members in JV shall be four (04).<br>Registration with Pakistan Engineering Council and FBR Pakistan are mandatory as per requirement outlined Section-III. |
| **ITP 4.5** | PPRA’s list of debarred firm is https://ppra.gov.pk/#/other/pepra-active-black-listed-firms . A list of debarred firms and individuals is also available on the World Bank’s external website: http://www.worldbank.org/debarr |
| **ITP 4.10** | Text of this sub-clause stands deleted removed. |
| **ITP 6.1** | The **ITP 6.1** is replaced with following:<br><br>The RFP/EPC Bidding Document consists of Three (03) Volumes, Volume-I, Volume-II and Volume-III which include all the Sections indicated below, and should be read in conjunction with any Addenda issued in accordance with **ITP 8:**<br><br>**VOLUME-I: BIDDING PROCEDURE AND CONDITIONS OF CONTRACT**<br><br>Section I - Instructions to Proposers (ITP)<br>Section II - Proposal Data Sheet (PDS)<br>Section III - Evaluation and Qualification Criteria<br>Section IV - Proposal Forms<br>Section V - Eligible Countries<br>Section VI - Fraud and Corruption |



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| | Section VII - General Conditions<br>Section VIII - Particular Conditions<br>Part A - Contract Data<br>Part B - Special Provisions<br>Section IX - Environmental and Social (ES) Metrics for Progress Reports<br>Section X - Contracts Forms<br><br>**VOLUME-II: EMPLOYER'S REQUIREMENTS**<br><br>Part-I: Specific Provisions<br>Part-II: Technical Provisions for Electro-Mechanical Works<br>Part-III: Conceptual Drawings<br><br>**VOLUME-III: ADDITIONAL INFORMATION**<br><br>Part-I: Feasibility Study Report (2021)<br>Part-II: Feasibility Review/Validation Report (2022)<br>Part-III: Topographic Survey Map Book (2025)<br>Part-IV: Updated Environmental Impact Assessment (EIA) Report (2023) |

## B. Contents of RFP/EPC Bidding Document

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| **ITP 7.1** | For **Clarification of Proposal purposes** only, the Employer's address is:<br><br>**Water and Power Development Authority (WAPDA),**<br>**Attention:** Chief Engineer / Project Director Attabad Lake HPP<br>**Liaison Office:** Office of Chief Engineer/PD ALHPP, Sunny View Estate, Kashmir Road, Lahore, Pakistan.<br><br>**Telephone:** 0092-42-99204981 0092-42-3334481116<br>All communication per e-mail shall also be copied to the following, additional<br>**Email Address:** gmpna01@gmail.com or pdalhpp@gmail.com<br><br>Requests for clarification should be received by the Employer no later than: **14 Days** prior to the Proposal submission deadline. |
| **ITP 7.1** | Web page: Not Applicable |
| **ITP 7.4** | A Pre-Proposal meeting shall take place at following date, time and place:<br><br>Date: April 14, 2026<br><br>Time: 1100 hrs.<br><br>Venue: Conference Hall / Committee room WAPDA House, Lahore. |
| **ITP 11.1** | The language of the Proposal is: **English.**<br>All correspondence exchange shall be in **English** language.<br>Language for translation of supporting documents and printed literature is **English.** |



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## C. Preparation of Proposals

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| **ITP 12.2 (j)** | The Proposer shall submit as part of its Technical Part the following additional documents:<br><br>a) **Code of Conduct for Contractor's Personnel (ES)**<br>The Proposer shall submit its Code of Conduct that will apply to EPC Contractor's Personnel (as defined in Sub-Clause 1.1.14 of the General Conditions), to ensure compliance with the EPC Contractor's Environmental and Social (ES) obligations under the Contract. The Proposer shall use for this purpose the Code of Conduct form provided in **Section IV (Proposal Forms)**. No substantial modifications shall be made to this form, except that the Proposer may introduce additional requirements, including as necessary to take to account specific Contract issues/risks.<br><br>b) **Fraud and Corruption & Integrity pact**<br>The Proposer shall use for this purpose the Code of Conduct form provided in **Section VI (Fraud and Corruption)**. No modifications shall be made to this form.<br><br>c) **Registration with Pakistan Engineering Council** (in relevant category)<br><br>d) **Registration with FBR Pakistan** (for Pakistani Firms). |
| **ITP 12.3 (e)** | a) Registration with Pakistan Engineering Council and FBR Pakistan.<br>b) Extracts of Active Tax payer List |
| **ITP 14.1** | Alternative Technical Proposal is not allowed. |
| **ITP 15.3** | The prices quoted by the Proposer **Shall be** subject to adjustment during the performance of the Contract. |
| **ITP 16.1** | The currency(ies) of the Proposal and the payment currency(ies) shall be in accordance with **Alternative A** as described below:<br><br>**Alternative A (Proposers to quote entirely in local currency)**<br><br>The prices shall be quoted by the Proposer entirely in **Pakistani Rupee (PKR)** and further referred to as "the local currency". A Proposer expecting to incur expenditures in other currencies for inputs to the Works supplied from outside the Employer's country (referred to as "the foreign currency requirements") shall indicate in the **Appendix to Proposal - Table C**, the percentage(s) of the Proposal Price (excluding Provisional Sums), needed by the Proposer for the payment of such foreign currency requirements, limited to no more than one (01) foreign currency. However, the portion of Proposal Price (excluding Provisional Sum) for such foreign currency requirement shall not be more than 80%.<br><br>The rates of exchange to be used by the Proposer in arriving at the local currency equivalent and the percentage(s) mentioned in (a) above shall be as specified in the **Appendix to Proposal - Table C**, and shall apply for all |

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| | payments under the Contract so that no exchange risk will be borne by the successful Proposer. |
| **ITP 19.1** | A Proposal Security **Shall be** required.<br>A Proposal Security Declaration **Shall not be** required.<br>The amount and currency of the Proposal Security shall be **PKR 120 Million** or equivalent amount in freely convertible currencies**.** Source of Exchange rate shall be State Bank of Pakistan**.**<br>Web link: https://www.sbp.org.pk/ecodata/rates/m2m/m2m-current.asp |
| **ITP 19.2** | Proposal Securing Declaration: **Not Applicable**<br>Proposal Securing Declaration is deleted as and were appearing in the document. |
| **ITP 19.3** | Last para of said Instruction starting from "If an unconditional guarantee…." |
| **ITP 19.3 (d)** | None |
| **ITP 20.1** | The Proposal shall be valid until **180 days** from date of submission of Proposal**.** |
| **ITP 20.3** | **Not Applicable** |
| **ITP 21.1** | The written confirmation of authorization to sign on behalf of the Proposer shall consist of:<br>An organizational document, board resolution or its equivalent, or power of attorney specifying the representative's authority to sign the Proposal on behalf of, and to legally bound, the Proposer. If the Proposer is an intended or an existing Joint Venture, the power of attorney shall be signed by all JV Partners and shall specify the authority of the named representative of the Joint Venture to sign on behalf of, and legally bound, the intended or existing Joint Venture. If the Joint Venture has not yet been formed, also include evidence from all proposed Joint Venture Partners of their intent to enter into a Joint Venture in the event of a Contract Award in accordance with ITP 12.2. |

## D. Submission of Proposals

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| **ITP 22.1 (b)** | The original Proposal shall be submitted/uploaded on EPADS v2.0 at (www.vendors.epads.gov.pk/). Proposals not submitted on EPADS v2.0 shall not be considered.<br>In addition to the Proposals submitted/uploaded on EPADS v2.0, the Proposer shall submit **three (03) hard copies** of Technical proposal only, in strict accordance with the procedure set forth in ITP Clause 22.1(b). In case of discrepancy between files uploaded on EPADS v2.0 and hard copies, the content of files uploaded on EPADS v2.0 shall prevail.<br>Original Proposal Security Instrument amounting to Rs.120 million shall be submitted to the address provided in PDS to ITP 23.1 on or before last date of submission or submission in person before the Proposal date and submission time.<br>The Proposer shall provide complete searchable PDF version. |
| **ITP 23.1** | The Proposal/Bids shall be submitted/uploaded on EPADS v2.0 at https://vendors.epads.gov.pk/ Proposal/Bids not submitted/uploaded on EPADS v2.0 shall not be accepted. |



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| | For **Proposal Submission Purposes (Technical Part and Original Proposal Security)** only, the Employer's address is:<br><br>**Water and Power Development Authority (WAPDA),**<br>WAPDA Auditorium, WAPDA House, Sharah-e-Quaid-e-Azam Lahore, Punjab, Pakistan<br>**Telephone:** 0092-42-99204981 0092-42-3334481116<br>**Electronic Mail Address:** gmpna01@gmail.com, pdalhpp@gmail.com<br><br>**Date:** August 20, 2026<br>**Time:** 1100 hrs. |
| **ITP 23.1** | The Electronic bids shall be submitted/uploaded through EPADs v2.0 on **(www.vendors.epads.gov.pk)** |

## E. Opening of Technical Parts of Proposals

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| **ITP 26.1** | The **Electronic Bids/Proposal Opening on EPADS v2.0** shall take place on:<br>**Date:** August 20, 2026<br>**Time:** 1130 hrs.<br>**Venue:** WAPDA Auditorium, WAPDA House, Sharah-e-Quaid-e-Azam Lahore, Punjab, Pakistan |

## G. Evaluation of Technical Parts of Proposals

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| **ITP 31.3** | The text of this sub-clause stands deleted/removed. | |
| **ITP 31.4** | The technical factors (sub-factors) and the corresponding weight in percentages are: | |
| | **Technical Factor** | **Weightage in Percentage %** |
| | **Proposed Works** | |
| | 1. To what extent the Proposed Works (Proposed Generating Capacity) exceed the Employer's Requirements (Evaluation shall be based on the output at Step up Transformer Terminals) | **5** |
| | **Approach and Methodology** | |
| | 2. Technical Plant Data (E&M Works) Evaluation shall be based on the following requirements: | **20** |
| | a) Technical schedules mentioned in the end of Technical Provisions (Vol-II Part-II) | 40% |
| | b) Sub-Contractor's/Manufacturer's list<br><br>Higher scores shall be awarded to Proposer's proposing equipment from manufacturers with proven experience in successful design, manufacture, testing and commissioning of similar Electro-Mechanical equipment in hydropower projects of comparable capacity and head. | 30% |



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| | c) Technical Standards (As per latest International Standards as given in Employer Requirements)<br>d) Type test and under Taking<br>The above- mentioned items shall be checked for each E&M equipment / System | 20%<br>10% |
| | 3. Design Methodology<br>Evaluation shall be based on the following requirements:<br>The Design Proposal shall demonstrate the Proposer's understanding of the Project and present a comprehensive technical solution for the Electro-Mechanical works, including Francis Turbine, Governor, Main Inlet Valve, Synchronous Generator, Power Transformer, 132 kV Switchgear and Hydraulic Gates. The Proposal shall clearly describe the design philosophy, compliance with applicable standards, interface with Civil Works, and long-term operational reliability of the plant.<br>a) Overview<br>b) References<br>c) Design criteria and basis<br>d) Technical narrative<br>e) Process flow diagram<br>f) Process design and calculation of components (including structural modelling and Load application)<br>g) Layout arrangement, component plans and spot details in A3<br>h) Proposed design deliverables for Contract execution<br>i) Site Investigation Reports (optional)<br>The Works shall be designed to withstand all description in accordance with the Employer's Requirements, and the appropriate codes and standards. | 10 |
| | 4. Testing and Commissioning Strategy<br>The Contractor shall submit a comprehensive Testing and Commissioning Strategy covering factory tests, site installation verification, pre-commissioning, commissioning, performance and reliability tests for all Electro-Mechanical equipment. | 10 |
| | 5. Method Statement for key construction activities for critical equipment<br>The Proposer shall submit Method Statements for key installation and erection activities of all major Electro-Mechanical equipment. The Method Statements shall describe the installation sequence, transportation | 15 |



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| | requirements from shipping port to Site, fabrication locations, tools and key equipment (as per listed under clause 1.4), quality control measures, safety precautions, and interface with other works. The methodology shall also demonstrate the Proposer's experience in similar type hydropower projects and complexity.<br><br>See specific requirements for method statement under Section IV Proposal Forms. | |
| | 6. Optimization of Timelines for E&M Equipment<br><br>The Proposer may propose optimization of timelines for Electro-Mechanical works within the overall completion period defined by the Employer. The Proposal shall clearly identify areas of schedule optimization, interface with Civil Works, associated risks and mitigation measures, and resource deployment. The optimized schedule shall be supported by a detailed program and shall not compromise safety, quality, testing requirements, or performance guarantees. | 10 |
| | 7. Code of Conduct<br><br>The Proposer shall submit a project-specific Code of Conduct, based on the template provided in the Bidding Documents, signed by an authorized representative. The submission shall include an implementation and monitoring plan describing how the Code will be communicated, enforced, monitored, and how breaches will be addressed. The Code of Conduct, once accepted, shall be part of the Contract and enforceable. See specific requirements for code of conduct under Section IV Proposal Forms. | 5 |
| | 8. EPC/Turnkey Work Program<br><br>The Proposer shall set out a work program for design and construction of the Works as per attached Proposal Forms. See specific requirements for work program under Section IV Proposal Forms. | 5 |
| | 9. Key Personnel qualifications, Contract Personnel Organization, experience and resource schedule (The likely key specialists required to execute the contract are listed under clause 1.3 (1A)) | 10 |
| | Project Manager | 20% |
| | Design Team Leader | 20% |
| | Contracts Manager | 10% |



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|---|---|---|
| | Quality Control Managers | 10% |
| | Testing and Commissioning Manager | 10% |
| | Health and Safety Manager | |
| | Welding Experts | 5% |
| | Environmental and Social Expert | 5% |
| | Construction Chief Site Manager | 5% |
| | Planning and Scheduling Engineer | 10% |
| | | 5% |
| | 10. Risk Assessment and proposed management plan<br>The Proposer is required to access the Project risks and suggest the proposed remedial measures, for various stages during the execution of the project. The Proposer should be able to list any risks and constraints involved that could affect the sequence / progress of works. See specific requirements for Risk Assessment under Section IV Proposal Forms. | 5 |
| | 11. Environmental, Social, Health and Safety (ESHS)<br>The Proposer's shall provide an ESHS Methodology providing information on how the Proposer's shall meet the requirements and objectives specified in Section IV Proposal Forms.<br>a) ES Approach and methodology as per the requirements mentioned in the design Proposal under technical Proposal forms.<br>b) Sustainable procurement Proposal<br>c) Specific experience in ESHS aspects as per the form EXP 4.2 (c) | 5<br>25%<br>25%<br>50% |
| **ITP 38.1** | The currency that shall be used for Proposal evaluation and comparison purposes to convert, at the selling exchange rate, all Proposal prices expressed in various currencies into a single currency is: **Pakistani Rupee (PKR)**<br>The source of exchange rate shall be: TT Selling Rates Published or authorized by **State Bank of Pakistan.**<br>The date for the exchange rate shall be the deadline for submission of Proposals as specified in **ITP 23.1**, unless otherwise specified by the Employer. | |



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| | The currency(ies) of the Proposal and the payment currency(ies) shall be in accordance with **Alternative A** as described below:<br><br>**Alternative A (Proposers to quote entirely in local currency)**<br><br>For comparison of Proposals, the Proposal Price, corrected pursuant to **ITP 37.1,** shall first be broken down into the respective amounts payable in various currencies by using the selling exchange rates specified by the Proposer in accordance with **ITP 16.1.**<br><br>In the second step, the Employer will convert the amounts in various currencies in which the Proposal Price is payable (excluding Provisional Sums but including Daywork where priced competitively) to the single currency identified above at the selling rates established for similar transactions by the authority specified and, on the date, stipulated above. |
| **ITP 39.1** | A margin of domestic preference **Shall not** Apply**.** |
| **ITP 40.1 (f)** | The adjustments shall be determined using the following criteria as detailed in **Section III (Evaluation and Qualification Criteria)**:<br><br>a) Performance Guarantees of the Plant and Installation Services. |

## J. Evaluation of Combined Technical and Financial Parts

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| **ITP 43.1** | The weight to be given for cost is: **0.7**<br>The weight to be given for technical is: **0.3** |
| **ITP 44.1** | BAFO **does not apply**. |
| **ITP 46.1** | Negotiation **does not apply.** |
| **ITP 49** | The text of this ITP 49 is amended as under:<br>Announcement of combined results will be announced as per **PPRA Rule No. 35.** |

## K. Award of Contract

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| **ITP 52** | **Not Applicable** |
| **ITP 53.1** | The successful Proposer shall submit the Beneficial Ownership Disclosure Form. |
| **ITP 54.1** | ES Performance Security: **Not Required**<br>The Performance Security shall be of an amount equal to 10% of the Accepted Contract Amount stated in the Letter of Acceptance. |
| **ITP 55.1** | Grievance Redressal Committee (GRC) WAPDA<br>Convener: General Manger (M&S)<br>414-WAPDA House, Shahrah-e-Quaid-e-Azam, Lahore, Pakistan. |



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## SECTION III - EVALUATION AND QUALIFICATION CRITERIA

### A. Technical Part

### 1. Qualification Criteria and Requirements

Eligibility and Qualification information described here below must be met by the legal entity(ies) comprising the Proposer, and not the Proposer's/JV partner's sister or parent companies, subsidiaries or affiliates.

| Eligibility and Qualification Criteria | | | Compliance Requirements | | | | Document / Form |
|---|---|---|---|---|---|---|---|
| No | Subject | Requirement | Single Entity | Joint Venture (existing or intended) | | | Submission Requirement |
| | | | | All Members Combined | Each Member | One Member | |
| **A. Eligibility** | | | | | | | |
| 1.1 | Nationality | Nationality in accordance with ITP 4.4 | Must meet requirement | N/A | Must meet requirement | N/A | Forms ELI 1.1 and 1.2, with attachments |
| 1.2 | Conflict of Interest | No conflicts of interest in accordance with ITP 4.2 | Must meet requirement | N/A | Must meet requirement | N/A | Letter of Proposal Technical Part |
| 1.3 | Eligibility | Not having been declared ineligible by the Government of Islamic Republic of Pakistan, as described in ITP 4.8 | Must meet requirement | N/A | Must meet requirement | N/A | Form ELI 1.1 |
| 1.4 | State-owned Entity of the Employer's | Proposer is required to meet the conditions of ITP 4.6 | Must meet requirement | N/A | Must meet requirement | N/A | Forms ELI 1.1 and 1.2, with attachments |



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| Eligibility and Qualification Criteria | | | Compliance Requirements | | | | Document / Form |
|---|---|---|---|---|---|---|---|
| No | Subject | Requirement | Single Entity | Joint Venture (existing or intended) | | | Submission Requirement |
| | | | | All Members Combined | Each Member | One Member | |
| | Country | | | | | | |
| 1.5 | United Nations resolution or Employer's country law | Not having been excluded as a result of prohibition in the Employer's country laws or official regulations against commercial relations with the Proposer's country, or by an act of compliance with UN Security Council resolution, both in accordance with ITP 4.8 and 5.1 and Section V. | Must meet requirement | N/A | Must meet requirement | N/A | Forms ELI 1.1 and 1.2, with attachments |
| 1.6 | Pakistan Engineering Council (PEC) Licensing | The Proposer shall be duly licensed by the Pakistan Engineering Council (PEC) for the year 2026 in Category C-A. In case of JV, the lead firm must fulfill the **C-**A category[1]. | Must meet requirement | N/A | Must meet category requirement as per share | Lead partner must meet **C-**A category. | Provisional / standard PEC license. In case validity of License has expired, application for renewal of required category while other JV partners shall have a least category (as per |

1 Foreign firm will be required to submit provisional PEC License in relevant category before submission of Bidding Documents. Standard PEC License shall be mandatory after award of contract.



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| Eligibility and Qualification Criteria | | | Compliance Requirements | | | | Document / Form |
|---|---|---|---|---|---|---|---|
| No | Subject | Requirement | Single Entity | Joint Venture (existing or intended) | | | Submission Requirement |
| | | | | All Members Combined | Each Member | One Member | |
| | | | | | | | requirement). |
| 1.7 | Pakistani Firm Tax Registration | The firm shall be registered with Income Tax and Sales Tax Departments and must be on Active Taxpayer List of the Federal Board of Revenue Pakistan at the time of submission of its Proposal. | Must meet requirement [2] | N/A | Must meet requirement | N/A | Income Tax Certificate. Extracts of ATL. |
| **B. Historical Contract Non-Performance** | | | | | | | |
| 2.1 | History of Non-Performing Contracts | Non-performance of a contract[3] did not occur as a result of EPC Contractor's default since 1st January 2010 | Must meet requirement | Must meet requirement | Must meet requirement[4] | N/A | Form CON 2 |
| 2.2 | Suspension | Not under suspension | Must meet | Must meet | Must meet | N/A | Letter of Proposal |

[2] For Pakistani Firms only.

[3] Non-performance, as decided by the Employer, shall include all contracts where (a) nonperformance was not challenged by the EPC Contractor, including through referral to the dispute resolution mechanism under the respective contract, and (b) contracts that were so challenged but fully settled against the EPC Contractor. Nonperformance shall not include contracts where Employers decision was overruled by the dispute resolution mechanism. Nonperformance must be based on all information on fully settled disputes or litigation, i.e., dispute or litigation that has been resolved in accordance with the dispute resolution mechanism under the respective contract and where all appeal instances available to the Proposer have been exhausted.

[4] This requirement also applies to contracts executed by the Proposer as JV member.



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| Eligibility and Qualification Criteria | | | Compliance Requirements | | | | Document / Form |
|---|---|---|---|---|---|---|---|
| No | Subject | Requirement | Single Entity | Joint Venture (existing or intended) | | | Submission Requirement |
| | | | | All Members Combined | Each Member | One Member | |
| | Based on Execution of Bid/Proposal Securing Declaration by the Employer | based on execution of a Bid/Proposal Securing Declaration pursuant to ITP 19. | requirement | requirement | requirement | | Technical Part |
| 2.3 | Pending Litigation | Proposer's financial position and prospective long-term profitability still sound according to criteria established in 3.1 below and assuming that all pending litigation will be resolved against the Proposer. | Must meet requirement | N/A | Must meet requirement | N/A | Form CON 2 |
| 2.4 | Litigation History | No consistent history of court/arbitral award decisions against the Proposer[5] since 1st January 2010 | Must meet requirement | Must meet requirement | Must meet requirement | N/A | Form CON 2 |

5 The Proposer shall provide accurate information on the related Application Form about any litigation or arbitration resulting from contracts completed or ongoing under its execution over the last Fifteen (15) years. A consistent history of awards against the Proposer or any member of a joint venture may result in rejection of the Proposal.



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| Eligibility and Qualification Criteria | | | Compliance Requirements | | | | Document / Form |
|---|---|---|---|---|---|---|---|
| No | Subject | Requirement | Single Entity | Joint Venture (existing or intended) | | | Submission Requirement |
| | | | | All Members Combined | Each Member | One Member | |
| 2.5 | Declaration: Environmental, Social, Health and Safety (ESHS) past performance | Declare any E&M work contracts that have been suspended or terminated and/or performance security called by an employer for reasons related to the non-compliance of any environmental, social, health or safety (including Sexual Exploitation and Abuse) contractual obligations in the past Fifteen (15) years[6]. | Must make the declaration. (including each Specialized Sub-contractor) | N/A | Each must make the declaration. (including each Specialized Sub-contractor) | N/A | Form CON 3 ES Performance Declaration |
| 2.6 | Employer's SEA and/or SH Disqualification | (i) At the time of Contract Award, not subject to disqualification by the Employer's for non-compliance with SEA / SH obligations.<br>(ii) If the Proposer had been subject to disqualification by the Employer's for non- | Must meet requirement (including each Sub-contractor) | N/A | Must meet requirement (including each Sub-contractor) | N/A | Application Submission Letter, Form CON 4 |

[6] The Employer may use this information to seek further information or clarifications during the bidding stage and the associated due diligence.



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| Eligibility and Qualification Criteria | | | Compliance Requirements | | | | Document / Form |
|---|---|---|---|---|---|---|---|
| No | Subject | Requirement | Single Entity | Joint Venture (existing or intended) | | | Submission Requirement |
| | | | | All Members Combined | Each Member | One Member | |
| | | compliance with SEA / SH obligations, the Proposer shall either<br>(a) provide evidence of an arbitral award on the disqualification made in its favour; or<br>(b) demonstrate that it has adequate capacity and commitment to comply with SEA / SH prevention and response obligations; or<br>(c) provide evidence that it has already demonstrated such capacity and commitment for another Employer's financed works contract. | | | | | |
| **C. Financial Situation and Performance** | | | | | | | |
| 3.1 | Financial Capabilities | (i) The Proposer shall demonstrate that it has access to, or has | Must meet requirement | Must meet requirement. Lead firm must | N/A | N/A | Form FIN 3.1, with attachments |



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| Eligibility and Qualification Criteria | | | Compliance Requirements | | | | Document / Form |
|---|---|---|---|---|---|---|---|
| No | Subject | Requirement | Single Entity | Joint Venture (existing or intended) | | | Submission Requirement |
| | | | | All Members Combined | Each Member | One Member | |
| | | available, liquid assets, unencumbered real assets, lines of credit, and other financial means (independent of any contractual advance payment) sufficient to meet the construction cash flow requirements estimated as PKR 650 Million or equivalent for the subject contract(s) net of the Proposers other commitments.<br><br>(ii) The Proposer shall also demonstrate, to the satisfaction of the Employer, that it has adequate sources of finance to meet the cash flow requirements on works currently in progress and for future contract commitments. | Must meet requirement | meet 40% of the requirement<br><br>Must meet requirement | .<br><br>N/A | N/A | |



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| Eligibility and Qualification Criteria | | | Compliance Requirements | | | | Document / Form |
|---|---|---|---|---|---|---|---|
| No | Subject | Requirement | Single Entity | Joint Venture (existing or intended) | | | Submission Requirement |
| | | | | All Members Combined | Each Member | One Member | |
| | | (iii) The audited balance sheets for past three (03) years or, if not required by the laws of the Proposer's country, other financial statements acceptable to the Employer, for the last three (03) years shall be submitted and must demonstrate the current soundness of the Proposer's financial position and indicate its prospective long-term profitability. | Must meet requirement | N/A | Must meet requirement | N/A | |
| 3.2 | Average Annual Construction Turnover | (i) Minimum average annual construction turnover of PKR 3,000 Million or equivalent calculated as total certified payments received for contracts in | Must meet requirement | Must meet requirement | Each member must meet as per his share in JV. | Lead Partner must have minimum forty (40%) percent share. | Form FIN 3.2 |



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| Eligibility and Qualification Criteria | | | Compliance Requirements | | | | Document / Form |
|---|---|---|---|---|---|---|---|
| No | Subject | Requirement | Single Entity | Joint Venture (existing or intended) | | | Submission Requirement |
| | | | | All Members Combined | Each Member | One Member | |
| | | progress and/or completed within the last three (03) years. | | | | | |

| D. Experience | | | | | | | |
|---|---|---|---|---|---|---|---|
| Eligibility and Qualification Criteria | | | Compliance Requirement | | | | Document/Form |
| Sr. No. | Subject | Requirement | Single Entity | Joint Venture (existing or intended) | | | Submission Requirement |
| | | | | All Members Combined | Each Member | One Member | |
| 4.1 | **General Experience**<br><br>*(To substantiate the experience, Proposer shall submit Authenticated Taking Over Certificates and other relevant* | Experience in the role of Prime Contractor, JV Member, Sub-Contractor or Management Contractor of at least fifteen (15) years. | Must meet requirement | N/A | Must meet requirement | N/A | Form EXP 4.1 |



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| D. Experience | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Eligibility and Qualification Criteria** | | | **Compliance Requirement** | | | | **Document/Form** |
| **Sr. No.** | **Subject** | **Requirement** | **Single Entity** | **Joint Venture (existing or intended)** | | | **Submission Requirement** |
| | | | | **All Members Combined** | **Each Member** | **One Member** | |
| | *documents.)* | | | | | | |
| 4.2 (a) | **Specific Construction & Contract Management Experience**[7]<br><br>*(To substantiate the experience, Proposer shall submit Authenticated Taking Over Certificates and* | The Employer accepts any of the key activities listed under to be Sub-Contracted. These Key Activities may be complied with the Proposer or by its proposed Specialized Sub-Contractor.<br>A minimum number of Contracts specified below that have been satisfactorily Completed | Must meet requirement (The Criteria can be met through specialized Sub-Contractor) | Must meet requirement | N/A | N/A | Form EXP 4.2(a) |

[7] The Employer accepts experience listed in Form EXP 4.2(a) *(Specific Construction & Contract Management Experience)* to be Subcontracted. They may be complied with by the Proposer or by its proposed specialized Subcontractor. The Proposer shall provide Subcontractors authorization using form Subcontractor's / Manufacturer's Authorization Form, provided in Section-IV (Proposal Forms).



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| D. Experience | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Eligibility and Qualification Criteria** | | | **Compliance Requirement** | | | | **Document/Form** |
| **Sr. No.** | **Subject** | **Requirement** | **Single Entity** | **Joint Venture (existing or intended)** | | | **Submission Requirement** |
| | | | | **All Members Combined** | **Each Member** | **One Member** | |
| | *other relevant documents.)* | as a Prime Contractor, Joint Venture Member, Management Contractor or Sub-Contractor between January 01, 2005 and Proposal submission deadline: Either<br>(i) One Contract of Hydropower Project of 45 MW or higher and should be in successful commercial operation for one year<br>Or<br>Two (02) separate Contracts of Hydropower Projects totaling 45 | | | | | |



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| D. Experience | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Eligibility and Qualification Criteria** | | | **Compliance Requirement** | | | | **Document/Form** |
| **Sr. No.** | **Subject** | **Requirement** | **Single Entity** | **Joint Venture (existing or intended)** | | | **Submission Requirement** |
| | | | | **All Members Combined** | **Each Member** | **One Member** | |
| | | MW or higher and at-least one should be in successful commercial operation for one year.<br><br>To fulfill the above, Plant Engineering Design firm experience required to integrate the Project. The Qualification requirement mentioned in Specific Provisions (Volume-II Part-I) under Sub-Clause 1.4. | | | | | |
| 4.2 (b) | **Experience in Key Activities** | The Employer accepts any of the key activities listed under to be Sub-Contracted. These Key | Must meet requirements (The Criteria can be met through | Must meet requirements | | Must meet the requirements (The Criteria can be met through Manufacturer / | Form EXP 4.2(b) |



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| D. Experience | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Eligibility and Qualification Criteria** | | | **Compliance Requirement** | | | | **Document/Form** |
| **Sr. No.** | **Subject** | **Requirement** | **Single Entity** | **Joint Venture (existing or intended)** | | | **Submission Requirement** |
| | | | | **All Members Combined** | **Each Member** | **One Member** | |
| | *(To substantiate the experience, Proposer shall submit Authenticated Taking Over Certificates, Manufacturers Authorization Letter etc. and other relevant documents.)* | Activities may be complied with the Proposer or by its proposed Specialized Sub-Contractor[8]. For the above and any other Contracts completed and under implementation as Prime Contractor, Joint Venture Member, Management Contractor or Sub-Contractor [9] between | specialized Sub-Contractor) | | | specialized Sub-Contractor) | |

[8] In the case of a Proposer who offers to supply and install major Equipment of Plant under the Contract, which the Proposer did not manufacture or otherwise produce, the Proposer shall provide the Manufacturer's Authorization Letter, using the form provided in Section IV (Proposal Forms), showing that the Proposer has been duly authorized by the Manufacturer or Producer of the related Plant and Equipment or component to supply and install that Equipment in the Employer's country. Failure to submit the Manufacturer's Authorization Letter at the first instance is considered a minor, Non-Material omission and shall be subject to clarification. However, failure of the Proposer to submit the omitted Authorization Letter shall lead to rejection of the Subcontractor or Manufacturer.

[9] For the Contracts under which the Proposer participated as a JV Member or Subcontractor, only the Proposer's share by value shall be considered to meet this requirement. Instead, each Contract performed by each JV Member shall satisfy the minimum value of a single Contract as required for single entity. In determining whether the JV meets the requirement of total number of Contracts, only the number of Contracts completed by all Members each of value equal or more than the minimum value required shall be aggregated.



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| D. Experience | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Eligibility and Qualification Criteria** | | | **Compliance Requirement** | | | | **Document/Form** |
| **Sr. No.** | **Subject** | **Requirement** | **Single Entity** | **Joint Venture (existing or intended)** | | | **Submission Requirement** |
| | | | | **All Members Combined** | **Each Member** | **One Member** | |
| | | January 01, 2005 and Proposal submission deadline, a minimum experience in the following key activities successfully completed[10]:<br><br>At least One (01) Contract of Design, Manufacturing, Installation, Testing and Commissioning of the following minimum major Plant Equipment:<br>(i) Turbine 15 MW (Francis)<br>(ii) Governor<br>(iii) Main Inlet Valve<br>(iv) Synchronous | | | | | |

[10] Volume of production of any key activity can be demonstrated in one or more Contracts combined if executed during same time period.



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| D. Experience | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Eligibility and Qualification Criteria** | | | **Compliance Requirement** | | | | **Document/Form** |
| **Sr. No.** | **Subject** | **Requirement** | **Single Entity** | **Joint Venture (existing or intended)** | | | **Submission Requirement** |
| | | | | **All Members Combined** | **Each Member** | **One Member** | |
| | | Generator 18 MVA<br>(v) Generator Step Up Transformer 20 MVA<br>(vi) 132 kV Switchgear<br>(vii) Hydraulic Gate<br><br>The minimum Criteria will be applied to all Sub-Contractors/ Manufacturers who are intended to be used:<br>1. The proposed Suppliers must demonstrate at least twenty (20) years of business starting from January 01, 1997 on International | | | | | |



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| D. Experience | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Eligibility and Qualification Criteria** | | | **Compliance Requirement** | | | | **Document/Form** |
| **Sr. No.** | **Subject** | **Requirement** | **Single Entity** | **Joint Venture (existing or intended)** | | | **Submission Requirement** |
| | | | | **All Members Combined** | **Each Member** | **One Member** | |
| | | Projects outside their home countries with similar equipment designed according to International Standards.<br><br>Main Plant Equipment i.e. Francis Turbine, Governor, Main Inlet Valve, Synchronous Generator, Power Transformer, 132 kV Switchgear and Hydraulic Gates shall comply with International Standards as mentioned in Employer's Requirements. | | | | | |



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| D. Experience | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Eligibility and Qualification Criteria** | | | **Compliance Requirement** | | | | **Document/Form** |
| **Sr. No.** | **Subject** | **Requirement** | **Single Entity** | **Joint Venture (existing or intended)** | | | **Submission Requirement** |
| | | | | **All Members Combined** | **Each Member** | **One Member** | |
| **4.2 (c)** | Specific Experience in managing ESHS aspects | For the Contracts in Form Exp 4.2 (a) above and / or any other Contracts [completed and under implementation] as a Prime Contractor, Joint Venture Member, or Sub-Contractor between January 01, 2005 and Proposal submission deadline, experience in Managing ESHS risks and impacts in the following aspects:<br>• Details of Safety Records / Statistics in terms of lost time incident frequency and any deaths. | Must meet requirement | Must meet requirement | N/A | N/A | Form EXP 4.2 (c) |



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| D. Experience | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Eligibility and Qualification Criteria** | | | **Compliance Requirement** | | | | **Document/Form** |
| **Sr. No.** | **Subject** | **Requirement** | **Single Entity** | **Joint Venture (existing or intended)** | | | **Submission Requirement** |
| | | | | **All Members Combined** | **Each Member** | **One Member** | |
| | | • Project ESHS Plan used (including Key Performance Indicators and ESHS Reporting to Employer)<br>• Organization / Institutional Chart and Responsibilities for the Project with reference to the ESHS Aspects.<br>• Experience of implementing Site Specific Environmental Management Plans such as:<br>a. Site Restoration Plan | | | | | |



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| D. Experience | | | | | | | |
|---|---|---|---|---|---|---|---|
| Eligibility and Qualification Criteria | | | Compliance Requirement | | | | Document/Form |
| Sr. No. | Subject | Requirement | Single Entity | Joint Venture (existing or intended) | | | Submission Requirement |
| | | | | All Members Combined | Each Member | One Member | |
| | | b. Waste Management Plan<br>c. Hazardous Waste Management Plan<br>d. Traffic Management Plan<br>• Experience of implementing Site Specific Health and Safety Management Plans<br>• HSE Communication Tools (the measures taken to spread awareness and | | | | | |



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| D. Experience | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Eligibility and Qualification Criteria** | | | **Compliance Requirement** | | | | **Document/Form** |
| **Sr. No.** | **Subject** | **Requirement** | **Single Entity** | **Joint Venture (existing or intended)** | | | **Submission Requirement** |
| | | | | **All Members Combined** | **Each Member** | **One Member** | |
| | | communicate hazards & risks at site such as HSE team meetings, safety posters, incident reporting etc.)<br>• ESHS Control Plan for Sub-Contractors<br>• Emergency Preparedness and Response Plan<br>• Systems for Capturing ESHS Incidents, Accidents and Near Misses<br>• ESHS Audits Plan<br>• Risk Assessment / Mitigation Plan | | | | | |



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| D. Experience | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Eligibility and Qualification Criteria** | | | **Compliance Requirement** | | | | **Document/Form** |
| **Sr. No.** | **Subject** | **Requirement** | **Single Entity** | **Joint Venture (existing or intended)** | | | **Submission Requirement** |
| | | | | **All Members Combined** | **Each Member** | **One Member** | |
| | | • Strategy for Staff and Labor Recruitment of temporary workforce and local labor, worker grievance mechanism<br>• Strategy for communication and interaction with stakeholders and local communities<br>**Certificates:**<br>Availability of a valid ISO Certification as below:<br>a) Quality Management Certificate ISO | | | | | |



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| D. Experience | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Eligibility and Qualification Criteria** | | | **Compliance Requirement** | | | | **Document/Form** |
| **Sr. No.** | **Subject** | **Requirement** | **Single Entity** | **Joint Venture (existing or intended)** | | | **Submission Requirement** |
| | | | | **All Members Combined** | **Each Member** | **One Member** | |
| | | 9001:2015<br>b) Environmental Management Certificate ISO 14001.2015.<br>c) Occupational Health and Safety Management Certificate OHSAS ISO 45001:2018. | | | | | |

***Note:*** *The qualification procedure for Plant Equipment other than those specified in Qualification and Evaluation Criteria under Clause 4.2(b), may be conducted after the Award of the Contract. The Qualification Criteria for such Plant items, as stipulated in the Specific Provisions (Volume-II, Part-I, Clause 1.5), shall be met by the successful Proposer.*



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### 1.3 EPC Contractor's Representative and Key Personnel

The Proposer must demonstrate that it will have a suitably qualified EPC Contractor's Representative and suitably qualified (and in adequate numbers) minimum Key Personnel, as described in the Employer's Requirements.

The Proposer shall provide details of the EPC Contractor's Representative and Key Personnel and such other Key Personnel that the Proposer considers appropriate to perform the Contract, together with their academic qualifications and work experience. The Proposer shall complete the relevant Forms in **Section IV (Proposal Forms).**

The Proposer must demonstrate that it has the Personnel for the key positions that meet the following requirements:

| Sr No. | Title of Position | Total Work Experience (years) | Experience in Similar Work (years) | Educational Experience |
|---|---|---|---|---|
| **1A** | **Key Personnel** | | | |
| 1 | Project Manager | 20 | 15 | Master Degree in Electrical/Mechanical Engineering |
| 2 | Design Team Leader | 20 | 15 | Master Degree in Electrical/Mechanical Engineering |
| 3 | Contracts Manager | 15 | 10 | BSc Engineering Electrical/Mechanical |
| 4 | Quality Control Managers | 15 | 10 | BSc Engineering Electrical/Mechanical |
| 5 | Testing and Commissioning Manager | 20 | 15 | BSc in Electrical/Mechanical Engineering |
| 6 | Health and Safety Manager | 15 | 10 | BSc Engineering with international certification |
| 7 | Welding Experts | 15 | 10 | BSc in Mechanical Engineering with international certification |
| 8 | Environmental and Social Expert | 15 | 10 | BSc Environment |
| 9 | Construction Chief Site Manager | 15 | 10 | BSc in Electrical/Mechanical Engineering |
| 10 | Planning and scheduling Engineer | 15 | 10 | BSc in Electrical/Mechanical Engineering |
| 11 | Control & Instrumentation Engineer | 15 | 10 | BSc in Electrical Engineering |



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| Sr No. | Title of Position | Total Work Experience (years) | Experience in Similar Work (years) | Educational Experience |
|---|---|---|---|---|
| 12 | Electrical Expert | 15 | 10 | Master degree in Electrical Engineering |
| 13 | Mechanical Expert | 15 | 10 | Master degree in Mechanical Engineering |
| **1B** | **Non-Key Personnel** | | | |
| 1 | Mechanical Engineers | 15 | 10 | BSc in Mechanical Engineering |
| 2 | Electrical Engineers | 15 | 10 | BSc in Electrical Engineering |
| 3 | Control & Instrumentation Engineer | 15 | 10 | BSc in Electrical Engineering |
| 4 | Telecommunication Engineer | 15 | 10 | BSc in Electrical/Telecom Engineering |
| 5 | Design Engineer Mechanical | 15 | 10 | BSc Degree in Mechanical Engineering |
| 6 | Design Engineer Electrical | 15 | 10 | BSc Degree in Electrical Engineering |
| 7 | Erection Engineer Mechanical (Turbine and Auxiliaries) | 15 | 10 | BSc in Mechanical Engineering |
| 8 | Erection Engineer Electrical (Generator and Auxiliaries) | 15 | 10 | BSc in Electrical Engineering |
| 9 | Commissioning Engineers Electrical | 15 | 10 | BSc in Electrical Engineering |
| 10 | Commissioning Engineers Mechanical | 15 | 10 | BSc in Mechanical Engineering |
| 11 | Environmental Engineers | 15 | 10 | BSc Environment |
| 12 | Surveyor | 15 | 10 | Technical Diploma |
| 13 | Procurement Manager | 15 | 10 | BSc Engineering |
| 14 | Safety Officer | 15 | 10 | Technical Diploma |
| 15 | Quality Control Inspector | 15 | 10 | Technical Diploma |

### 1.4 Equipment

The Proposer shall provide its strategy for acquiring and maintaining the key equipment that may be needed to execute the Works in accordance with the Work Program. The Proposer must demonstrate that it has the following Key Equipment that meet the requirements.

The Proposer also shall provide details in the relevant Form in **Section IV (Proposal Forms).**



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| Sr No. | Key Equipment |
|---|---|
| 1 | Cranes |
| 2 | Hydraulic Power Units (if required) |
| 3 | Pumps |
| 4 | Generators |
| 5 | Welding Equipment |
| 6 | Surveying Instruments |
| 7 | Safety Equipment |
| 8 | Ventilation System |
| 9 | Ground Support Equipment |
| 10 | Testing equipment and Tools |
| 11 | Stator core erection machine |
| 12 | Erection machines |
| 13 | Drilling Equipment |

### 1.5 Sub-Contractors

Any Specialized Sub-Contractor identified at the time of submission of Proposal shall continue to meet the applicable requirements set forth in **ITP 4**. The Proposer can only propose Specialized Sub-Contractor for parts of works permitted under Form EXP **4.2(a) Specific Construction and Contract Management Experience** and Form EXP **4.2(b) Specific Experience in Key Activities.**

### A. Evaluation of Technical Part (ITP 31)

The technical factors (sub-factors) and the corresponding weight in percentages are:

| Technical Factor | Weightage in Percentage % |
|---|---|
| **Proposed Works** | |
| 1. To what extent the Proposed Works (Proposed Generating Capacity) exceed the Employer's Requirements (Evaluation shall be based on the output at Step up Transformer Terminals) | 5 |
| **Approach and Methodology** | |
| 2. Technical Plant Data (E&M Works)<br>Evaluation shall be based on the following requirements:<br>a) Technical schedules mentioned in the end of Technical Provisions (Vol-II Part-II)<br>b) Sub-Contractor's/Manufacturer's list<br><br>Higher scores shall be awarded to Proposer's proposing equipment from manufacturers with proven experience in successful design, manufacture, testing and commissioning of similar Electro-Mechanical equipment in hydropower projects of comparable capacity and head. | 20<br><br>40%<br><br>30% |



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| Technical Factor | Weightage in Percentage % |
|---|---|
| c) Technical Standards (As per latest International Standards as given in Employer Requirements)<br>d) Type test and under Taking<br>The above- mentioned items shall be checked for each E&M equipment / System | 20%<br><br>10% |
| 3. Design Methodology<br><br>Evaluation shall be based on the following requirements:<br>The Design Proposal shall demonstrate the Proposer's understanding of the Project and present a comprehensive technical solution for the Electro-Mechanical works, including Francis Turbine, Governor, Main Inlet Valve, Synchronous Generator, Power Transformer, 132 kV Switchgear and Hydraulic Gates. The Proposal shall clearly describe the design philosophy, compliance with applicable standards, interface with Civil Works, and long-term operational reliability of the plant.<br><br>a) Overview<br>b) References<br>c) Design criteria and basis<br>d) Technical narrative<br>e) Process flow diagram<br>f) Process design and calculation of components (including structural modelling and Load application)<br>g) Layout arrangement, component plans and spot details in A3<br>h) Proposed design deliverables for Contract execution<br>i) Site Investigation Reports (optional)<br><br>The Works shall be designed to withstand all description in accordance with the Employer's Requirements, and the appropriate codes and standards. | 10 |
| 4. Testing and Commissioning Strategy<br><br>The Contractor shall submit a comprehensive Testing and Commissioning Strategy covering factory tests, site installation verification, pre-commissioning, commissioning, performance and reliability tests for all Electro-Mechanical equipment. | 10 |
| 5. Method Statement for key construction activities for critical equipment<br><br>The Proposer shall submit Method Statements for key installation and erection activities of all major Electro-Mechanical equipment. The Method Statements shall describe the installation sequence, transportation requirements from shipping port to Site, fabrication locations, tools and key equipment (as per listed under clause 1.4), quality control measures, safety precautions, and interface with other works. The methodology shall | 15 |



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| Technical Factor | Weightage in Percentage % |
|---|---|
| also demonstrate the Proposer's experience in similar type hydropower projects and complexity.<br><br>See specific requirements for method statement under Section IV Proposal Forms. | |
| 6. Optimization of Timelines for E&M Equipment<br><br>The Proposer may propose optimization of timelines for Electro-Mechanical works within the overall completion period defined by the Employer. The Proposal shall clearly identify areas of schedule optimization, interface with Civil Works, associated risks and mitigation measures, and resource deployment. The optimized schedule shall be supported by a detailed program and shall not compromise safety, quality, testing requirements, or performance guarantees. | 10 |
| 7. Code of Conduct<br><br>The Proposer shall submit a Project-specific Code of Conduct, based on the template provided in the Bidding Documents, signed by an authorized representative. The submission shall include an implementation and monitoring plan describing how the Code will be communicated, enforced, monitored, and how breaches will be addressed. The Code of Conduct, once accepted, shall be part of the Contract and enforceable. See specific requirements for code of conduct under Section IV Proposal Forms. | 5 |
| 8. EPC/Turnkey Work Program<br><br>The Proposer shall set out a work program for design and construction of the Works as per attached Proposal Forms. See specific requirements for work program under Section IV Proposal Forms. | 5 |
| 9. Key Personnel qualifications, Contract Personnel Organization, experience and resource schedule (The likely key specialists required to execute the contract are listed under Clause 1.3 (1A) | 10 |
| Project Manager | 15% |
| Design Team Leader | 10% |
| Contracts Manager | 10% |
| Quality Control Manager | 10% |
| Testing and Commissioning Manager | 10% |
| Health and Safety Manager | 5% |
| Welding Experts | 5% |



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| Technical Factor | Weightage in Percentage % |
|---|---|
| Environmental and Social Expert | 5% |
| Construction Chief Site Manager | 10% |
| Planning and Scheduling Engineer | 5% |
| Control and Instrumentation Engineer | 5% |
| Mechanical Expert | 5% |
| Electrical Expert | 5% |
| 10. Risk Assessment and proposed management plan<br>The Proposer is required to access the project risks and suggest the proposed remedial measures, for various stages during the execution of the Project. The Proposer should be able to list any risks and constraints involved that could affect the sequence / progress of works. See specific requirements for Risk Assessment under Section IV Proposal Forms. | 5 |
| 11. Environmental, Social, Health and Safety (ESHS)<br>The Proposer's shall provide an ESHS Methodology providing information on how the Proposer's shall meet the requirements and objectives specified in Section IV Proposal Forms.<br>a) ES Approach and methodology as per the requirements mentioned in the design Proposal under technical Proposal forms.<br>b) Sustainable procurement Proposal<br>c) Specific experience in ESHS aspects as per the form EXP 4.2 (c) | 5<br>25%<br>25%<br>50% |

The technical factors evaluated and the scores to be given to sub-factors of above as under:

| Score (of the total score for the factor/sub-factor as applicable | Description | Remarks |
|---|---|---|
| 0 | Required feature is absent; no relevant information to demonstrate how the requirement is met | 0 |
| 1 | Required feature present with deficiencies such as insufficient or information that lacks clarity | 50% |
| 2 | Sufficient information to demonstrate how the requirement will be met | 80% |



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| Score (of the total score for the factor/sub-factor as applicable | Description | Remarks |
|---|---|---|
| 3 | Sufficient information to demonstrate that the requirement will be marginally exceeded | 90% |
| 4 | Sufficient information that significantly exceed the requirement/ Proposal contributes to significant value addition | 100% |

**Technical Proposal Scoring Methodology**

If as per **ITP 31.4**, the technical factors (and sub- factors, if applicable) are weighted in terms of relevance, the total technical score would be the weighted average in percent.

The score for each sub-factor (i) within a factor (j) will be combined with the scores of sub-factors in the same factor as a weighted sum to form the Factor Technical Score using the following formula:

Where:

$t_{ji}$ = the technical score for sub- factor "i" in factor "j"
$w_{ji}$ = the weight of sub- factor "i" in factor "j",
$k$ = the number of scored sub-factors in factor "j"

and $\sum_{i=1}^{k} w_{ji} = 1$

The Factor Technical Scores will be combined in a weighted sum to form the total Technical Proposal Score using the following formula:

$$T \equiv \sum_{j=1}^{n} S_j * W_j$$

where:

$S_j$ = the Factor Technical Score of factor "j"
$W_j$ = the weight of factor "j" as specified **in the PDS**
$n$ = the number of Factors

and $\sum_{j=1}^{n} W_j = 1$

**B. Financial Part**

The Financial part of the Proposal shall be evaluated as per ITP 36, 37 and 38 and also criteria provided hereunder

**1. Margin of Preference**

Not Applicable



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**2. Evaluation of Financial Part (ITP 40.1(f))**

The following factors and methods will apply in accordance wi*th* ***ITP 40.1 (f) of the PDS****:*

**(a) Evaluation Criteria of the Plant and Installation Services**

The evaluation criteria are specified in the following table:

**Table 3-1 Evaluation Criteria of the Plant and Installation Services**

| Plant and Installation Services | Minimum Efficiency Requirement |
|---|---|
| 1. Turbines | 93% |
| 2. Generators | 98% |
| 3. Generator transformers | 99% |

In the event that the Rated Capacity of the Unit proposed by the Proposer exceeds the guaranteed capacity (18.56MW), the Bid/ Proposal price will be reduced by 2000 USD per kW for each unit exceeding the guaranteed capacity and reduction in the contract price shall apply solely for evaluation purpose.

The Proposer will be disqualified if it is unable to meet the minimum efficiency and rated capacity requirements given above and substantiate by providing certificates from previous Employer/Owners confirming that the installed equipment met the required performance levels (efficiency and rated capacity), certificates should mention:

- Actual efficiency achieved during site testing.
- Any deviations from the design efficiency.
- Confirmation that the plant is in successful operation.

**C. Combined Evaluation**

The Employer will evaluate and compare the Proposals that have been determined to be substantially responsive.

An Evaluated Proposal Score (B) will be calculated for each responsive Proposal using the following formula, which permits a comprehensive assessment of the evaluated cost and the technical merits of each Proposal:

$$B = \frac{C_{low}}{C} * X * 100 + \frac{T}{T_{high}} * (1 - X) * 100$$

Where:

| | | |
|---|---|---|
| C | = | Evaluated Proposal Cost |
| $C_{low}$ | = | The lowest of all Evaluated Proposal Cost among responsive Proposals |
| T | = | The total Technical Score awarded to the Proposal |
| $T_{high}$ | = | The Technical Score achieved by the Proposal that was scored best among all responsive Proposals |
| X | = | Weight for Cost as specified **in the PDS** |



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The Proposal with the best evaluated Proposal Score (B) among responsive Proposals shall be the Most Advantageous Proposal provided the Proposer is qualified to perform the Contract.



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## SECTION IV - PROPOSAL FORMS

### Proposal Forms

### Letter of Proposal - Technical Part

**Date of this Proposal submission**:

**RFP No.:** BD/ICB-ALHPP-03

To: **Water and Power Development Authority (WAPDA)**,
Represented by Chief Engineer / PD Attabad Lake Hydropower Project
**Liaison Office:** Sunny View Estate, Kashmir road, Lahore, Pakistan.

**Site Office:** Office of Chief Engineer / PD Attabad Lake HPP, Dour Khan, Aliabad, Hunza.

Dear Sir or Madam:

We, the undersigned Proposer, hereby submit our Proposal, in two parts, namely:

(a) the Technical Part, and

(b) The Financial Part.

Having examined the RFP/EPC Bidding Documents, including any Addenda issued in accordance with **ITP 8,** we, the undersigned, offer to execute the Works on EPC/Turnkey basis to WAPDA, in full conformity with the said RFP/EPC Bidding Documents, and any Addenda.

We undertake, if our Proposal is accepted, to commence the Works and achieve Completion within the respective times stated in the RFP/EPC Bidding Documents.

We hereby certify that we, including any subcontractors or manufacturers for any part of the contract, meet the eligibility requirements and have no conflict of interest in accordance with **ITP 4.**

**Sexual Exploitation and Abuse (SEA) and/or Sexual Harassment (SH):** [*select the appropriate option from (i) to (v) below and delete the others*].

We *[where JV, insert:* "including any of our JV members"*]*, and any of our subcontractors:

(i) [have not been subject to disqualification by the Employer for non-compliance with SEA/SH obligations.]

(ii) [are subject to disqualification by the Employer for non-compliance with SEA/SH obligations.]

(iii) [had been subject to disqualification by the Employer for non-compliance with SEA/SH obligations. An arbitral award on the disqualification case has been made in our favor.]

(iv) [had been subject to disqualification by the Employer for non-compliance with SEA/SH obligations for a period of two years. We have subsequently provided and demonstrated that we have adequate capacity and commitment to comply with SEA and SH prevention and response obligations.]

(v) [had been subject to disqualification by the Employer for non-compliance with SEA/SH obligations for a period of two years. We have attached documents demonstrating that we have adequate capacity and commitment to comply with SEA and SH prevention and response obligations.]



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We, along with any of our subcontractors, suppliers, consultants, manufacturers, or service providers for any part of the contract, are not subject to, and not controlled by any entity or individual that is subject to, a temporary suspension or a debarment imposed by the Employer or a debarment imposed by the Employer in accordance with the Agreement for Mutual Enforcement of Debarment Decisions between the Employer and other development banks. Further, we are not ineligible under the Employer's Country laws or official regulations or pursuant to a decision of the United Nations Security Council;

We hereby certify that we have taken steps to ensure that no person acting for us or on our behalf engages in any type of Fraud and Corruption.

State-owned enterprise or institution: *[select the appropriate option and delete the other] [We are not a state-owned enterprise or institution] / [We are a state-owned enterprise or institution but meet the requirements of **ITP 4.6**]*;

**Potential DAAB Members:** We hereby propose the following three persons, whose curriculum vitae are attached, as potential DAAB members:

| Name | Address |
|---|---|
| 1. …….. | |
| 2. …….. | |
| 3. …… | |

We agree to abide by this Proposal, which, in accordance with **ITP 12** and **ITP 13**, consists of this letter (Letter of Proposal - Technical Part) and enclosures, until [insert day, month and year in accordance with **PDS 20.1**], and it shall remain binding upon us and may be accepted by you at any time on or before this date.

Until the formal final Contract is prepared and executed between us, this Proposal, together with your written acceptance thereof included in your Letter of Acceptance, shall constitute a binding contract between us.

**Name of the Proposer**: **[insert complete name of the Proposer]*

**Name of the person duly authorized to sign the Proposal on behalf of the Proposer**: ** *[insert complete name of person duly authorized to sign the Proposal]*

**Title of the person signing the Proposal**: *[insert complete title of the person signing the Proposal]*

**Signature of the person named above**: *[insert signature of person whose name and capacity are shown above]*

**Date signed** *[insert date of signing]* **day of** *[insert month]*, *[insert year]*

*: In the case of the Proposal submitted by a Joint Venture specify the name of the Joint Venture as Proposer.

**: Person signing the Proposal shall have the power of attorney given by the Proposer. The power of attorney shall be attached with the Proposal Schedules.

ENCLOSURE(S):

## Letter of Proposal - Financial Part

**Date of this Proposal submission**:

**RFP No.:** BD/ICB-ALHPP-03

To: **Water and Power Development Authority (WAPDA)**,
Represented by Chief Engineer / PD Attabad Lake Hydropower Project
**Liaison Office:** Sunny View Estate, Kashmir road, Lahore, Pakistan.

**Site Office:** Office of Chief Engineer / PD Attabad Lake HPP, Dour Khan, Aliabad, Hunza.

Dear Sir or Madam:

We, the undersigned Proposer, hereby submit the second part of our Proposal, the Financial Part.

Having examined the RFP/EPC Bidding Documents, the Addenda issued in accordance with **ITP 8,** we, the undersigned, offer to execute the Works on EPC/Turnkey basis to WAPDA, in full conformity with the said RFP/EPC Bidding Documents, and any Addenda for the Proposal Price, excluding any discounts offered as follows:

Proposal Price: *[insert the* Proposal *price of in words and figures, indicating the various amounts and the respective currencies]*;

The discounts offered and the methodology for their Proposal is:

(i) The discounts offered are: [Specify in detail each discount offered]

(ii) The exact method of calculations to determine the net price after Proposal of discounts is shown below: [Specify in detail the method that shall be used to apply the discounts];

If our Proposal is accepted, we undertake to provide an advance payment security, and a Performance Security *[and an Environmental and Social (ES) Performance Security. **Delete if not applicable]*** in the forms, in the amounts, and within the times specified in the RFP/EPC Bidding Documents.

We agree to abide by this Proposal, which, in accordance with **ITP 12** and **ITP 13**, consists of this letter (Letter of Proposal - Financial Part) and the enclosures listed below, until [insert day, month and year in accordance with **PDS 20.1**], and it shall remain binding upon us and may be accepted by you at any time on or before this date.

**Commissions, gratuities and fees:** We have paid, or will pay the following commissions, gratuities, or fees with respect to the RFP process or execution of the Contract: *[insert complete name of each Recipient, its full address, the reason for which each commission or gratuity was paid and the amount and currency of each such commission or gratuity]*.

| Name of Recipient | Address | Reason | Amount |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

(If none has been paid or is to be paid, indicate “none.”)



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Until the formal final Contract is prepared and executed between us, this Proposal, together with your written acceptance thereof included in your Letter of Acceptance, shall constitute a binding contract between us.

**Name of the Proposer**:*\[insert complete name of the Proposer\]*

**Name of the person duly authorized to sign the Proposal on behalf of the Proposer**: ** *\[insert complete name of person duly authorized to sign the Proposal\]*

**Title of the person signing the Proposal**: *\[insert complete title of the person signing the Proposal\]*

**Signature of the person named above**: *\[insert signature of person whose name and capacity are shown above\]*

**Date signed** *\[insert date of signing\]* **day of** *\[insert month\]*, *\[insert year\]*

*: In the case of the Proposal submitted by a Joint Venture specify the name of the Joint Venture as Proposer.

**: Person signing the Proposal shall have the power of attorney given by the Proposer. The power of attorney shall be attached with the Proposal Schedules.

ENCLOSURE(S):



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## Appendix to Proposal

## Schedule of Cost Indexation

If in accordance with GC 13.7, prices shall be adjustable, the following method shall be used to calculate the price adjustment:

Prices payable to the EPC Contractor, in accordance with the Contract, shall be subject to adjustment during performance of the Contract to reflect changes in the cost of labor and material components, in accordance with the following formula:

**Pn= a + b Ln / Lo + c En/ Eo + d Mn/Mo + .....**

*Where:*

"Pn" is the adjustment multiplier to be applied to the estimated contract value in the relevant currency of the work carried out in period "n", this period being a month unless otherwise stated in the Contract Data;

"a" is a fixed coefficient, stated in the relevant table of adjustment data, representing the non-adjustable portion in contractual payments;

"b", "c", "d", ... are coefficients representing the estimated proportion of each cost element related to the execution of the Works as stated in the relevant table of adjustment data; such tabulated cost elements may be indicative of resources such as labor, equipment and materials;

"Ln", "En", "Mn", ... are the current cost indices or reference prices for period "n", expressed in the relevant currency of payment, each of which is applicable to the relevant tabulated cost element on the date 49 days prior to the last day of the period (to which the particular Payment Certificate relates); and

"Lo", "Eo", "Mo", ... are the base cost indices or reference prices, expressed in the relevant currency of payment, each of which is applicable to the relevant tabulated cost element on the Base Date.

The cost indices or reference prices stated in the Table of Adjustment Data shall be used. If their source is in doubt, it shall be determined by the Engineer. For this purpose, reference shall be made to the values of the indices at stated dates (quoted in the fourth and fifth columns respectively of the table).

If the currency in which the Contract price is expressed is different from the currency of the country of origin of the labour and/or materials indices, a correction factor will be applied to avoid incorrect adjustments of the Contract price. The correction factor shall be: $Z_0 / Z_1$, where,

$Z_0$ = the number of units of currency of the origin of the indices which equal to one unit of the currency of the Contract Price on the Base date, and

$Z_1$ = the number of units of currency of the origin of the indices which equal to one unit of the currency of the Contract Price on the Date of Adjustment.

## Table of Adjustment Data

### Table A : Local Currency

*[In Tables A, B, and C, below, the Proposer shall (a) indicate its amount of local currency payment, (b) indicate its proposed source and base values of indices for the different foreign currency elements of cost, (c) derive its proposed weightings for local and foreign currency payment, and (d) list the exchange rates used in the currency conversion. In the case of very large and/or complex works contracts, it may be necessary to specify several families of price adjustment formulae corresponding to the different works involved.]*

| Index code | Index description | Source of index | Base value and date* | Proposer's related currency amount | Proposer's proposed weighting |
|---|---|---|---|---|---|
| **a** | **Nonadjustable (25%)** | — | — | — | a: 0.25 |
| **b** | **Labour** | | | | b: 0.15 to 0.25* |
| **c** | **HI-Speed Diesel** | | | | c: 0.10-0.15 |
| **d** | **Material** | | | | **d**: 0.42-0.5 |
| d-1 | *Material (1)* | | | | d-1: _____ * |
| d-2 | *Material (2)* | | | | d-2: _____ * |
| | ..... | | | | |
| **e** | **Machinery and Equipment** | | | | **e**: 0.08-0.10 |
| | | | **Total** | | **1.00** |

** To be specified by the Proposers. Whereas "a" is a fixed percentage, while the Proposer should specify range within maximum percentage allowed for material and labour for b, c, d, e, f, g & h such that the total weighting = 1.00. Source of index for local curreny is 'Pakistan Bearaue of Statistics'.*



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## Table of Adjustment Data

Table B : Foreign Currency

| Index code | Index description | Source of index* | Base value and date* | Proposer's related source currency in type/amount | Equivalent in FC1 | Proposer's proposed weighting |
|---|---|---|---|---|---|---|
| a | **Nonadjustable (50%)** | — | — | — | | a : 0.5* |
| | **Labor:** | | | | | |
| b | Expatriates | | | | | b: 0.03-0.05* |
| c | Local | | | | | c: 0.12-0.15* |
| d | **Material :** | | | | | d: 0.25-0.3 |
| d-1 | *Material (1)* | | | | | d-1: _____ * |
| d-2 | *Material (2)* | | | | | d-2: _____ * |
| e | **Machinery & Equipment** | | | | | e: 0.05-0.07* |
| | | | | **Total** | | **1.00** |

* To be specified by the Proposers. Whereas "a" is a fixed percentage, while the Proposer should specify range within maximum percentage allowed for material and labour for b, c, d, e, f, g & h such that the total weighting = 1.00.



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## Table C: Summary of Payment Currencies

**Table: Alternative A**

Foreign currency requirement shall be in the portion of Proposal Price (excluding Provisional Sum) for such that Foreign Currency requirement shall not be more than 80%.

For ..... *[insert name of Section of the Works]*

| Name of payment currency | A<br>Amount of currency | B<br>Rate of exchange (local currency per unit of foreign) | C<br>Local currency equivalent<br>C = A x B | D<br>Percentage of Proposal Price (PP)<br>$\frac{100xC}{PP}$ |
|---|---|---|---|---|
| Local currency | | 1.00 | | 20% or greater |
| Foreign currency | | * | | 80% or less |
| Proposal Price (excluding provisional sums) | | | | 100.00 |

**Note:**

*The Conversion for Proposal evaluation shall be made on TT&OD composite selling exchange rate published / authorized by State Bank of Pakistan (SBP) for the day of deadline for submission of Proposals.



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## Schedule of Payment for E&M Works

**Price Schedule No. 01: Supply of Plant from Abroad (Pre-Engineered Structures) including Fixtures and other Materials, Goods and Spare Parts (if any) (Schedule of Price basis)**

*[**Note:** To be completed / updated by the Proposer.]*

| Activity No. | Description of Activity | Unit Price (US$) | Qty | Total CIP (US$) Excluding Sales Tax | Custom Duty (PKR) |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5=3x4 | 6 |
| .1 | Vertical Francis Turbines | | | | |
| 2 | Governors | | | | |
| 3 | Main Inlet Valves | | | | |
| 4 | Powerhouse Overhead Cranes | | | | |
| 5 | Gantry and Mobiles Cranes | | | | |
| 6 | Mechanical Auxiliaries | | | | |
| 7 | Mechanical Workshop Equipment | | | | |
| 8 | Generators & Auxiliaries | | | | |
| 9 | Excitation System | | | | |
| 10 | Generator Step up Transformers | | | | |
| 11 | Power Transformer | | | | |
| 12 | Auxiliary Transformers | | | | |
| 13 | Segregated Phase Bus | | | | |
| 14 | Power and Control Cables | | | | |
| 15 | Medium Voltage Switchgear | | | | |
| 16 | Low Voltage Switchgear | | | | |
| 17 | 132 kV Switchyard / Equipment | | | | |
| 18 | SCADA System | | | | |
| 19 | DC and UPS system | | | | |
| 20 | Emergency Diesel Generators | | | | |
| 21 | Plant Control and Instrumentation System | | | | |
| 22 | Telecommunication System | | | | |
| 23 | Protection System | | | | |
| 24 | Grounding System | | | | |
| 25 | Mandatory Spare Parts | | | | |
| **Total Price of Activities carried forward to Schedule No. 5 Summary (excluding Custom Duty), Page ____** | | | | | |
| | **Total Custom duties** | | | | |



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Name of Proposer _____

Signature of Proposer _____

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## Schedule of Payment for E&M Works

**Price Schedule No. 02: Supply of Plant from within the Employer's Country (Pre-Engineered Structures) including Fixtures and other Materials, Goods and Spare Parts (if any) (Schedule of Price basis)**

*[**Note:** To be completed / updated by the Proposer.]*

| Activity No. | Description of Activity | Unit Price (PKR) | Qty | Total PKR |
|---|---|---|---|---|
| **1** | **2** | **3** | **4** | **5=3x4** |
| 1 | Vertical Francis Turbines | | | |
| 2 | Governors | | | |
| 3 | Main Inlet Valves | | | |
| 4 | Powerhouse Overhead Cranes | | | |
| 5 | Gantry and Mobiles Cranes | | | |
| 6 | Mechanical Auxiliaries | | | |
| 7 | Mechanical Workshop Equipment | | | |
| 8 | Generators & Auxiliaries | | | |
| 9 | Excitation System | | | |
| 10 | Generator Step up Transformers | | | |
| 11 | Power Transformer | | | |
| 12 | Auxiliary Transformers | | | |
| 13 | Segregated Phase Bus | | | |
| 14 | Power and Control Cables | | | |
| 15 | Medium Voltage Switchgear | | | |
| 16 | Low Voltage Switchgear | | | |
| 17 | 132 kV Switchyard/Equipment | | | |
| 18 | SCADA System | | | |
| 19 | DC and UPS system | | | |
| 20 | Emergency Diesel Generators | | | |
| 21 | Plant Control and Instrumentation System | | | |
| 22 | Telecommunication System | | | |
| 23 | Protection System | | | |
| 24 | Grounding System | | | |
| 25 | Mandatory Spare Parts | | | |
| **Total Price of Activities carried forward to Schedule No. 5 Summary, Page ____** | | | | |



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**Note 1:** The scope mentioned above shall be read in conjunction with the applicable Employer's Requirements, missing items can be added in the schedules 1 & 2 as per employer's requirements.

**Note 2:** Weightages in %age to Contract Price excluding Provisional Sums for all Activities put together shall be 100%.

**Note 3:** The Proposer shall quote/ include the price of FAT (Factory Acceptance Tests) in the above Price Schedules 1 & 2.

Name of Proposer _____

Signature of Proposer _____

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## Price Schedule No. 03: Design Services

*[**Note:** To be completed / updated by the Proposer.]*

| Activity No. | Description of Activity | Unit Price (PKR) | Qty | Total PKR |
|---|---|---|---|---|
| **1** | **2** | **3** | **4** | **5=3x4** |
| 3 | Design Services | | | |
| 3.1 | Design of E&M Works | | | |
| 3.2 | Design & Erection sequence Drawings for E&M Works | | | |
| 3.3 | As Built Drawings | | | |
| **Total Price of Activities carried forward to Schedule No. 5 Summary, Page ____** | | | | |

Name of Proposer _____

Signature of Proposer _____



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## Price Schedule No. 04: Installation and All other Services

*[**Note:** To be completed / updated by the Proposer.]*

| Activity No. | Description of Activity | Unit Price (PKR) | Qty | Total PKR |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5=3x4 |
| 1 | Vertical Francis Turbines | | | |
| 2 | Governors | | | |
| 3 | Main Inlet Valves | | | |
| 4 | Powerhouse Overhead Cranes | | | |
| 5 | Gantry and Mobiles Cranes | | | |
| 6 | Mechanical Auxiliaries | | | |
| 7 | Mechanical Workshop Equipment | | | |
| 8 | Generators & Auxiliaries | | | |
| 9 | Excitation System | | | |
| 10 | Generator Step up Transformers | | | |
| 11 | Power Transformer | | | |
| 12 | Auxiliary Transformers | | | |
| 13 | Segregated Phase Bus | | | |
| 14 | Power and Control Cables | | | |
| 15 | Medium Voltage Switchgear | | | |
| 16 | Low Voltage Switchgear | | | |
| 17 | 132 kV Switchyard/Equipment | | | |
| 18 | SCADA System | | | |
| 19 | DC and UPS system | | | |
| 20 | Emergency Diesel Generators | | | |
| 21 | Plant Control and Instrumentation System | | | |
| 22 | Telecommunication System | | | |
| 23 | Protection System | | | |
| 24 | Grounding System | | | |
| 25 | Testing and Commissioning | | | |
| 26 | Employer Trainings | | | |



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| Activity No. | Description of Activity | Unit Price (PKR) | Qty | Total PKR |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5=3x4 |
| 27 | Operation and Maintenance for DNP | | | |
| **Total Price of Activities carried forward to Schedule No. 5 Summary, Page ____** | | | | |

Name of Proposer _____

Signature of Proposer _____

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## Schedule of Payment for E&M Works

**Schedule No. 05: –Summary**

| Activity No. / Schedule No. | Title | Total Local (PKR) | Total Foreign (US$) |
|---|---|---|---|
| 1 | Plant and Mandatory Spare Parts Supplied from Abroad | | |
| 2 | Plant and Mandatory Spare Parts Supplied within Pakistan | | |
| 3 | Design Services | | |
| 4 | Installation and All other Services | | |
| **Sub-Total (carried forward to Grand Summary Page No. _____)** | | | |

Name of Proposer _____

Signature of Proposer _____



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## Schedule of Payment for E&M Works

**Schedule No. 06: – Recommended Spare Parts**

| Description | Description | Qty | Unit Price | Total Price |
|---|---|---|---|---|
| | | | PKR Million | PKR Million |
| 1 | 2 | 3 | 4 | 5 = 3 x 4 |
| | | | | |

**Note:** The Proposer shall quote/ include the price of recommended spare parts in the Price Schedules 1 & 2.

Name of Proposer _____

Signature of Proposer _____



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## Priced Sub-Activity Schedule for E&M Works
## (Breakdown of Prices)

*[**Note:** To be completed / updated by the Proposer (more tables to be used as appropriate.)]*

Activity: _____

| Sub-Activity No. | Description of Sub-Activity | Sub-Activity Price |
|---|---|---|
| 1. | …….. | |
| | | |
| 2. | …… | |
| | | |
| 3. | …… | |
| | | |
| 4. | | |
| | | |
| 5. | | |
| | | |
| 6. | | |
| | | |
| 7. | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| **Total Price of Sub-Activities carried forward to the Priced Activity Schedule, Page No. ____** | | |



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## Schedule of Payments for E&M Works

### Currency Wise Break-Up of Priced Sub-Activity Schedule

*[**Note:** To be completed / updated by the Proposer (more tables to be used as appropriate.)]*

| Sub-Activity | Weightage of Sub-Activity/Activity Cost A=B+C | Breakup % of Column (2) for Various Currencies for Payment | |
|---|---|---|---|
| | | Foreign Currency (%) B | Local Currency (%) C |
| (1) | (2) | (3) | (4) |
| ***Note:** The total of percentages given in column (3) and column (4), in the table should be 100%. In case the total is not 100%, the figures in column (3) and (4) shall be adjusted pro rad. Any arithmetical error in the break-up percentage of the Sub-Activity Cost shall be corrected before signing of the Agreement.* | | | |
| **Break down of Prices - Activity 1** | | | |
| 1.1 | 100% | | |
| 1.2 | 100% | | |
| 1.3 | 100% | | |
| 1.4 | 100% | | |
| 1.5 | 100% | | |
| **Break down of Prices - Activity 2** | | | |
| 2.1 | 100% | | |
| 2.2 | 100% | | |
| 2.3 | 100% | | |
| 2.4 | | | |



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## Schedule of Payments for E&M Works

### Apportionment of Contract Price According to Activity

| Sub-activity | Description | Weightage (%) |
|---|---|---|
| (1) | (2) | (3) |
| **Activity 1: Weightage in %age to Contract Price excluding Provisional Sums - ____ %age** | | |
| 1.1 | | |
| 1.2 | | |
| 1.3 | | |
| 1.4 | | |
| 1.5 | | |
| | **Total for Activity No. 01** | **100%** |
| **Activity 2: Weightage in %age to Contract Price excluding Provisional Sums - ____ %age** | | |
| 2.1 | | |
| 2.2 | | |
| 2.3 | | |
| | **Total for Activity No. 02** | **100%** |
| | | |
| | | |
| **Total weightage for all Activities [Activity No. 01 ( ___ %age), Activity No. 02 (____ %age), Activity No. 03 (…%age), Activity No. 04 (…%age) …… Activity N (…%age)]** | | **100%** |



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## Daywork Schedule

Reference is made to Sub-Clause 13.5 of the General Conditions. Work shall not be executed on a daywork basis except by written order of the Employer. Proposers shall enter basic rates for daywork items in the Schedules, which rates shall apply to any quantity of daywork ordered by the Employer. Nominal quantities have been indicated against each item of daywork, and the extended total for daywork shall be carried forward as a Provisional Sum to the Summary Proposal Price. Unless otherwise adjusted, payments for daywork shall be subject to price adjustment in accordance with the provisions in the Conditions of Contract.

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## Schedule of Daywork Rates: 1. Labour

| Item no. | Description | Unit | Nominal Quantity | Rate (PKR) | Extended Amount |
|---|---|---|---|---|---|
| DW.101 | General Laborer (Male) | Man day | 200 | | |
| DW.102 | Pneumatic Driller | Man day | 50 | | |
| DW.103 | Riggers | Man day | 25 | | |
| DW.104 | Pump Operator / Attendant | Man day | 100 | | |
| DW.105 | Chainman | Man day | 100 | | |
| DW.106 | Ganger (Or Charge Hand) | Man day | 100 | | |
| DW.107 | Compressor / Wireman | Man day | 100 | | |
| DW.108 | Electrician / Wireman | Man day | 100 | | |
| DW.109 | Welder | Man day | 50 | | |
| DW.110 | Welder's Assistant | Man day | 100 | | |
| DW.111 | Plumber | Man day | 50 | | |
| DW.112 | Drain layer (Or Jointer) | Man day | 50 | | |
| DW.113 | Pipe layer (Or Jointer) | Man day | 50 | | |
| DW.114 | Carpenter | Man day | 50 | | |
| DW.115 | Painter | Man day | 50 | | |
| DW.116 | Fitter/Mechanic | Man day | 50 | | |
| DW.117 | Fitter's/Mechanic's Assistant | Man day | 100 | | |
| DW.118 | "Frog" Type Mechanical Rammer Operator | Man day | 50 | | |
| DW.119 | Truck/Lorry Driver | Man day | 50 | | |
| DW.120 | Lorry Attendant | Man day | 50 | | |
| DW.121 | Crane Driver (Of All Classes) | Man day | 25 | | |
| DW.122 | Crane Driver's Assistant /Signaler | Man day | 25 | | |
| DW.123 | Heavy Plant Driver (Of All Classes) | Man day | 25 | | |
| DW.124 | Plant Operator | Man day | 25 | | |
| | | | | **SUBTOTAL** | |
| | | | | **Total for Daywork: Labour (carried forward to Daywork Summary, p. _____)** | |

[a] To be entered by the Proposer.



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## Schedule of Day work Rates: 2. Materials

| Item no. | Description | Unit | Nominal Quantity | Rate (PKR) | Extended Amount |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | **SUBTOTAL** | |
| | | | | **Total for Daywork: Materials (carried forward to Daywork Summary, p. ____)** | |

[a] To be entered by the Proposer.



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## Schedule of Daywork Rates: 3. EPC Contractor's Equipment

| Item No. | Description | Nominal Quantity (Hours) | Basic Hourly Rental Rate | Extended Amount |
|---|---|---|---|---|
| | **Compressor, Portable, with Breakers, Spades, Air Lines, Lubricators, Tools** | | | |
| | | | | |
| | | | | |
| | | | | |
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| | | | | |
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| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | **SUBTOTAL** | |
| | | | **Total for Daywork: EPC Contractor's Equipment (carried forward to Daywork Summary, p. ____ )** | |

[a] To be entered by the Proposer.



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## Daywork Summary

| Description | Amount (PKR) | % Foreign |
|---|---|---|
| 1. Total for Daywork: Labour | | |
| 2. Total for Daywork: Materials | | |
| 3. Total for Daywork: EPC Contractor's Equipment | | |
| **Total for Daywork (Provisional Sum) (carried forward to Proposal Summary(B), p. ___)** | | |

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## Specified Provisional Sums

| Item No. | Description | Amount (Million PKR) |
|---|---|---|
| 1. | Protection of the Environment GC Sub-Clause 4.18 | 20.00 |
| 2. | Health and Safety GC Sub-Clause 4.8 | |
| 3. | Security Arrangements GC Sub Clause 4.21 | 10.00 |
| 4. | Provisional Sums for the Employer's portion of DAAB costs | 15.00 |
| 5. | Adjustment for Change in Legislation, Royalties and Custom Duties GC Sub-Clause 13.6 | 20.00 |
| | **Total for Specified Provisional Sums (Carried forward to Grand Summary (C), p. _____ )** | **65.00** |



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## Grand Summary

| General Summary | Page No. | Amount (Million PKR) |
|---|---|---|
| Lump sum price excluding provisional sums offered by the Proposer | **(A)** | |
| Total for Daywork (Provisional Sum)* | **(B)** | |
| Specified Provisional Sums | **(C)** | 213 |
| **Sub Total (A + B + C)** [i] | **(D)** | |
| Provisional Sum for Contingency Allowance | **(E)** | 142 |
| **Proposal Price (D + E)** **(Carried forward to Letter of Proposal)** | **(F)** | |

[i] All Provisional Sums are to be expended in whole or in part at the direction and discretion of the Employer in accordance with Sub-Clause 13.4 and Sub-Clause 13.5 of the General Conditions, except with respect to DAAB Fees and Expenses for which Sub-Clause 13.4 of the Particular Conditions Part B shall apply.

* For evaluation purposes, Provisional Sum, other than Daywork will be excluded.

+



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## Technical Proposal Forms

1. Design Proposal
2. Method Statement for Key Construction Activities
3. Mobilization Schedule
4. Sustainable Procurement Proposal
5. Code of Conduct
6. Work Program
7. Proposer's Personnel Organization Chart
8. Risk Assessment and Proposed Management Plan
9. Operation and Maintenance *[if applicable]*
10. Proposer's Equipment
11. Sub-Contractors
12. Others

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## Design Proposal

The Proposer shall submit a design Proposal which addresses as a minimum the following:

(a) organizational arrangements for the design including: team structure, roles and responsibilities, interface arrangements, design review and approval procedures and quality assurance arrangements;

(b) Proposed design deliverables are:

| Description | No. of Copies for Review | No. of Copies for Final Issue | Digital Copy |
|---|---|---|---|
| List of Design Documents for Review, Approval & Information | 4 | 6 | 2 |
| Design Criteria & Basic Design (Level-1 Design) | 4 | 6 | 2 |
| Detailed Design Criteria & Detailed Design (Level-2 Design) | 4 | 6 | 2 |
| Detailed Design (Level-2) | 4 | 6 | 2 |
| Detailed Design Specifications | 4 | 6 | 2 |
| Construction drawings | 4 | 6 | 2 |
| Manufacturer's shop drawings | 4 | 6 | 2 |
| As-Built Drawings | 4 | 6 | 2 |
| Inspection and Test Plans | 4 | 6 | 2 |
| O&M Manuals | 10 | 10 | 2 |
| Erection & Testing Manuals | 4 | 6 | 2 |

(c) design statement setting out how the Employer's Requirements will be achieved;

(d) Any added value the Proposer will bring including examples of innovative aspects of the design;

(e) comments on the Employer's Requirements, including:

i. status of the information available and relevant design issues for the Works;
ii. comments on any errors, defects or ambiguities noted in the Employer's Requirements; and
iii. *[details of any exceptions in the conceptual design taken to the Employer's Requirements]*;

(f) Sustainable Procurement: sustainability aspects (e.g., energy efficiency, reduction of wastages, material reduction, sources of materials.) demonstrating the Proposer's approach and commitment to sustainable design and construction practices;

(g) strategy for gathering baseline ES information in time to inform design development;

(h) details of how the ES requirements, and any Proposal to enhance ES outcomes, will be incorporated into all design stages, and how the implications for the construction phase has been considered;



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(i) details of the approach to managing risks, stakeholder engagement, consultation and environmental permits/consents;

(j) value engineering (value management) arrangements, including consideration of ES issues; and

(k) Software systems intended to be employed for planning, design, records and reporting.

(l) *[Modify/include any other relevant information, as appropriate.]*

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## Method Statement for Key Construction Activities

The Proposer shall provide its method statements for addressing the following risks and carrying out the following construction activities. Each method statement shall describe the proposed approach, the level of staffing and experience, the safe system of work, and the equipment or materials to be used to manage risk or activity in accordance with the Employer's Requirements.

### Key Activities

- Mobilization
- Basic Design
- Detailed Design
- Vertical Francis Turbine
- Synchronous Generator
- Generator Transformer
- Excitation System
- Mechanical Auxiliaries
- Power Transformer
- Draft Tube Gates
- Main Inlet Valves
- Cranes
- Hydraulic Steel Structures
- LV/HV Switchgear
- Auxiliary Transformers
- Control and Instrumentation
- SCADA and Telecom Systems
- Grounding System
- 132kV Switchgear
- DC and UPS System
- Segregated Phase Bus (SPB)

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## Sustainable Procurement Proposal

*[**Note to Proposer**: In addition to submitting the required ES Management Strategies and Implementation Plans, the Proposer shall provide its* Proposal *to demonstrate how additional sustainable procurement requirements, if any, specified in **Volume-II (Employer's Requirements)** would be addressed. The Proposer shall also provide its* Proposal*, if any, for exceeding the sustainable procurement requirements.]*

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## Code of Conduct for Proposer's Personnel (ES) Form

***[Note to the Proposer**: **The minimum content of the Code of Conduct form as set out by the Employer shall not be substantially modified**. However, the Proposer may add requirements as appropriate, including to take to account Contract-specific issues/risks. The Proposer shall initial and submit the Code of Conduct form as part of its Proposal .]*

### Code of Conduct for Proposer's Personnel

We are the Proposer, [*enter name of EPC Contractor*]. We have signed a contract with Water and Power Development Authority (WAPDA) for [*enter description of the Works*]. These Works will be carried out at [*enter the Site and other locations where the Works will be carried out*]. Our contract requires us to implement measures to address environmental and social risks related to the Works, including the risks of sexual exploitation, sexual abuse and sexual harassment.

This Code of Conduct is part of our measures to deal with environmental and social risks related to the Works. It applies to all our staff, laborers and other employees at the Works Site or other places where the Works are being carried out. It also applies to the personnel of each subcontractor and any other personnel assisting us in the execution of the Works. All such persons are referred to as "**EPC Contractor's Personnel"** and are subject to this Code of Conduct.

This Code of Conduct identifies the behavior that we require from all EPC Contractor's Personnel.

Our workplace is an environment where unsafe, offensive, abusive or violent behavior will not be tolerated and where all persons should feel comfortable raising issues or concerns without fear of retaliation.

### Required Conduct

EPC Contractor's Personnel shall:

1. carry out his/her duties competently and diligently;
2. comply with this Code of Conduct and all applicable laws, regulations and other requirements, including requirements to protect the health, safety and well-being of other EPC Contractor's Personnel and any other person;
3. maintain a safe working environment including by:
    a. ensuring that workplaces, machinery, equipment and processes under each person's control are safe and without risk to health;
    b. wearing required personal protective equipment;
    c. using appropriate measures relating to chemical, physical and biological substances and agents; and
    d. following applicable emergency operating procedures.
4. report work situations that he/she believes are not safe or healthy and remove himself/herself from a work situation which he/she reasonably believes presents an imminent and serious danger to his/her life or health;
5. treat other people with respect, and not discriminate against specific groups such as women, people with disabilities, migrant workers or children;

6. not engage in any form of Sexual Harassment, which means unwelcome sexual advances, requests for sexual favors, and other verbal or physical conduct of a sexual nature with other EPC Contractor's or Employer's Personnel;

7. not engage in Sexual Exploitation, which means any actual or attempted abuse of position of vulnerability, differential power or trust, for sexual purposes, including, but not limited to, profiting monetarily, socially or politically from the sexual exploitation of another;

8. not engage in Sexual Abuse, which means the actual or threatened physical intrusion of a sexual nature, whether by force or under unequal or coercive conditions;
9. not engage in any form of sexual activity with individuals under the age of 18, except in case of pre-existing marriage;

10. complete relevant training courses that will be provided related to the environmental and social aspects of the Contract, including on health and safety matters, Sexual Exploitation and Abuse (SEA), and Sexual Harassment (SH);

11. report violations of this Code of Conduct; and

12. not retaliate against any person who reports violations of this Code of Conduct, whether to us or the Employer, or who makes use of the grievance mechanism for EPC Contractor's Personnel or the project's Grievance Redress Mechanism.

**Raising Concerns**

If any person observes behavior that he/she believes may represent a violation of this Code of Conduct, or that otherwise concerns him/her, he/she should raise the issue promptly. This can be done in either of the following ways:

1. Contact [*enter name of the EPC Contractor's Social Expert with relevant experience in handling sexual exploitation, sexual abuse and sexual harassment cases, or if such person is not required under the Contract, another individual designated by the EPC Contractor to handle these matters*] in writing at this address [ _____ ] or by telephone at [ _____ ] or in person at [ _____ ]; or

2. Call [_____] to reach the EPC Contractor's hotline *(if any)* and leave a message.

The person's identity will be kept confidential, unless reporting of allegations is mandated by the country law. Anonymous complaints or allegations may also be submitted and will be given all due and appropriate consideration. We take seriously all reports of possible misconduct and will investigate and take appropriate action. We will provide warm referrals to service providers that may help support the person who experienced the alleged incident, as appropriate.

There will be no retaliation against any person who raises a concern in good faith about any behavior prohibited by this Code of Conduct. Such retaliation would be a violation of this Code of Conduct.

**Consequences of Violating the Code of Conduct**

Any violation of this Code of Conduct by EPC Contractor's Personnel may result in serious consequences, up to and including termination and possible referral to legal authorities.

FOR EPC CONTRACTOR'S PERSONNEL:

I have received a copy of this Code of Conduct written in a language that I comprehend. I understand that if I have any questions about this Code of Conduct, I can contact [*enter name of EPC Contractor's contact person(s) with relevant experience*] requesting an explanation.

Name of EPC Contractor's Personnel: [insert name]

Signature: _____

Date: (day month year): _____

Countersignature of authorized representative of the EPC Contractor:

Signature: _____

Date: (day month year): _____

**Attachment 1:** Behaviors constituting Sexual Exploitation and Abuse (SEA) and behaviors constituting Sexual Harassment (SH)

**Attachment No. 01 to the Code of Conduct Form**

**Behaviors Constituting Sexual Exploitation and Abuse (SEA) and Behaviors Constituting Sexual Harassment (SH)**

The following non-exhaustive list is intended to illustrate types of prohibited behaviors.

**(1) Examples of sexual exploitation and abuse include, but are not limited to**:

- An EPC Contractor's Personnel tells a member of the community that he/she can get them jobs related to the work site (e.g., cooking and cleaning) in exchange for sex.
- An EPC Contractor's Personnel that is connecting electricity input to households says that he can connect women headed households to the grid in exchange for sex.
- An EPC Contractor's Personnel rapes, or otherwise sexually assaults a member of the community.
- An EPC Contractor's Personnel denies a person access to the Site unless he/she performs a sexual favor.
- An EPC Contractor's Personnel tells a person applying for employment under the Contract that he/she will only hire him/her if he/she has sex with him/her.

**(2) Examples of sexual harassment in a work context**

- EPC Contractor's Personnel comment on the appearance of another EPC Contractor's Personnel (either positive or negative) and sexual desirability.
- When a EPC Contractor's Personnel complains about comments made by another EPC Contractor's Personnel on his/her appearance, the other EPC Contractor's Personnel comment that he/she is "asking for it" because of how he/she dresses.
- Unwelcome touching of an EPC Contractor's or Employer's Personnel by another EPC Contractor's Personnel.
- An EPC Contractor's Personnel tells another EPC Contractor's Personnel that he/she will get him/her a salary raise, or promotion if he/she sends him/her naked photographs of himself/herself.



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## Work Program

The Proposer shall set out a work program for design and construction of the Works (and for operation and/or maintenance of the Works, if applicable), including identification of major milestones and critical path. The proposed work program shall be developed based on the Employer's Requirements and shall include the:

(a) design of the Works, including the submission of the design deliverables, review and approval of the design by the Employer;

(b) processes and deliverables needed to commence the Works;

(c) execution of the Works and/or Erection within the Time for Completion, highlighting activities imposing constraints on the construction sequence;

(d) testing, commissioning and handing over of the completed Works;

(e) No-objection to the EPC Contractor's MSIPs, which collectively form the CESMP, in accordance with the Particular Conditions- Part B- Sub-Clause 4.1;

(f) Constitution of the DAAB;

(g) SEA and SH orientation conference;

(h) Outline work program for operation and/or maintenance of the Works, if applicable; and

(i) *[Modify as appropriate.]*

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## Proposer's Personnel Organization Chart

The Proposer shall provide an organization chart illustrating the proposed management structure and reporting lines for delivery of the Contract. The organization chart shall include the names of all Key Personnel. A separate site organization chart shall clarify the site organization, reporting lines at site, and shall include names of key personnel at site.

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## Risk Assessment and Proposed Management Plan

The Proposer should submit a risk register identifying the hazards anticipated during the implementation of the contract.

For the key hazards ranked by impact, the risk register shall include a description of the hazard, an assessment of the potential impact on health and safety, environment, cost, program or other, and the proposed mitigation strategy for each hazard.

*[**Note to the Proposer**: (i) If the contract has been assessed to present potential or actual cyber security risks, also include method statement, management strategies and implementation plans and innovations, to manage cyber security risks; (ii) if there are assessed supply chain risks, the risk assessment and proposed management plans, must include proposed supply chain risks management plan.]*

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## Proposer's Equipment

## Form EQU

The Proposer shall provide its strategy for acquiring and maintaining the key equipment that may be needed to execute the Works in accordance with the Work Program. In the strategy, the Proposer shall specify the manufacturer, capacity, model, power rating, age and maintenance condition, and how it will ensure that the equipment is maintained in accordance with manufacturer's specifications for the duration of the Contract. The Proposer shall specify whether it will own, lease, rent or specially manufacture the key equipment.

A separate Form shall be prepared for each item of equipment proposed.

| Item of equipment | | |
|---|---|---|
| Equipment information | Name of manufacturer | Model and power rating |
| | Capacity | Year of manufacture |
| Current status | Current location | |
| | Details of current commitments | |
| Source | Indicate source of the equipment<br>☐ Owned ☐ Rented ☐ Leased ☐ Specially manufactured | |

Omit the following information for equipment owned by the Proposer.

| Owner | Name of owner | |
|---|---|---|
| | Address of owner | |
| | Telephone | Contact name and title |
| | Fax | Telex |
| Agreements | Details of rental / lease / manufacture agreements specific to the Project | |



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## Personnel

### Form PER-1
### Key Personnel Qualifications and Resource Schedule

Proposers should provide the names and details of the suitably qualified EPC Contractor's Representative and Key Personnel to perform the Contract. The data on their experience should be supplied using the Form PER-2 below for each candidate. Proposers should submit a fully detailed Key Personnel resource schedule for the whole contract implementation period. The resource schedule must include:

- The Name and role for each Key Personnel position
- The duration of each Key Personnel appointment
- The level of effort (time) allocated to each Key Personnel position and its distribution throughout the contract implementation period.

| Sr. No. | Title of Position | Name of Candidate | |
|---|---|---|---|
| *1.* | *[EPC Contractor's Representative]* | | |
| *2.* | *[Cyber security Expert/s] [Include as required]* | | |
| ***Key Personnel for Design*** | | | |
| *3.* | *[Design Manager]* | | |
| *4.* | *[Environmental Impact Assessment Specialist]* | | |
| *5.* | *[Social Impact Assessment Specialist]* | | |
| *6.* | *[Health and Safety Specialist]* | | |
| *7.* | *[Biodiversity, Air Quality, Noise. Specialists]* | | |
| *8.* | *[Modify/add others as appropriate]* | | |
| ***Key Personnel for Construction and Installation*** | | | |
| *9.* | *[Construction Manager]* | | |
| *10.* | *[Environmental Specialist]* | | |
| *11.* | *[Health and Safety Specialist]* | | |
| *12.* | *[Social Specialist]* | | |
| *13.* | *[Biodiversity, Air Quality, Noise. Specialists]* | | |
| *14.* | *Survey Manager* | | |
| *15.* | *[Sexual Exploitation, Abuse and Harassment Expert(s)]*<br>*[Where Project SEA risks are assessed to be substantial or high, Key Personnel shall include an expert (s) with relevant experience in addressing sexual exploitation, sexual abuse and sexual harassment cases]* | | |
| *16.* | *[Quality Management Specialist]* | | |
| *17.* | *[Testing and Commissioning Specialist]* | | |
| *18.* | *[Modify/add others as appropriate]* | | |



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| Sr. No. | Title of Position | Name of Candidate | |
|---|---|---|---|
| ***Key Personnel for Operation and Maintenance [if applicable]*** | | | |
| *19.* | … | | |
| *20.* | … | | |
| *21.* | … | | |

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**Form PER-2**
**Resume and Declaration**

**EPC Contractor's Representative and Key Personnel**

| **Name of Proposer** |
|---|
| |

| **Position [#1]: [title of position from Form PER-1]** | | |
|---|---|---|
| **Personnel information** | **Name** | **Date of Birth** |
| | **Address** | **E-mail** |
| | **Professional Qualifications** | |
| | **Academic Qualifications** | |
| | **Language Proficiency:** [language and levels of speaking, reading and writing skills] | |
| **Details** | **Address of Employer** | |
| | **Telephone** | **Contact (Manager / Personnel Officer)** |
| | **Fax** | |
| | **Job Title** | **Years with Present Employer** |

Summarize professional experience in reverse chronological order. Indicate particular technical and managerial experience relevant to the Project.

| **Project** | **Role** | **Duration of involvement** | **Relevant experience** |
|---|---|---|---|
| [main project details] | [role and responsibilities on the Project] | [time in role] | [describe the experience relevant to this position] |
| | | | |
| | | | |
| | | | |



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**Declaration**

I, the undersigned Key Personnel, certify that to the best of my knowledge and belief, the information contained in this Form PER-2 correctly describes myself, my qualifications and my experience.

I confirm that I am available as certified in the following table and throughout the expected time schedule for this position as provided in the Proposal:

| Commitment | Details |
|---|---|
| **Commitment to Duration of Contract** | [insert period (start and end dates) for which this Key Personnel is available to work on this contract] |
| **Time Commitment** | [insert the number of days/week/months/ that this Key Personnel will be engaged] |

I understand that any misrepresentation or omission in this Form may:

(a) be taken into consideration during Proposal evaluation;

(b) result in my disqualification from participating in the Proposal;

(c) result in my dismissal from the contract.

**Name of Key Personnel: *[insert name]*** _____

Signature: _____

Date: (day month year): _____

**Countersignature of authorized representative of the Proposer:**

Signature: _____

Date: (day month year): _____



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## Sub-Contractors

### Proposed Sub-Contractors and/or Manufacturers

The following Sub-Contractors and/or Manufacturers are proposed for carrying out the Activity/Sub-Activity indicated. Proposers are free to propose more than one Sub-Contractor for each Activity/Sub-Activity.

Enclose documentation outlining experience of Sub-contractors, the curriculum vitae and experience of their key personnel who will be assigned to the contract, equipment to be supplied by them, size, location and type of contracts carried out in the past.

The Manufacturer/ Sub-Contractor must have European or American Manufacturer Certificate or Equivalent.

| Activity/Sub-Activity | Proposed Sub-Contractor's Name and Address | Nationality |
|---|---|---|
| | | |
| | | |
| | | |

*[Note: Parts of the Works for which Sub-Contracting permitted are listed in 4.2(a) Specialized Construction and Contract Management Experience and 4.2(b) Specific Experience in Key Activities.]*



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## Sub-Contractor's Authorization

*(Letterhead by the Sub-Contractor to the Employer)*

*(The Proposer shall require each Sub-Contractor to fill in this Form in accordance with the instructions indicated. This letter of authorization shall be signed by a person having proper authority to sign documents that are binding on the Sub-Contractor. The Proposer shall include this authorization letter in its Proposal as per list of proposed Sub-Contractors/Manufacturer's in Section-IV Proposal Forms.)*

**RFP No.: BD/ICB-ALHPP-03**
**Package-III Electro-Mechanical Works,**
**Attabad lake Hydropower Project (54 MW)**

To: **Water and Power Development Authority (WAPDA),**
**Represented by** Chief Engineer / PD Attabad Lake Hydropower Project (54 MW)
**Liaison Office:** Sunny View Estate, Kashmir road, Lahore, Pakistan.
**Site Office:** Office of Chief Engineer / PD Attabad Lake HPP, Dour Khan, Aliabad, Hunza.

We *(insert complete name of Sub-Contractor)* having registered office located at *(insert complete name of Sub-Contractor's office)* do hereby authorize the Proposer, M/s *(insert complete name of Proposer)* to submit a Proposal for RFP No. BD/ICB-ALHPPP-03, Package-III Electro-Mechanical Works, Attabad Lake Hydropower Project (54 MW), comprising the following part(s) of Works to be executed by us as Sub-Contractor:

1: _____

2: _____

3: _____

We hereby undertake that in case of Contract is awarded to Proposer, we shall be bound by this authorization letter to execute and complete the above said part(s) of Works in complete conformity with the Contract Documents.

Signature: _____

Name: _____

Tittle: _____

Duly authorized to sign this Authorization on behalf of: (insert complete name of Sub-Contractor)

Dated on _____ day of _____ *(insert date of signing)*

*(Stamp of the Sub-Contractor)*

## Qualification Forms

### Form ELI 1.1
### Proposer Information Sheet

Date: _____

RFP No.: BD/ICB-ALHPP-01

Page _____ of _____ pages

| |
|---|
| 1. Proposer's Legal Name |
| 2. In case of JV, legal name of each party: |
| 3. Proposer's actual or intended Country of Registration: |
| 4. Proposer's Year of Registration: |
| 5. Proposer's Legal Address in Country of Registration: |
| 6. Proposer's Authorized Representative Information<br>Name:<br>Address:<br>Telephone/Fax numbers:<br>Email Address: |
| 7. Attached are copies of original documents of<br>☐ Articles of Incorporation (or equivalent documents of constitution or association), and/or documents of registration of the legal entity named above, in accordance with **ITP 4.4.**<br>☐ In case of JV, letter of intent to form JV or JV agreement, in accordance with **ITP 4.1.**<br>☐ In case of state-owned enterprise or institution, in accordance with **ITP 4.6**, documents establishing:<br>• Legal and financial autonomy<br>• Operation under commercial law<br>• Establishing that the Proposer is not under the supervision of the Employer<br>8. Included are the organizational chart, a list of Board of Directors, and the beneficial ownership. The successful Proposer shall provide additional information on beneficial ownership, using the Beneficial Ownership Disclosure Form. |

**Form ELI 1.2**
**Party to JV Information Sheet**

Date: _____

RFP No.: BD/ICB-ALHPP-01

Page _____ of _____ pages

| |
|---|
| 1. Proposer's Legal Name: |
| 2. JV's Party legal name: |
| 3. JV's Party Country of Registration: |
| 4. JV's Party Year of Registration: |
| 5. JV's Party Legal Address in Country of Registration: |
| 6. JV's Party Authorized Representative Information<br>Name:<br>Address:<br>Telephone/Fax numbers:<br>Email Address: |
| 7. Attached are copies of original documents of<br>☐ Articles of Incorporation (or equivalent documents of constitution or association), and/or registration documents of the legal entity named above, in accordance with **ITP 4.4**.<br>☐ In case of a state-owned enterprise or institution, documents establishing legal and financial autonomy, operation in accordance with commercial law, and that they are not under the supervision of the Employer, in accordance with **ITP 4.6**.<br>8. Included are the organizational chart, a list of Board of Directors, and the beneficial ownership. The successful Proposer shall provide additional information on beneficial ownership for each JV member using the Beneficial Ownership Disclosure Form. |



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**Form CON 2**
**Historical Contract Non-Performance, Pending Litigation and Litigation History**

Proposer's Name: *[insert full name]*
Date: *[insert day, month, year]*
JV Member's Name: *[insert full name]*
RFP No. and title: BD/ICB-ALHPP-01 *[insert RFP title]*
Page *[insert page number]* of *[insert total number]* pages

| **Non-Performed Contracts in accordance with Section III Qualification Criteria and Requirements** | | | |
|---|---|---|---|
| ☐ Contract non-performance did not occur since 1st January *[insert year]*<br>☐ Contract(s) not performed since 1st January *[insert year]* | | | |
| **Year** | **Non-performed portion of contract** | **Contract Identification** | **Total Contract Amount (current value, currency, exchange rate and PKR equivalent)** |
| *[insert year]* | *[insert amount and percentage]* | Contract Identification: *[indicate complete contract name/ number, and any other identification]*<br>Name of Employer: *[insert full name]*<br>Address of Employer: *[insert street/city/country]*<br>Reason(s) for nonperformance: *[indicate main reason(s)]* | *[insert amount]* |

| **Pending Litigation, in accordance with Section III Evaluation and Qualification Criteria** | | | |
|---|---|---|---|
| ☐ No pending litigation<br>☐ Pending litigation | | | |
| **Year of dispute** | **Amount in dispute (currency)** | **Contract Identification** | **Total Contract Amount (currency), PKR Equivalent (exchange rate)** |
| | | Contract Identification: _____<br>Name of Employer: _____<br>Address of Employer: _____<br>Matter in dispute: _____<br>Party who initiated the dispute: _____<br>Status of dispute: _____ | |

| **Litigation History in accordance with Section III Evaluation and Qualification Criteria** |
|---|
| ☐ No Litigation History<br>☐ Litigation History |



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| Year of award | Outcome as percentage of Net Worth | Contract Identification | Total Contract Amount (currency), PKR Equivalent (exchange rate) |
|---|---|---|---|
| *[insert year]* | *[insert percentage]* | Contract Identification: *[indicate complete contract name, number, and any other identification]*<br>Name of Employer: *[insert full name]*<br>Address of Employer: *[insert street/city/country]*<br>Matter in dispute: *[indicate main issues in dispute]*<br>Party who initiated the dispute: *[indicate "Employer" or "Contractor"]*<br>Reason(s) for Litigation and award decision *[indicate main reason(s)]* | *[insert amount]* |



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## Form CON 3
## Environmental and Social Performance Declaration

Proposer's Name: *[insert full name]*
Date: *[insert day, month, year]*
Joint Venture Member's or Specialized Subcontractor's Name: *[insert full name]*
RFP No. and title: BD/ICB-ALHPP-01 *[insert RFP title]*
Page *[insert page number]* of *[insert total number]* pages

**Environmental and Social Performance Declaration in accordance with Section III Evaluation and Qualification Criteria**

☐ **No suspension or termination of contract**: An employer has not suspended or terminated a contract and/or called the performance security for a contract for reasons related to Environmental and Social (ES) performance since the time specified in Section III (Evaluation and Qualification Criteria) of the Sub-Factor 2.5.

☐ **Declaration of suspension or termination of contract**: The following contract(s) has/have been suspended or terminated and/or Performance Security called by an employer(s) for reasons related to Environmental and Social (ES) performance since the time specified in Section III (Evaluation and Qualification Criteria) Sub-Factor 2.5. Details are described below:

| Year | Suspended or terminated portion of contract | Contract Identification | Total Contract Amount (current value, currency, exchange rate and PKR equivalent) |
|---|---|---|---|
| *[insert year]* | *[insert amount and percentage]* | Contract Identification: *[indicate complete contract name/ number, and any other identification]*<br>Name of Employer: *[insert full name]*<br>Address of Employer: *[insert street/city/country]*<br>Reason(s) for suspension or termination: *[indicate main reason(s) e.g., gender-based violence; sexual exploitation or sexual abuse breaches]* | *[insert amount]* |
| *[insert year]* | *[insert amount and percentage]* | Contract Identification: *[indicate complete contract name/ number, and any other identification]*<br>Name of Employer: *[insert full name]*<br>Address of Employer: *[insert street/city/country]*<br>Reason(s) for suspension or termination: *[indicate main reason(s)]* | *[insert amount]* |
| … | … | *[list all applicable contracts]* | … |

**Performance Security called by an employer(s) for reasons related to ES performance in accordance with Section III Evaluation and Qualification Criteria**

| Year | Contract Identification | Total Contract Amount (current |
|---|---|---|

| | | |
|---|---|---|
| | | **value, currency, exchange rate and PKR equivalent)** |
| *[insert year]* | Contract Identification: *[indicate complete contract name/ number, and any other identification]*<br>Name of Employer: *[insert full name]*<br>Address of Employer: *[insert street/city/country]*<br>Reason(s) for calling of performance security: *[indicate main reason(s) e.g., gender-based violence; sexual exploitation or sexual abuse breaches]* | *[insert amount]* |

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS



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**Form CON 4**

**Sexual Exploitation and Abuse (SEA) and/or Sexual Harassment Performance Declaration**

Proposer's Name: *[insert full name]*
Date: *[insert day, month, year]*
Joint Venture Member's or Subcontractor's Name: *[insert full name]*
RFP No. and title: *[insert and title]*
Page *[insert page number]* of *[insert total number]* pages

| **SEA and/or SH Declaration in accordance with Section III Evaluation and Qualification Criteria** |
|---|
| We:<br>☐ (a) have not been subject to disqualification by the Employer for non-compliance with SEA/SH obligations<br>☐ (b) are subject to disqualification by the Employer for non-compliance with SEA/SH obligations<br>☐ (c) had been subject to disqualification by the Employer for non-compliance with SEA/ SH obligations. An arbitral award on the disqualification case has been made in our favor.<br>☐ (d) had been subject to disqualification by the Employer for non-compliance with SEA/ SH obligations for a period of two years. We have subsequently demonstrated that we have adequate capacity and commitment to comply with SEA/ SH obligations.<br>☐ (e) had been subject to disqualification by the Employer for non-compliance with SEA/ SH obligations for a period of two years. We have attached evidence demonstrating that we have adequate capacity and commitment to comply with SEA/ SH obligations. |
| **[*If (c) above is applicable, attach evidence of an arbitral award reversing the findings on the issues underlying the disqualification.]*** |
| ***[If (d) or (e) above are applicable, provide the following information:]*** |
| Period of disqualification: From: _____ To: _____ |
| If previously provided on another works contract, details of evidence that demonstrated adequate capacity and commitment to comply with SEA/ SH obligations (**as per (d) above)**<br>Name of Employer: _____<br>Name of Project: _____<br>Contract description: _____<br>Brief summary of evidence provided: _____<br>_____<br>Contact Information: (Tel, email, name of contact person): _____<br>_____ |
| As an alternative to the evidence under (d), other evidence demonstrating adequate capacity and commitment to comply with SEA/ SH obligations (**as per (e) above)** *[attach details as appropriate].* |



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## Form CCC
## Current Contract Commitments / Works in Progress

Proposers and each partner to a JV should provide information on their current commitments on all contracts that have been awarded, or for which a letter of intent or acceptance has been received, or for contracts approaching completion, but for which an unqualified, full completion certificate has yet to be issued.

| Name of contract | Employer, contact address/tele | Value of outstanding work (current PKR equivalent) | Estimated completion date | Average monthly invoicing over last six months (PKR/month) |
|---|---|---|---|---|
| 1. | | | | |
| 2. | | | | |
| 3. | | | | |
| 4. | | | | |
| 5. | | | | |
| 6 | | | | |

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

**Form FIN 3.1**

*[The following table shall be filled in for the Proposer and for each member of a Joint Venture]*

Proposer's Name: *[insert full name]*
Date: *[insert day, month, year]*
Joint Venture Member Name: *[insert full name]*
PDS No. and title: *[insert PDS number and title]*
Page *[insert page number]* of *[insert total number]* pages

## 1. Financial Data

| **Type of Financial information in (currency)** | **Historic information for previous three (03) years, (amount in currency, currency exchange rate[12], PKR equivalent)** | | |
|---|---|---|---|
| | Year 1 | Year 2 | Year 3 |
| **Statement of Financial Position (Information from Balance Sheet)** | | | |
| Total Assets (TA) | | | |
| Total Liabilities (TL) | | | |
| Total Equity/Net Worth (NW) | | | |
| Current Assets (CA) | | | |
| Current Liabilities (CL) | | | |
| Working Capital (WC) | | | |
| **Information from Income Statement** | | | |
| Total Revenue (TR) | | | |
| Profits Before Taxes (PBT) | | | |
| **Cash Flow Information** | | | |
| Cash Flow from Operating Activities | | | |

[12] For construction turnover or financial data required for each year - Exchange rate prevailing on the last day of the respective calendar year (in which the amounts for that year are to be converted). The source of Exchange rate is identified ITP 38.1 of PDS.

**2. Sources of Finance**

**3.** *[The following table shall be filled in for the Proposer and all parties combined in case of a Joint Venture]*

Specify sources of finance to meet the cash flow requirements on works currently in progress and for future Contract commitments.

| No. | Source of finance | Amount (PKR equivalent) |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| | | |

**3. Financial documents**

The Proposer and its parties shall provide copies of financial statements for five (05) years pursuant Section III, Evaluation and Qualification Criteria, Sub-factor 3.1. The financial statements shall:

(a) reflect the financial situation of the Proposer or in case of JV member, and not an affiliated entity (such as parent company or group member).
(b) be independently audited or certified in accordance with local legislation.
(c) be complete, including all notes to the financial statements.
(d) correspond to accounting periods already completed and audited.

☐ Attached are copies of financial statements[13] for the five (05) years required above; and complying with the requirements

Note: Cash Flow requirement and source of finance shall be evaluated as per criteria mentioned in 3.1 (i) & (ii) of Section-III

[13] If the most recent set of financial statements is for a period earlier than 12 months from the date of Proposal, the reason for this should be justified.



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## Form FIN 3.2
## Average Annual Construction Turnover

*[The following table shall be filled in for the Proposer and for each member of a Joint Venture]*

Proposer's Name: *[insert full name]*
Date: *[insert day, month, year]*
Joint Venture Member Name: *[insert full name]*
PDS No. and title: *[insert PDS number and title]*
Page *[insert page number]* of *[insert total number]* pages

| **Annual turnover data (construction only)** | | | |
|---|---|---|---|
| **Year** | **Amount Currency** | **Exchange rate** | **PKR equivalent** |
| *[indicate calendar year]* | *[insert amount and indicate currency]* | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | Average Annual Construction Turnover ** | |

** Total USD equivalent for all years divided by the total number of years. See Section III, Qualification Criteria and Requirements, 3.2.



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**Form FIN – 3.3:**
**Current Contract Commitments / Works in Progress**

Proposer's and each member to a JV should provide information on their current commitments onall contracts that have been awarded, or for which a letter of intent or acceptance has been received, or for contracts approaching completion, but for which an unqualified, full completion certificate has yet to be issued.

| Current Contract Commitments | | | | | |
|---|---|---|---|---|---|
| **No.** | **Name of Contract** | **Employer's Contact Address,Tel, Fax** | **Value of Outstanding Work [Current Eq. PKR]** | **Estimated Completion Date** | **Average Monthly Invoicing Over Last Six Months [Eq. PKR /month)]** |
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| | | | | | |



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**Form EXP 4.1**
**General E&M Experience**

*[The following table shall be filled in for the Proposer and in the case of a JV Proposer, each Member]*

Proposer's Name: *[insert full name]*
Date: *[insert day, month, year]*
Joint Venture Member Name: *[insert full name]*
PDS No. and title: *[insert PDS number and title]*
Page *[insert page number]* of *[insert total number]* pages

*[Identify Contracts that demonstrate continuous construction work over the past ten (10) years pursuant to Section III, Evaluation and Qualification Criteria, Sub-Factor 4.1. List Contracts chronologically, according to their commencement (starting) dates.]*

| Starting Year | Ending Year | Contract Identification | Role of Proposer |
|---|---|---|---|
| *[indicate year]* | *[indicate year]* | Contract name: *[insert full name]*<br>Brief Description of the Works performed by the Proposer: *[describe works performed briefly]*<br>Amount of Contract: *[insert amount in currency, mention currency used, exchange rate and US$ equivalent[1]]*<br>Name of Employer: *[indicate full name]*<br>Address: *[indicate street/number/town or city/country]* | *[insert "Prime Contractor" or "JV Member" or "Sub-Contractor" or "Management Contractor"]* |
| | | Contract name: *[insert full name]*<br>Brief Description of the Works performed by the Proposer: *[describe works performed briefly]*<br>Amount of Contract: *[insert amount in currency, mention currency used, exchange rate and US$ equivalent*]*<br>Name of Employer: *[indicate full name]*<br>Address: *[indicate street/number/town or city/country]* | *[insert "Prime Contractor" or "JV Member" or "Sub-Contractor" or "Management Contractor"]* |
| | | Contract name: *[insert full name]*<br>Brief Description of the Works performed by the Proposer: *[describe works performed briefly]*<br>Amount of Contract: *[insert amount in currency, mention currency used, exchange rate and US$ equivalent*]*<br>Name of Employer: *[indicate full name]*<br>Address: *[indicate street/number/town or city/country]* | *[insert "Prime Contractor" or "JV Member" or "Subcontractor" or "Management Contractor"]* |

[1] Value of single Contract - Exchange rate prevailing on the date of the Contract. The source of Exchange rate is identified in ITP 38.1 of PDS.

**Form EXP 4.2(a)**
**Specific Construction and Contract Management Experience**

*[The following table shall be filled in for Contracts performed by the Proposer, each member of a Joint Venture, and Specialized Sub-Contractors]*

Applicant's Name: *[insert full name]*
Date: *[insert day, month, year]*
Joint Venture Member Name: *[insert full name]*
PDS No. and title: *[insert PDS number and title]*
Page *[insert page number]* of *[insert total number]* pages

<table>
<tr><td>Similar Contract No.<br>[insert number] of [insert number of Contracts required]</td><td colspan="4">Information</td></tr>
<tr><td>Contract Identification</td><td colspan="4">[insert Contract name and number, if applicable]</td></tr>
<tr><td>Award date</td><td colspan="4">[insert day, month, year, e.g., 15 June, 2015]</td></tr>
<tr><td>Completion date</td><td colspan="4">[insert day, month, year, e.g., 03 October, 2017]</td></tr>
<tr><td>Role in Contract<br>[check the appropriate box]</td><td>Prime Contractor ☐</td><td>Member in JV ☐</td><td>Management Contractor ☐</td><td>Sub-contractor ☐</td></tr>
<tr><td>Total Contract Amount</td><td colspan="2">[insert total Contract amount in local currency]</td><td colspan="2">US$ [insert Exchange rate and total Contract amount in US$ equivalent] *</td></tr>
<tr><td rowspan="2">If member in a JV or Sub-Contractor, specify share in value in total Contract amount and roles and responsibilities</td><td>[insert a percentage amount]</td><td>[insert total Contract amount in local currency]</td><td colspan="2">[insert exchange rate and total Contract amount in US$ equivalent] *</td></tr>
<tr><td colspan="4">[insert roles and responsibilities]</td></tr>
<tr><td>Employer's Name:</td><td colspan="4">[insert full name]</td></tr>
<tr><td>Address:<br>Telephone/fax number<br>E-mail:</td><td colspan="4">[indicate street / number / town or city / country]<br>[insert telephone/fax numbers, including country and city area codes]<br>[insert e-mail address, if available]</td></tr>
</table>

* Exchange rate prevailing on the date of the Contract.

.



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| **Similar Contract No.** *[insert number]* of *[insert number of Contracts required]* | **Information** |
|---|---|
| Description of the similarity in accordance with Sub-Factor 4.2(a) of Section III: | |
| **1. Amount** | *[insert amount in local currency, exchange rate, US$ in words and in Figures]* |
| **2. Physical size of required works items** | *[insert physical size of items]* |
| **3. Complexity** | *[insert description of complexity]* |
| **4. Methods/Technology** | *[insert specific aspects of the methods/technology involved in the Contract]* |
| **5. Construction rate for key activities** | *[insert rates and items]* |
| **6. Other Characteristics** | *[insert other characteristics as described in Volume-II]* |



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**Form EXP 4.2(b)**
**Experience in Key Activities**

*[The following table shall be filled in for Contracts performed by the Proposer, each member of a Joint Venture, and Specialized Sub-Contractors]*

Proposer's Name: *[insert full name]*
Date: *[insert day, month, year]*
Proposer's JV Member Name: *[insert full name]*
*Sub-Contractor's Name*[2]*: [insert full name]*
PDS No. and title: *[insert PDS number and title]*
Page *[insert page number]* of *[insert total number]* pages

| **Similar Contract No.** *[insert number]* of *[insert number of Contracts required]* | **Information** | | | |
|---|---|---|---|---|
| Contract Identification | *[insert Contract name and number, if applicable]* | | | |
| Award date | *[insert day, month, year, e.g., 15 June, 2015]* | | | |
| Completion date | *[insert day, month, year, e.g., 03 October, 2017]* | | | |
| Role in Contract *[check the appropriate box]* | Prime Contractor ☐ | Member in JV ☐ | Management Contractor ☐ | Sub-contractor ☐ |
| Total Contract Amount | *[insert total Contract amount in local currency]* | | US$ *[insert Exchange rate and total Contract amount in US$ equivalent]* | |
| Quantity, Volume, number or rate of production (as applicable) performed under the Contract or year or part of the year. *(Insert extent of participation indicating actual quantity of key activity successfully completed in the role performed)* | Total Quantity in the Contract (i) | Percentage Participation (ii) | Actual Quantity Performed (i) x (ii) | |
| | | | | |
| Year 1 | | | | |
| Year 2 | | | | |

[2] As per Sub-Factor 4.2(a) Specific Experience of Evaluation and Qualification Criteria Section-III and Section-VIII, Particular Conditions Part A-Contract Data Sub-Clause 4.4(b)



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| | |
|---|---|
| Year 3 | |

[2] If Applicable

| | |
|---|---|
| Employer's Full Name | *(insert full name)* |
| Address:<br>Telephone/Fax Number:<br>Email: | *[indicate street / number / town or city / country]*<br>*[insert telephone/fax numbers, including country and city area codes]*<br>*[insert e-mail address, if available]* |

2. Activity No.

3. ……

| **Description** | **Information** |
|---|---|
| Description of the key activities in accordance with Sub-Factor 4.2(a) E&M Experience of Section III: | |
| | *[insert response to inquiry indicated in left column]* |
| | |
| | |
| | |
| | |



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**Form EXP 4.2(c)**
**Specific Experience in Managing Environmental, Social, Health & Safety (ESHS) Aspects**

*[The following table shall be filled in for Contracts performed by the Proposer, and each member of a Joint Venture]*

Proposer's Name: *[insert full name]*
Date: *[insert day, month, year]*
Proposer's JV Member Name: *[insert full name]*
*Sub-Contractor's Name*[3] *: [insert full name]*
PDS No. and title: *[insert PDS number and title]*
Page *[insert page number]* of *[insert total number]* pages

1. Key Requirement no 1 in accordance with 4.2 (b):
Experience in Projects with Significant ESHS Impact

| | | | | |
|---|---|---|---|---|
| Contract Identification | | | | |
| Award date | | | | |
| Completion date | | | | |
| Role in Contract | Prime Contractor ☐ | Member in JV ☐ | Management Contractor ☐ | Sub-Contractor ☐ |
| Total Contract Amount | | | US$ | |
| Details of relevant experience | | | | |

2. Key Requirement No. 02 in accordance with Sub-Factor 4.2 (b):
Environmental Management Certificate

| **Description** | **Information** |
|---|---|
| Identification of the Certificate | *[insert full name of the certificate]* |
| First Award Date | *[insert day, month, year of first certificate award]* |
| Last update of the Certificate | *[insert day, month, year of latest renewal, if any]* |
| Issuers Name | *[insert full name]* |
| Address | *[insert street / number / town or city / country]* |
| Telephone/fax number | *[insert phone/fax no., incl. country & city area codes]* |
| E-mail | *[insert e-mail address, if available]* |
| Compliance with International Standards | The certificate is ISO 14001:2015<br>☐ Yes ☐ No<br>The Proposer shall provide a copy of the certificate. |
| If no, proof of conformity with the International Standard by the Proposer | *[The Proposer shall demonstrate the equivalency of their management systems with the international standards]* |

[3] As per Sub-Factor 4.2(b) Specific Experience of Evaluation and Qualification Criteria Section-III and Section-VIII, Particular Conditions Part A-Contract Data Sub-Clause 4.4(b)



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3. Key Requirement No. 03 in accordance with Sub-Factor 4.2 (b): Environmental Management Capacity

| Sr. No. | The Proposer shall demonstrate | Information and Documentation |
|---|---|---|
| 1 | The existence of an Environmental Policy | *[Provide relevant details of the Corporate Values or similar policy documents and declarations]* |
| *[insert brief description or, if applicable, short abstract of the documentation annexed]* | | |
| 2 | The existence of an Environmental Management System, incl. an adequate organizational set-up for definition, enforcement and monitoring. | *[Provide details of the organizational set-up and procedures for relevant issues within your company. If applicable, please specify roles or function in the project team of key ESHS personnel.]* |
| *[insert brief description or, if applicable, short abstract of the documentation annexed]* | | |
| 3 | That all members of a **JV**, Suppliers, Sub-Contractors and temporary workforce<br>a. are aware of and<br>b. comply with the Environmental Management System. | *[Provide information on*<br>*a. how awareness, know how transfer and enforcement is implemented to external partners*<br>*b. nature, content and frequency of internal trainings to employees.]* |
| [insert brief description or, if applicable, short abstract of the documentation annexed] | | |

4. Key Requirement No. 03 in accordance with Sub-Factor 4.2 (b): Occupational Health and Safety Capacity

| Sr. No. | The Proposer shall demonstrate | Information and Documentation |
|---|---|---|
| 1 | The existence of an Occupational Health & Safety Policy | *[Provide a policy document and the index of the Occupational Health & Safety manual or other relevant documents and declarations]* |
| *[insert brief description or, if applicable, short abstract of the documentation annexed]* | | |
| 2 | The existence of a H&S management system, incl. an adequate organizational set-up for definition, enforcement and monitoring. | *[Provide details of the organizational set-up and procedures for relevant issues within your company. If applicable, please specify roles or function of the project team for managing H&S issues.]* |
| *[insert brief description or, if applicable, short abstract of the documentation annexed]* | | |
| 3 | The existence of a training plan that covers relevant H&S requirements. | *[Provide a training plan that covers relevant H&S requirements.]* |



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| Sr. No. | The Proposer shall demonstrate | Information and Documentation |
|---|---|---|
| *[insert brief description or, if applicable, short abstract of the documentation annexed]* | | |

5. Key Requirement No. 03 in accordance with Sub-Factor 4.2 (b):
List of Available ESHS and Construction Personnel

| Name | Designation, in accordance with Section VII, Scope of Works | Education / Degree | Years of Professional Experience | Relationship with / Years within the Proposer |
|---|---|---|---|---|
| | **Health & Safety expert** | | | |
| Country/Regional Experience | Relevant Project References (Description of Project-Related experience) | | | Languages |
| | | | | |
| | **Environmental expert** | | | |
| Country/Regional Experience | Relevant Project References (Description of Project-Related experience) | | | Languages |
| | | | | |
| | **Social expert** | | | |
| Country/Regional Experience | Relevant Project References (Description of Project-Related experience) | | | Languages |
| | | | | |



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**Others**

Commercial or contractual aspects of the RFP/EPC Bidding Documents that the Proposer would like to discuss with the Employer during clarifications.

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

## Form of Proposal Security

**Security Executed on** _____
*(Date)*

**Expiry on** _____
*(Date)*

**Name of Surety with Address:** _____

**Name of Principal *(Proposer)* with Address**_____
_____

**Penal Sum of Security PKR** _____ (Pakistani Rupees _____)

**Request for Proposal No.** _____

KNOW ALL MEN BY THESE PRESENTS, that in pursuance of the terms of the Proposal and at the request of the said Principal (Proposer) we, the Surety above named, are held and firmly bound unto _____
*(Hereinafter called the 'Employer')* in the sum stated above for the payment of which sum well and truly to be made, we bind ourselves, our heirs, executors, administrators and successors, jointly and severally, firmly by these presents.

THE CONDITION OF THIS OBLIGATION IS SUCH, that whereas the Proposer has submitted the accompanying Proposal dated _____ for_____
_____ (*Particulars of Proposal*) to the said Employer; and

(1) WHEREAS, the Employer has required as a condition for considering said Proposal that the Proposer furnishes a Proposal Security in the above said sum to the Employer, conditioned as under that the Proposal Security shall remain in force for a period twenty-eight (28) days beyond the Proposal Validity date i.e., up to _____ and US Dollar as Proposal Security has also been allowed in addition to PKR.

(2) that the Proposal Securities of the Proposers except the lowest three will be returned by the Employer within twenty-eight (28) days from the opening of Proposals, provided a Proposer request for the return of its Proposal Security, or on the expiry of original validity of Proposal Security or as extended, whichever is earlier;

(3) that the Proposal Security of the lowest three Proposers comprising the successful Proposer will be returned when the successful Proposer has furnished the required Performance Security; and

(4) that in the event of failure of the successful Proposer to furnish the required Performance Security, the entire said sum be paid immediately to the said Employer pursuant to Clause.19 and Clause.54 of the Instructions to Proposers for the successful Proposer's failure to perform.

NOW THEREFORE, if the successful Proposer shall, within the period specified therefor, on the prescribed form presented to him for signature enter into a formal Contract with the said Employer in accordance with his Proposal as accepted and furnish within twenty eight (28) days of his being requested to do so, a Performance Security with good and sufficient surety, as may be required, upon the form prescribed by the said Employer for the faithful performance and proper fulfilment of the said Contract or in the event of non-withdrawal of the said Proposal within the time specified for its validity then this obligation shall be void and of no effect, but otherwise to remain in full force and effect.



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PROVIDED THAT the Surety shall forthwith pay the Employer the said sum upon first written demand of the Employer (without cavil or argument) and without requiring the Employer to prove or to show grounds or reasons for such demand, notice of which shall be sent by the Employer by registered post duly addressed to the Surety at its address given above.

PROVIDED ALSO THAT the Employer shall decide, whether the principal (Proposer) has duly performed his obligations to sign the Contract Agreement and to furnish the requisite Performance Security within the time stated above, or has defaulted in fulfilling said requirements and the Surety shall pay without objection the said sum upon demand from the Employer forthwith and without any reference to the principal (Proposer) or any other person.

IN WITNESS WHEREOF, the above bounden Surety has executed the instrument under its seal on the date indicated above, the name and seal of the Surety being hereto affixed and these presents duly signed by its undersigned representative pursuant to authority of its governing body.

SURETY

(Scheduled Bank/Insurance Company)

WITNESS:

Signature _____

1. _____

Name _____

_____

Title _____

Corporate Secretary (Seal)

Corporate Guarantor (Seal)

2. _____

_____

Name, Title & Address



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## SECTION V - ELIGIBLE COUNTRIES

### Eligibility for the Provision of Goods, Works and Non-Consulting Services in Government of Pakistan Financed Procurement

Eligible countries to participate in this bidding process are those which have been notified by Ministry of Interior, Government of Pakistan as business-friendly Countries (BVL); information can be accessed through following link:
http://www.dgip.gov.pk/Files/Visa%20Categories.aspx#L

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

## SECTION VI - FRAUD AND CORRUPTION

**(Section VI shall not be modified)**

### 1. Purpose

1.1 The PPRA's Anti-Corruption Guidelines and this annex apply with respect to procurement under Government of Pakistan Financing operations.

### 2. Requirements

2.1 The Employer requires that Proposers (Proposers/Proposers), consultants, EPC contractors and suppliers; any Sub-contractors, sub-consultants, service providers or suppliers; any agents (whether declared or not); and any of their personnel, observe the highest standard of ethics during the procurement process, selection and contract execution of contracts, and refrain from Fraud and Corruption.

2.2 To this end, the Employer:

a. Defines, for the purposes of this provision, the terms set forth below as follows:

i. "corrupt practice" is the offering, giving, receiving, or soliciting, directly or indirectly, of anything of value to influence improperly the actions of another party;

ii. "fraudulent practice" is any act or omission, including misrepresentation, that knowingly or recklessly misleads, or attempts to mislead, a party to obtain financial or other benefit or to avoid an obligation;

iii. "collusive practice" is an arrangement between two or more parties designed to achieve an improper purpose, including to influence improperly the actions of another party;

iv. "coercive practice" is impairing or harming, or threatening to impair or harm, directly or indirectly, any party or the property of the party to influence improperly the actions of a party;

v. "obstructive practice" is:

(a) deliberately destroying, falsifying, altering, or concealing of evidence material to the investigation or making false statements to investigators in order to materially impede an Employer investigation into allegations of a corrupt, fraudulent, coercive, or collusive practice; and/or threatening, harassing, or intimidating any party to prevent it from disclosing its knowledge of matters relevant to the investigation or from pursuing the investigation; or

(b) acts intended to materially impede the exercise of the Employer's inspection and audit rights provided for under paragraph 2.2 e. below.

b. Rejects a Proposal for award if the Employer determines that the firm or individual recommended for award, any of its personnel, or its agents, or its sub-consultants, Sub-contractors, service providers, suppliers and/ or their employees, has, directly or indirectly, engaged in corrupt, fraudulent, collusive, coercive, or obstructive practices in competing for the contract in question;



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c. In addition to the legal remedies set out in the relevant Legal Agreement, may take other appropriate actions, including declaring miss-procurement, if the Government of Pakistan determines at any time that representatives of the Employer engaged in corrupt, fraudulent, collusive, coercive, or obstructive practices during the procurement process, selection and/or execution of the contract in question, without the Employer having taken timely and appropriate action satisfactory to the Government of Pakistan to address such practices when they occur, including by failing to inform the Government of Pakistan in a timely manner at the time they knew of the practices;

d. Pursuant to the PPRA's Guidelines and in accordance with the PPRA's prevailing sanctions policies and procedures, may sanction a firm or individual, either indefinitely or for a stated period of time, including by publicly declaring such firm or individual ineligible (i) to be awarded or otherwise benefit from a Government of Pakistan financed contract, financially or in any other manner;[1] (ii) to be a nominated[2] Sub-contractor, consultant, manufacturer or supplier, or service provider of an otherwise eligible firm being awarded a contract; and (iii) to receive the proceeds of any contracts made by the Employer or otherwise to participate further in the preparation or implementation of any Government of Pakistan project;

e. Requires that a clause be included in Bidding/Request for Proposal Documents and in contracts financed by a Government of Pakistan, requiring (i) Proposers (Proposers/Proposers), consultants, EPC contractors, and suppliers: and their Sub-contractors, sub-consultants, service providers, suppliers, agents, personnel, permit the Employer to inspect[3] all accounts, records and other documents relating to the procurement process, selection and/or contract execution, and to have them audited by auditors appointed by the Employer.

[1] For the avoidance of doubt, a sanctioned party's ineligibility to be awarded a contract shall include, without limitation, (i) applying for pre-qualification, expressing interest in a consultancy, and bidding, either directly or as a nominated Subcontractor, nominated consultant, nominated manufacturer or supplier, or nominated service provider, in respect of such contract, and (ii) entering into an addendum or amendment introducing a material modification to any existing contract.

[2] A nominated Subcontractor, nominated consultant, nominated manufacturer or supplier, or nominated service provider (different names are used depending on the particular bidding document) is one which has been: (i) included by the Proposer in its pre-qualification application or Proposal because it brings specific and critical experience and know-how that allow the Proposer to meet the qualification requirements for the particular Proposal ; or (ii) appointed by the Borrower.

[3] Inspections in this context usually are investigative (i.e., forensic) in nature. They involve fact-finding activities undertaken by the Employer or persons appointed by the Employer to address specific matters related to investigations/audits, such as evaluating the veracity of an allegation of possible Fraud and Corruption, through the appropriate mechanisms. Such activity includes but is not limited to: accessing and examining a firm's or individual's financial records and information, and making copies thereof as relevant; accessing and examining any other documents, data and information (whether in hard copy or electronic format) deemed relevant for the investigation/audit, and making copies thereof as relevant; interviewing staff and other relevant individuals; performing physical inspections and site visits; and obtaining third party verification of information.

## Integrity Pact

***[To be filled and signed by the Proposer]***

Contract No._____ Dated _____
Contract Value: _____
Contract Title: _____

_____ *(Name of EPC Contractor)* hereby declares that it has not obtained or induced the procurement of any contract, right, interest, privilege or other obligation or benefit from Government of Pakistan (GOP) or any administrative subdivision or agency thereof or any other entity owned or controlled by (GOP) through any corrupt business practice.

Without limiting the generality of the foregoing, [name of Supplier] represents and warrants that it has fully declared the brokerage, commission, fees etc. paid or payable to anyone and not given or agreed to give and shall not give or agree to give to anyone within or outside Pakistan either directly or indirectly through any natural or juridical person, including its affiliate, agent, associate, broker, consultant, director, promoter, shareholder, sponsor or subsidiary, any commission, gratification, bribe, finder's fee or kickback, whether described as consultation fee or otherwise, with the object of obtaining or inducing the procurement of a contract, right, interest, privilege or other obligation or benefit in whatsoever form from (GOP), except that which has been expressly declared pursuant hereto.

_____ *(Name of EPC Contractor)* certifies that it has made and will make full disclosure of all agreements and arrangements with all persons in respect of or related to the transaction with (GOP) and has not taken any action or will not take any action to circumvent the above declaration, representation or warranty.

_____ *(Name of EPC Contractor)* accepts full responsibility and strict liability for making any false declaration, not making full disclosure, misrepresenting facts or taking any action likely to defeat the purpose of this declaration, representation and warranty. It agrees that any contract, right, interest, privilege or other obligation or benefit obtained or procured as aforesaid shall, without prejudice to any other rights and remedies available to (GOP) under any law, contract or other instrument, be voidable at the option of (GOP).

Notwithstanding any rights and remedies exercised by (GOP) in this regard, [name of Supplier] agrees to indemnify (GOP) for any loss or damage incurred by it on account of its corrupt business practices and further pay compensation to (GOP) in an amount equivalent to ten time the sum of any commission, gratification, bribe, finder's fee or kickback given by [name of Supplier] as aforesaid for the purpose of obtaining or inducing the procurement of any contract, right, interest, privilege or other obligation or benefit in whatsoever form from (GOP).

| | |
|---|---|
| Name of Buyer: …… | Name of Seller/Supplier: …… |
| Signature: …… | Signature: …… |
| *[Seal]* | *[Seal]* |

**Silver Book**

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The Conditions of Contract are the "General Conditions" which form part of the "Conditions of Contract for EPC/Turnkey Projects ("Silver book") Second edition 2017, reprinted 2022 with amendments" published by the Federation Internationale Des Ingenieurs Conseils (FIDIC) and the following "Particular Conditions" which comprise of the World Bank's COPA and the amendments and additions to such General Conditions.

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## SECTION VIII - PARTICULAR CONDITIONS

### Part A - Contract Data

The following Particular Conditions shall supplement the General Conditions. Whenever there is a conflict, the provisions herein shall prevail over those in General Conditions.

| Sr. No. | Data Required | Sub-Clause | Data |
|---|---|---|---|
| 1. | Where the contract allows for cost plus profit, percentage profit added to the cost | 1.1.17 | 5% |
| 2. | Defects Notification Period (DNP) | 1.1.24 | 730 days from the effective date of issuance of Taking Over Certificates. |
| 3. | Employer's Name and Address | 1.1.27 | **Name:**<br>Water and Power Development Authority (WAPDA)<br>**Address:**<br>WAPDA House, Sharah-e-Quaid-e-Azam Lahore, Punjab, Pakistan.<br>**Represented by:**<br>Chief Engineer / PD Attabad lake Hydropower Project<br>**Liaison Office**: Office of Chief Engineer/PD ALHPP, Sunny View Estate, Kashmir Road, Lahore, Pakistan.<br>**Site Office:** Office of Chief Engineer / PD Attabad Lake HPP, Dour Khan, Aliabad, Hunza. |
| 4. | Employer's Representative | 1.1.30 | **Name:**<br>Attabad Hydropower Management Consultants (AHMC)<br>**Address:**<br>37-B, Block N, Model Town Extension, Lahore.<br>**Site Office:**<br>Helipad Guest House, Mominabad Hunza, Gilgit-Baltistan |
| 5. | Time for Completion | 1.1.76 | 42 Months for whole of the works. |
| 6. | Milestones | 1.1.84 | Refer to Table 2 **Summary of Procedure for Delay Damages** |
| 7. | Notices and Other Communications | 1.3(a)(ii) | N/A |



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| Sr. No. | Data Required | Sub-Clause | Data |
|---|---|---|---|
| 8. | Address of Employer for communications | 1.3(d) | Water and Power Development Authority (WAPDA)<br>Represented by Chief Engineer / PD Attabad lake Hydropower Project<br>**Liaison Office**: Office of Chief Engineer/PD ALHPP, Sunny View Estate, Kashmir Road, Lahore, Pakistan.<br>**Site Office:** Office of Chief Engineer / PD Attabad Lake HPP, Dour Khan, Aliabad, Hunza.<br>**Telephone:** 0092-42-99204981 0092-42-3334481116<br>**E-mail address**: gmpna01@gmail.com, pdalhpp@gmail.com |
| 9. | Address of Employer's Representative for communications | 1.3(d) | **Name:**<br>Attabad Hydropower Management Consultants (AHMC)<br>**Address:**<br>37-B, Block N, Model Town Extension, Lahore.<br>**Site Office:**<br>Helipad Guest House, Mominabad Hunza, Gilgit-Baltistan.<br>**Telephone:** +92-4235194885<br>**E-mail:** alhpp.nespak@gmail.com |
| 10. | Address of EPC Contractor for communications | 1.3(d) | |
| 11. | Contract shall be governed by the law of | 1.4 | Islamic Republic of Pakistan |
| 12. | Ruling Language | 1.4 | English |
| 13. | Language for Communications | 1.4 | English |
| 14. | Time for Parties to Sign a Contract Agreement. | 1.6 | 28 Days after receipt of Letter of acceptance. |
| 15. | Number of additional paper copies of EPC Contractor's Documents | 1.8 | Three (03) Copies |
| 16. | Total liability of the EPC Contractor to the Employer | 1.14 | 1.15 times the Contract Amount stated in the Contract Agreement. |



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| Sr. No. | Data Required | Sub-Clause | Data |
|---|---|---|---|
| | under or in connection with the Contract | | |
| 17. | After receiving the Letter of Acceptance, the EPC Contractor shall be given right of access to all or part of the Site within | 2.1 | 28 days after both parties have signed the Contract Agreement after obtaining Performance Security from the EPC Contractor under sub clause 4.2. |
| 18. | Employer's Financial Arrangements | 2.4 | The Employer shall receive funds from Government of Pakistan from PSDP allocation for the project.<br>The PC-1 stands approved |
| 19. | Performance Security (as percentages of the Accepted Contract Amount in Currency/ies) | 4.2 | The performance security will be 10 % of the Accepted Contract Amount and in the same currency (ies) of the Accepted Contract Amount. |
| 20. | Maximum allowable accumulated value of work subcontracted (as a percentage of the Accepted Contract Amount) | 4.4(a) | Sub-contracting is only allowed for Specialized work. |
| 21. | Parts of the Works for which subcontracting is not permitted: | 4.4(b) | No subcontracting is allowed other than Specialized Work. |
| 22. | Number of additional paper copies of progress reports | 4.20 | Ten (10) copies |
| 23. | Normal working hours on site | 6.5 | As per applicable Law of Islamic Republic of Pakistan. |
| 24. | Number of additional paper | 8.3 | Six (06) copies |



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| Sr. No. | Data Required | Sub-Clause | Data |
|---|---|---|---|
| | copies of programs | | |
| 25. | Delay Damages payable for each day of delay | 8.8 | For each section of the works and Inter-contract Handover dates as described in Summary of Procedure for Delay Damages. |
| 26. | Maximum Amount of Delay Damages | 8.8 | 10% of the Accepted Contract Amount stated in the Letter of Acceptance. |
| 27. | Percentage rate to be applied to Provisional Sums for overhead charges and profit. | 13.4(b)(ii) | 10%.<br>This percentage shall not be applied to reimbursement of payment w.r.t taxes, duties, royalties, DAAB and insurance invoices etc. |
| 28. | Total amount of Advance Payment | 14.2 | The Mobilization Advance Payment shall be 10% of Accepted Contract Amount |
| 29. | Currency/(ies) of Advance Payment | 14.2 | An interest free Mobilization Advance of 10% shall be made to the EPC Contractor in local currency (foreign currency portion shall be paid in equivalent PKR) as per the Percentage of Proposal Price for Table-B Summary of Payment Currencies against Bank Guarantees in amounts and currencies equal to the Advance Payment as per Sub-Clause 14.2 of Special Provisions – Part B. |
| 30. | Number of additional paper copies of Statements | 14.3(b) | Six (06) Copy |
| 31. | Percentage of retention | 14.3(iii) | 10% |
| 32. | Limit of Retention Money (as a percentage of Accepted Contract Price) | 14.3(iii) | 5% |
| 33. | Plant and Materials for payment when shipped. | 14.5(b)(i) | N/A |
| 34. | Plant and Materials for payment when | 14.5(c)(i) | N/A |



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| Sr. No. | Data Required | Sub-Clause | Data |
|---|---|---|---|
| | delivered to the Site. | | |
| 35. | Minimum amount of Interim Payment Certificates (IPC) | 14.6.2 | Rs. 100 Million |
| 36. | Period for the Employer to make interim payments to the EPC Contractor under Sub-Clause 14.6 [Interim Payment] | 14.7(b)(i) | 45 days |
| 37. | Period for the Employer to make final payment to the EPC Contractor | 14.7(c) | 84 days |
| 38. | Financing charges for delayed payment (percentage points above the average bank short-term lending rate as referred to under sub-paragraph (a)) | 14.8 | KIBOR+2% per annum for local currency SOFR +1% (Secured Overnight Financing Rate) per annum for foreign currency. |
| 39. | Number of additional paper copies of draft Final Statement | 14.11.1(b) | Six (06) copies |
| 40. | Currencies for Payment of Contract Price | 14.15 | The Contract Price shall be paid in PKR. The Foreign currency portion of Contract Price shall be paid in equivalent PKR. The source of exchange rate shall be TT Selling Rates Published or authorized by **State Bank of Pakistan.** |
| 41. | Proportions or amounts of Local and Foreign Currencies are: Local: | 14.15(a)(i) | Table C - Summary of Payment Currencies.. |



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| Sr. No. | Data Required | Sub-Clause | Data |
|---|---|---|---|
| | Foreign: | | |
| 42. | Currencies and Proportions for Payment of Delay Damages | 14.15(c) | Currency: PKR<br>Proportions: Table C - Summary of Payment Currencies |
| 43. | Rates of Exchange | 14.15(g) | The date for exchange rate shall be 28-days prior to the submission of invoice. |
| 44. | Forces of Nature | 17.2(d) | Nil |
| 45. | Permitted Deductible Limits:<br>i. Insurance required for the Works<br>ii. Insurance required for Goods<br>iii. Insurance required for Liability for Breach of Professional Duty.<br>iv. Insurance required against Liability for Fitness purpose (if any is required)<br>v. Insurance required for Injury to Persons and Damage to Property<br>vi. Insurance required for injury to Employees<br>vii. Other Insurances required by Laws and by local practice: | 19.1 | i. 1.15 times of replacement cost<br>ii. Nil<br>iii. Nil<br>iv. Nil<br>v. Nil<br>vi. Nil<br>vii. Nil |



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| Sr. No. | Data Required | Sub-Clause | Data |
|---|---|---|---|
| 46. | (a) Evidence of Insurance<br>(b) Relevant Policies | 19.1.1 (a)<br>19.1 (a) & 19.1(b) | a) Not later than commencement date.<br>b) Within Twenty-eight (28) days from the commencement date. |
| 47. | Additional amount to be Insured (as a percentage of the replacement value, if less or more than 15%). | 19.2.1(b) | 15% of replacement value (Accepted Contract Amount). |
| 48. | • Extent of insurance required for Goods.<br>• Amount of Insurance required for Goods. | 19.2.2 | • From Ex-Works (i.e., works, factory, warehouse, etc.) to delivery at site.<br>• Full replacement Value. |
| 49. | Amount of Insurance required for Liability for Breach of Professional Duty (Design Works) | 19.2.3(a) | Full replacement value of the works to be designed by the EPC Contractor. |
| 50. | Insurance required against Liability for Fitness purpose | 19.2.3(b) | Yes |
| 51. | Period of Insurance required for Liability for Breach of Professional Duty (Design Works) | 19.2.3 | Two (02) years from the stipulated date of completion of construction. |
| 52. | Amount of Insurance required for Injury to Persons and Damage to Property. | 19.2.4 | Injury to person and Fatal case:<br>Please refer to Schedule IV of Workman Compensation Act 1924 amended up to date.<br>Damage to Property:<br>Six Thousand Rupees (PKR 6000) per square feet. |



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| Sr. No. | Data Required | Sub-Clause | Data |
|---|---|---|---|
| 53. | Other Insurances required by Laws and by local practice (give details.) | 19.2.6 | All insurances as applicable, to the extent of execution of the project, under Federal and Provincial laws of Islamic Republic of Pakistan |
| 54. | Time for Appointment of DAAB | 21.1 | 42 days after signature by both parties of the Contract Agreement |
| 55. | The DAAB shall comprise | 21.1 | Three (03) members |
| 56. | List of proposed Members of DAAB<br>- proposed by Employer<br>- proposed by EPC Contractor | 21.1 | Proposed by Employer<br>*1.Engr Dr Mahmood Ahmad Sulehri*<br>*2.Muhammad Amin*<br>*3. Mushtaq Ahmad Somra*<br>Proposed by EPC Contractor [Attach CVs to the Contract]<br>1._____<br>2._____<br>3._____<br>To be provided in due course of time. |
| 57. | Appointing Entity (official) for DAAB Members | 21.2 | Chairman Pakistan Engineering Council. |
| 59. | The language of Arbitration shall be:<br>The Place of Arbitration shall be:<br>Rules of Arbitration: | 21.6 | PEC Rules of Conciliation and Arbitration or Pakistan Arbitration Act of 1940, if the former is inactive.<br>The place of Arbitration shall be in the Employer's country:<br>Lahore, Pakistan. |



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## Summary of Procedure for Delay Damages for Interface Milestones

The dates to be given in Table 2 shall be finalized during the final pre-award negotiations with the preferred Package-I and Package-III Proposers to be mutually acceptable.

The procedure for determining Delay Damages due to failure to meet the Inter-Contract Milestone dates for each Section of the Works given in Table 2 shall be as follows:

### Introduction

The intent of this procedure is to minimize any delay in taking over the generating units. For the purposes of this clause, it is assumed that all the Works are scheduled on the critical path with no float. The penalty per day for not meeting an interface date (a date one EPC Contractor needs to hand an area of the works to the other EPC Contractor) should therefore be the value of the actual loss expected to be incurred by WAPDA for not being able to generate for one day on one unit. A corresponding benefit will be credited for time saved although no benefit will be payable for completion in advance of the date in the Contract schedule.

### Definition

An interface date is a date on which one EPC Contractor is scheduled to hand over a part of the work to the other EPC Contractor. These interface dates are provided in the table below (Table- 2). The selected interface dates are considered critical for the timely completion of the works. The recovery amount for each day recovered, when a delay has already occurred, shall be the same as the penalty amount per day.

### Reduction and Recovery Amounts in Contract Price

The reduction in the contract price for each day an interface date is missed shall be PKR 4,700,000/- as this reflects the true measure of the lost income due to reduced generating capacity. This amount has been determined by dividing the value of the expected average annual energy generated by the Attabad Lake HPP (in MWh) by 365 (days) and three (the number of new generating units), and then multiplying by the value of energy (PKR/MWh).

### Procedure

The EPC Contractors are expected to plan their work such that all the intermediate dates in the contract schedule are met.

It is intended that any delay in achieving a milestone will be recovered as soon as possible from subsequent milestones. The Civil Works and E&M Works EPC Contractors will each have a milestone "account" for delay costs and recovery benefits. No monetary transfers will take place to or from this account until the completion of each Section of the works.

The account will work as follows: If a particular milestone is completed late, the account for the responsible EPC Contractor will be debited accordingly. Should this occur, the duration of the remaining tasks will remain the same, but the completion date for that section will be extended by the amount of the delay. If an EPC Contractor can complete a subsequent task in less time than allowed, their account will be credited with the time saved until the work stream is brought back on schedule.

No credit will be given for completing any milestone before the date for that milestone, as given in the table-2, because it is considered unlikely that the EPC Contractor responsible for the subsequent activity will be in a position to take advantage of early handover.



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Payments to or deductions from each EPC Contractor, based on the sum of all credits and debits for each section of the works, will only be made once the final milestone for that section has been achieved.

**Example of Operation of the Procedure**

If the E&M EPC Contractor is given access to start work on time but then takes three days longer than contracted to complete the next milestone, his account will be debited by the value of the three-day delay. If the Civil Works EPC Contractor can recover those three days or a proportion thereof (whole days only) when undertaking the next task, then his account will be credited for the time saved at the same rate. The maximum credit in this case would be three days, as that would bring the works back on schedule. If the Civil Works EPC Contractor is only able to recover two days, the works will be returned to the EM EPC Contractor one day behind schedule. If the E&M EPC Contractor can recover this day, his account will be credited accordingly. This process continues from the start of work on each section of the works and ends when the plant is taken over.

**Extensions of Time**

The above process will take place without reference to any claims for Extension of Time that might be under review for the concerned works. The effect of the above process will be considered as part of the Extension of Time adjudication.

**Table-1 Time Schedule for Delay Damages for Delayed Completion of Units**

| Unit No. | Date | Per Day Delay Damages (PKR) |
|---|---|---|
| Unit-1 (Commercial Operation) | 37 Months from the date of commencement | 4,700,000 |
| Unit-2 (Commercial Operation) | 39 Months from the date of commencement | 4,700,000 |
| Unit-3 (Commercial Operation) | 41 Months from the date of commencement | 4,700,000 |

**Table-2 Time Schedule of Inter-Contract Milestones**

| Sr. No. | Inter-Contract Milestone | Dates of Completion *(To be provided by EPC Contractor)* | Responsible EPC Contractor |
|---|---|---|---|
| **Unit 1 and items necessary to commission** | | | |
| **Unit 1:** | | | |
| 1 | Powerhouse completed to top roof level and ready for installation of rails and overhead travelling crane (for installation of Stay Ring) | | Civil Works |
| 2 | Make erection bay ready for use by the E&M EPC Contractor | | Civil Works |



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| Sr. No. | Inter-Contract Milestone | Dates of Completion *(To be provided by EPC Contractor)* | Responsible EPC Contractor |
|---|---|---|---|
| | | | |
| 3 | Hand draft tube area over to the E&M EPC Contractor for first stage of draft tube erection | | Civil Works |
| 4 | Take first stage draft tube over from the E&M EPC Contractor for embedment and E&M EPC Contractor continue the second stage of Draft tube erection | | E&M Works |
| 5 | Hand spiral case area over to the E&M EPC Contractor | | Civil Works |
| 6 | Take spiral case over from the E&M EPC Contractor for embedment and construction up to generator foundations | | E&M Works |
| 7 | Hand generator foundations and turbine floor area to E&M EPC Contractor for machine erection | | Civil Works |
| 8 | Hand Office Buildings to E&M EPC Contractor with working main services | | Civil Works |
| 9 | Unit 1 Start or Commercial Operation (Ready for Reliability Run) | | E&M Works |
| **Unit 2** | | | |
| 10 | Hand draft tube area over to the E&M EPC Contractor for first stage of draft tube erection | | Civil Works |
| 11 | Take first stage draft tube over from the E&M EPC Contractor for embedment and E&M EPC Contractor continued he second stage of Draft tube erection | | E&M Works |
| 12 | Hand spiral case area over to the E&M EPC Contractor for erection | | Civil Works |
| 13 | Take spiral case over from the E&M EPC Contractor for embedment and construction up to generator foundations | | EM Works |
| 14 | Hand generator foundations and turbine floor area to E&M EPC Contractor for machine erection | | Civil Works |
| 15 | Unit 2 Start of Commercial Operation (Ready for Reliability Run) | | E&M Works |
| **Unit 3** | | | |
| 16 | Hand draft tube area over to the E&M EPC Contractor for first stage of draft tube erection | | Civil Works |



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| Sr. No. | Inter-Contract Milestone | Dates of Completion *(To be provided by EPC Contractor)* | Responsible EPC Contractor |
|---|---|---|---|
| 17 | Take first stage draft tube over from the E&M EPC Contractor for embedment and E&M EPC Contractor continue the second stage of Draft tube erection | | E&M Works |
| 18 | Hand spiral case area over to the E&M EPC Contractor for erection | | Civil Works |
| 19 | Take spiral case over from the E&M EPC Contractor for embedment and construction up to generator foundations | | E&M Works |
| 20 | Hand generator foundations and turbine floor area to E&M EPC Contractor for machine erection | | Civil Works |
| 21 | Unit 3 Start of Commercial Operation (Ready for Reliability Run) | | E&M Works |
| 22 | Hand Finished site to Employer | | Civil Works |



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## Part B - Special Provisions

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| **Sub-clause 1.1.24**<br>**Defects Notification Period or DNP** | Add the following text at the end:<br>'as certified under sub-clause 10.1 (Taking Over the Works and Sections). |
| **Sub-Clause 1.1.42**<br>**Key Personnel** | On the third line, "Specification" is replaced with "Employer's Requirements". |
| **Sub-Clause 1.1.43**<br>**Laws** | **"Laws"** means all Applicable Law of Pakistan, national (or state) legislation, statutes, ordinances and other laws, and regulations and by-laws of any legally constituted public authority. |
| **Sub-Clause 1.1.67**<br>**Site** | The Sub-clause is replaced with: "**Site**" means the places where the Permanent Works are to be executed, including storage and working area, and to which Plant and Materials are to be delivered, and any other places specified in the Contract as forming part of the Site. |
| **Sub-Clause 1.1.73**<br>**Tender** | The word 'Bid' is synonymous with 'Proposal' and the words 'Bid Documents' are synonymous with 'Proposal Documents.' |
| **Sub-Clause 1.1.74**<br>**Tests after Completion** | On the second line, "Specification" is replaced with "Employer's Requirements". |
| **Sub-Clause 1.1.78**<br>**Variation** | On the first line, "any change to the Works" is replaced with "any change to the Employer's Requirements or the Works". |
| **Sub-Clause 1.1.81, 1.1.82 and 1.1.83 are added after Sub-Clause 1.1.80.** | |
| **Sub-Clause 1.1.81**<br>**Project** | "Project" means Attabad Lake Hydropower Project (54 MW) to be constructed on the natural built lake at Attabad village on Hunza River. |
| **Sub-Clause 1.1.82**<br>**ES** | **"ES"** means environmental and social (including Sexual Exploitation and Abuse (SEA), and Sexual Harassment (SH))." |
| **Sub-Clause 1.1.83 Letter of Acceptance** | **"Letter of Acceptance"** means the letter of formal acceptance of Contract Amount, signed by the Employer, of the Letter of Proposal, including any annexed memorandum Comprising agreements between and signed by both Parties. |
| **Sub-Clause 1.1.84**<br>**Milestone** | "Milestone" means a part of the Works stated in the Contract Data (if any), and described in detail in the Employer's Requirements as a Milestone, which is to be completed by the time for completion stated in Sub-Clause 4.26 [*Milestones*] but is not to be taken over by the Employer after completion. |



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| **Sub-Clause 1.1.85 Accepted Contract Amount** | **"Accepted Contract Amount"** means the proposal price, excluding provisional sums and the provision, if any for contingencies in the Schedule of Rates and Prices (if any), but including Daywork items. |
| **Sub-Clause 1.2**<br><br>**Interpretation** | (a) is replaced with: "(a) Words indicating one gender include all genders; and<br><br>"he/she" is replaced with:" it";<br><br>"him/her" is replaced with "it";<br><br>"his" and "his/her" are replaced with: "its";<br><br>"himself/herself" are replaced with: "itself".<br><br>Further, "and" is deleted from the end of sub-paragraph (i) and added at the end of sub-paragraph (j).<br><br>sub-paragraph (k) is added:<br>The word "tender" is synonymous with "Bid" or "Proposal", the word tenderer with "Bidder" or "Proposer" and the words "tender documents" with "Request for Bids Documents" or "Request for Proposal Documents" or "Bidding/Bid document(s)", as applicable." |
| **Sub-Clause 1.5**<br><br>**Priority of Documents** | Replace the list of documents from (a) to (i) with the following:<br><br>a) the Contract Agreement<br>b) the Letter of Acceptance<br>c) the Letter of Proposal<br>d) the Particular Conditions Part A - Contract Data<br>e) the Particular Conditions Part B - Special Provisions<br>f) the General Conditions<br>g) the Employer's Requirements<br>h) the Schedule of Prices<br>i) the completed Schedules<br>j) the Proposal<br>k) the JV Agreement (if the EPC Contractor is a JV), and<br>l) any other document forming part of the Contract. |
| **Sub-Clause 1.6**<br><br>**Contract Agreement** | In the Last line of the 1st paragraph the text "shall be borne by the Employer" is substituted by "shall be reimbursed by the Employer to EPC Contractor". |
| **Sub-Clause 3.1**<br><br>**The Employer's Representative** | The Employer' Representative shall obtain the consent in writing of the Employer before taking action under the following Sub-Clauses of these Conditions:<br><br>(a) Sub-Clause 8.5 [Extension of Time for Completion]: agreeing or determining an extension of time<br><br>(b) Any action under Sub-Clauses 8.9 [Employer's Suspension], 8.10 [Consequences of Employer's |



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| | Suspension], 8.11 [Payment for Plant and Materials after Employer's Suspension], 8.12 [Prolonged Suspension] and 8.13 [Resumption of Work].<br><br>(c) Issuance of "Taking Over Certificate" under Sub-Clause 10.1 & 10.2 [Taking Over the Works and Sections].<br><br>(d) Issuing the "Performance Certificate" under Sub-Clause 11.9 [Performance Certificate].<br><br>(e) Sub-Clause 13.1 [Right to Vary]: instructing a Variation, except;<br><br>(i) in an emergency situation as determined by the Engineer, or<br><br>(f) Sub-Clause 13.3 [Variation Procedure]: approving a Proposal for Variation submitted by the EPC Contractor in accordance with Sub-Clause 13.1 [Right to Vary] or 13.2 [Value Engineering].<br><br>(g) Certifying release of second half of the Retention Money under Sub-Clause 14.9 [Release of Retention Money].<br><br>(h) Issuing Final Payment Certificate under Sub-Clause 14.13 [Application of Interim Payment].<br><br>(i) Agreeing or determining EOT and/or additional payment under Sub-Clause 20.2 [Claims for Payment and/or EOT].<br><br>(k) Special approval of Employer is required for inclusion or removal of subcontractor.<br><br>Notwithstanding the obligation, as set out above, to obtain approval, if, in the opinion of the Employer's Representative, an emergency occurs affecting the safety of life or of the Works or of adjoining property, he may, without relieving the EPC Contractor of any of his duties and responsibility under the Contract, instruct the EPC Contractor to execute all such work or to do all such things as may, in the opinion of the Engineer, be necessary to abate or reduce the risk. The EPC Contractor shall forthwith comply, despite the absence of approval of the Employer, with any such instruction of the Employer's Representative. The Employer's Representative shall determine an addition to the Contract Price, in respect of such instruction, in accordance with Clause 13 and shall notify the EPC Contractor accordingly, with a copy to the Employer. |
| **Sub-Clause 3.2**<br><br>**Other Employer's Personnel** | <u>Following paragraph is added at the end of this clause:</u><br>The Employer has appointed The Management Consultants named as Attabad Hydropower Management Consultants (AHMC) comprising of national and international firms with |



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| | National Engineering Services (NESPAK) as lead firm through a consultancy contract to assist Employer's Representative to perform the duties assigned to him.<br><br>AHMC shall act as the Technical Advisor and shall assist the Employer's Representative in reviewing the EPC Contractor's submissions, assist in contract administration and provide recommendations Technical and Contractual matters. The Employer's Representative shall, however, retain final decision-making authority. |
| **Sub-Clause 4.2**<br><br>**Performance Security** | Sub-Clause 4.2.1 "EPC Contractor's Obligations"<br><br>The first paragraph has been substituted with the following:<br><br>"The EPC Contractor shall deliver the Performance Security to the Employer within 28 days after receipt of the Letter of Acceptance. The Performance Security shall be in the form of a Bank Guarantee issued by, at the option of the EPC Contractor, either (a) any Scheduled Bank in Pakistan or (b) a bank located outside Pakistan duly counter-guaranteed by a Scheduled Bank in Pakistan and shall be in the prescribed form." |
| **Sub-Clause 4.3**<br><br>**EPC Contractor's Representative** | The following sentence is added at the end of the Sub-Clause:<br><br>"If the EPC Contractor's Representative's delegates are not fluent in the said language, the EPC Contractor shall make competent interpreters available during all working hours in a number deemed sufficient by the Employer." |
| **Sub-Clause 4.4**<br><br>**Subcontractors** | The following is added at the beginning of the second paragraph:<br><br>"The EPC Contractor shall require in all subcontracts relating to the Works that Subcontractors execute the Works in accordance with the Contract, including complying with the relevant ES requirements and the SEA/SH Prevention and Response Obligations.<br><br>All subcontracts relating to the Works shall include a provision stipulating that the Sub-contractor accepts that the Employer may disqualify the Sub-contractor from being awarded a Government of Pakistan financed contract for a period of two years if the Sub-contractor is determined to have failed to comply with its SEA/SH Prevention and Response Obligations."<br><br>The following is added at the end of the last paragraph of Sub-Clause 4.4:<br><br>"All subcontracts relating to the Works shall include provisions which entitle the Employer to require the subcontract to be |



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| | assigned to the Employer under sub-paragraph (a) of Sub-Clause 15.2.3 [After Termination].<br><br>Where practicable, the EPC Contractor shall give fair and reasonable opportunity for EPC contractors from the Country to be appointed as Sub-contractors."<br><br>4.4.1 Specialized Sub-contractor<br>The Specialized Subcontractor means the Subcontractor duly evaluated during the selection of the EPC Contractor for specialized job. |
| **Sub-Clause 4.5**<br><br>**Nominated Subcontractors** | Not Applicable |
| **Sub-Clause 4.6**<br><br>**Co-operation** | On the second-last line of the first paragraph before "EPC Contractor's", add "of the".<br><br>The following is added after the first paragraph:<br><br>"The EPC Contractor shall also, as be stated in the Employer's Requirements or as instructed by the Employer, cooperate with and allow appropriate opportunities for the Employer's Personnel to conduct any environmental and social assessment." |
| **Sub-Clause 4.8**<br><br>**Health and Safety Obligations** | The following are included after deleting "and" at the end of (f) and replacing "." with "; and" at the end of (g):<br><br>(h) where a health service provider for the Contract is stated in the Employer's Requirements, provide all reasonable assistance (room, accommodation, water etc.) to enable the service provider to perform its functions;<br><br>(i) provide health and safety training of EPC Contractor's Personnel as appropriate and maintain training records;<br><br>(j) actively engage the EPC Contractor's Personnel in promoting understanding, and methods for, implementation of health and safety requirements, as well as in providing information to EPC Contractor's Personnel, training on occupational safety and health, and provision of personal protective equipment without expense to the EPC Contractor's Personnel;<br><br>(k) put in place workplace processes for EPC Contractor's Personnel to report work situations that they believe are not safe or healthy, and to remove themselves from a work situation which they have reasonable justification to believe |



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| | presents an imminent and serious danger to their life or health.<br><br>(l) EPC Contractor's Personnel who remove themselves from such work situations shall not be required to return to work until necessary remedial action to correct the situation has been taken. EPC Contractor's Personnel shall not be retaliated against or otherwise subject to reprisal or negative action for such reporting or removal;<br><br>(m) subject to Sub-Clause 4.6, where the Employer's Personnel, any other EPC Contractors employed by the Employer, and/or personnel of any legally constituted public authorities and private utility companies are employed in carrying out, on or near the site, of any work not included in the Contract, collaborate in applying the health and safety requirements, without prejudice to the responsibility of the relevant entities for the health and safety of their own personnel; and<br><br>(n) establish and implement a system for regular (not less than six-monthly) review of health and safety performance and the working environment."<br><br>The second and third paragraphs are replaced with the following:<br><br>"Subject to Sub-Clause 4.1, the EPC Contractor shall submit to the Employer for Review a health and safety manual which has been specifically prepared for the Works, the Site and other places (if any) where the EPC Contractor intends to execute the Works. The procedures for Review of the health and safety manual and its updates shall be as described in Sub-Clause 5.2 (EPC Contractor's Documents).<br><br>The health and safety manual shall set out all the health and safety requirements under the Contract,<br><br>(a) which shall include at a minimum:<br><br>(i) the procedures to establish and maintain a safe working environment without risk to health at all workplaces, machinery, equipment and processes under the control of the EPC Contractor, including control measures for chemical, physical and biological substances and agents;<br><br>(ii) details of the training to be provided, records to be kept;<br><br>(iii) the procedures for prevention, preparedness and response activities to be implemented in the case of |



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| | an emergency event (i.e., an unanticipated incident, arising from both natural and man-made hazards, typically in the form of fire, explosions, leaks or spills, which may occur for a variety of different reasons including failure to implement operating procedures that are designed to prevent their occurrence, extreme weather or lack of early warning);<br><br>(iv) the measures to be taken to avoid or minimize the potential for community exposure to water-borne, water-based, water-related, and vector-borne diseases,<br><br>(v) the measures to be implemented to avoid or minimize the spread of communicable diseases (including transfer of Sexually Transmitted Diseases or Infections (STDs), such as HIV virus) and non-communicable diseases associated with the execution of the Works, taking into consideration differentiated exposure to and higher sensitivity of vulnerable groups. This includes taking measures to avoid or minimize the transmission of communicable diseases that may be associated with the influx of temporary or permanent Contract-related labour;<br><br>(vi) the policies and procedures on the management and quality of accommodation and welfare facilities if such accommodation and welfare facilities are provided by the EPC Contractor in accordance with Sub-Clause 6.6; and<br><br>(b) any other requirements stated in the Employer's Requirements."<br><br>The paragraph starting with: "In addition to the reporting requirement of…" is deleted and replaced with the addition to GC Sub-Clause 4.20 in Sub-Clause 4.20 of the Special Provisions. |
| **Sub-Clause 4.15**<br><br>**Access Route** | The following is added at the end of Sub-Clause 4.15:<br><br>"The EPC Contractor shall take all necessary safety measures to avoid the occurrence of incidents and injuries to any third party associated with the use of, if any, EPC Contractor's Equipment on public roads or other public infrastructure.<br><br>The EPC Contractor shall monitor and use road safety incidents and accidents reports to identify negative safety issues, and establish and implement necessary measures to resolve them." |



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| **Sub-Clause 4.16**<br><br>**Transport of Goods** | The following is added at the end:<br><br>The EPC Contractor shall duly consider the nature, volume and weight of all Plant and major items of the Goods for the safe inland transportation up to the Site. After consultation with the Employer, the EPC Contractor shall, at its own risk and cost, use the most appropriate route for transporting the Plant and Goods without causing the impediments to the public transport and without causing any delay to the approved program of the Works. |
| **Sub-Clause 4.18**<br><br>**Protection of the Environment** | The Sub-Clause is replaced with: "The EPC Contractor shall take all necessary measures to:<br><br>(a) protect the environment (both on and off the Site); and<br><br>(b) limit damage and nuisance to people and property resulting from pollution, noise and other results of the EPC Contractor's operations and/ or activities.<br><br>The EPC Contractor shall ensure that emissions, surface discharges, effluent and any other pollutants from the EPC Contractor's activities shall exceed neither the values indicated in the Employer's Requirements, nor those prescribed by applicable Laws.<br><br>In the event of damage to the environment, property and/or nuisance to people, on or off Site as a result of the EPC Contractor's operations, the EPC Contractor shall agree with the Employer the appropriate actions and time scale to remedy, as practicable, the damaged environment to its former condition. The EPC Contractor shall implement such remedies at its cost to the satisfaction of the Employer." |
| **Sub-Clause 4.20**<br><br>**Progress Reports** | At the end of sub-paragraph (g) the word "and" is deleted and at the end of sub-paragraph (h) the full stop (.) is replaced with ";", and the following new sub-paragraphs are added as:<br><br>(i) planned programme for the execution of the Works for next 56 days to enable the Engineer to determine its programme of inspection and testing;<br><br>(j) monthly summery of daily job record indicating weather conditions, deployment of EPC Contractor's Equipment, labour employment, local material procurement and material import, if any; and<br><br>(k) salient contractual and project information. |
| **Sub-Clause 4.21**<br><br>**Security of the Site** | Sub-Clause 4.21 is replaced with:<br><br>**"**The EPC Contractor shall be responsible for the security of the Site, and: |



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| | (a) for keeping unauthorized persons off the Site;<br><br>(b) authorized persons shall be limited to the EPC Contractor's Personnel, the Employer's Personnel, and to any other personnel identified as authorized personnel (including the Employer's other EPC Contractors on the Site), by a Notice from the Employer to the EPC Contractor; and<br><br>Subject to Sub-Clause 4.1, the EPC Contractor shall submit for the Employer's No-objection a security management plan that sets out the security arrangements for the Site.<br><br>The EPC Contractor shall (i) conduct appropriate background checks on any personnel retained to provide security; (ii) train the security personnel adequately (or determine that they are properly trained) in the use of force (and where applicable, firearms), and appropriate conduct towards EPC Contractor's Personnel, Employer's Personnel and affected communities; and (iii) require the security personnel to act within the applicable Laws and any requirements set out in the Employer's Requirements.<br><br>The EPC Contractor shall not permit any use of force by security personnel in providing security except when used for preventive and defensive purposes in proportion to the nature and extent of the threat.<br><br>In making security arrangements, the EPC Contractor shall also comply with any additional requirements stated in the Employer's Requirements." |
| **Sub-Clause 4.22**<br><br>**EPC Contractor's Operations on Site** | On the third line of the second paragraph before "4.17", "Sub-Clause" is added. |
| **Sub-Clause 4.23 Archaeological and Geological Findings** | The first paragraph is replaced with the following:<br><br>"All fossils, coins, articles of value or antiquity, structures, groups of structures, and other remains or items of geological, archaeological, paleontological, historical, architectural or religious interest found on the Site shall be placed under the care and custody of the Employer. The EPC Contractor shall:<br><br>(a) take all reasonable precautions, including fencing-off the area or site of the finding, to avoid further disturbance and prevent EPC Contractor's Personnel or other persons from removing or damaging any of these findings;<br><br>(b) train relevant EPC Contractor's Personnel on appropriate actions to be taken in the event of such findings; and |

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| | (c) implement any other action consistent with the requirements of the Employer's Requirements and relevant Laws." |
| **Sub-Clause 4.24**<br><br>**Suppliers (other than Subcontractors)** | The following Sub-Clause is added:<br><br>**4.24.1 Forced Labor**<br><br>The EPC Contractor shall take measures to require its suppliers (other than Subcontractors) not to employ or engage forced labor including trafficked persons as described in Sub-Clause 6.21. If forced labor/trafficking cases are identified, the EPC Contractor shall take measures to require the suppliers to take appropriate steps to remedy them. Where the supplier does not remedy the situation, the EPC Contractor shall within a reasonable period substitute the supplier with a supplier that is able to manage such risks.<br><br>**4.24.2 Child labor**<br><br>The EPC Contractor shall take measures to require its suppliers (other than Subcontractors) not to employ or engage child labor as described in Sub-Clause 6.22. If child labor cases are identified, the EPC Contractor shall take measures to require the suppliers to take appropriate steps to remedy them. Where the supplier does not remedy the situation, the EPC Contractor shall within a reasonable period substitute the supplier with a supplier that is able to manage such risks.<br><br>**4.24.3 Serious Safety Issues**<br><br>The EPC Contractor, including its Subcontractors, shall comply with all applicable safety obligations, including as stated in Sub-Clauses 4.4, 4.8 and 6.7. The EPC Contractor shall also take measures to require its suppliers (other than Subcontractors) to adopt procedures and mitigation measures adequate to address safety issues related to their personnel. If serious safety issues are identified, the EPC Contractor shall take measures to require the suppliers to take appropriate steps to remedy them. Where the supplier does not remedy the situation, the EPC Contractor shall within a reasonable period substitute the supplier with a supplier that is able to manage such risks.<br><br>**4.24.4 Obtaining natural resource materials in relation to supplier**<br><br>The EPC Contractor shall obtain natural resource materials from suppliers that can demonstrate, through compliance with the applicable verification and/ or certification requirements, that obtaining such materials is not contributing to the risk of significant conversion or significant degradation of natural or |



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| | critical habitats such as unsustainably harvested wood products, gravel or sand extraction from river beds or beaches.<br><br>If a supplier cannot continue to demonstrate that obtaining such materials is not contributing to the risk of significant conversion or significant degradation of natural or critical habitats, the EPC Contractor shall within a reasonable period substitute the supplier with a supplier that is able to demonstrate that they are not significantly adversely impacting the habitats |
| **Sub-Clause 4.25**<br><br>**Code of Conduct** | The following is added as Sub-Clause 4.25:<br><br>"The EPC Contractor shall take all necessary measures to ensure that each EPC Contractor's Personnel is made aware of the Code of Conduct including specific behaviors that are prohibited, and understands the consequences of engaging in such prohibited behaviors.<br><br>These measures include providing instructions and documentation that can be understood by the EPC Contractor's Personnel and seeking to obtain that person's signature acknowledging receipt of such instructions and/or documentation, as appropriate.<br><br>The EPC Contractor shall also ensure that the Code of Conduct is visibly displayed in multiple locations on the Site and any other place where the Works will be carried out, as well as in areas outside the Site accessible to the local community and project affected people. The posted Code of Conduct shall be provided in languages comprehensible to EPC Contractor's Personnel, Employer's Personnel and the local community.<br><br>The EPC Contractor's Management Strategy and Implementation Plans shall include appropriate processes for the EPC Contractor to verify compliance with these obligations" |
| **Sub-Clause 4.26**<br><br>**Milestones** | The following Sub-Clause is added:<br><br>"If no Milestones are specified in the Contract Data, this Sub-Clause shall not apply.<br><br>The EPC Contractor shall complete the works of each Milestone (including all work which is stated in the Employer's Requirements as being required for the Milestone to be considered complete) within the time for completion of the milestone, as stated in the Contract Data, calculated from the Commencement Date.<br><br>The EPC Contractor shall include, in the initial Programme and each revised Programme, under sub-paragraph (a) of Sub-Clause 8.3 [Programme], the time for completion of each Milestone. |



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| | Sub-paragraph (d) of Sub-Clause 8.4 [Advance Warning] and Sub-Clause 8.5 [Extension of the Time for Completion] shall apply to each Milestone, such that "Time for Completion" under Sub-Clause 8.5 shall be read as the time for completion of a Milestone under this Sub-Clause.<br><br>The EPC Contractor may apply, by Notice to the Employer's Representative, for a Milestone certificate not earlier than 14 days before the works of a Milestone will, in the EPC Contractor's opinion, be complete. The Employer's Representative shall, within 28 days after receiving the Contactor's Notice:<br><br>(a) issue the Milestone Certificate to the EPC Contractor, stating the date on which the works of a Milestone were completed in accordance with the Contract, except for any minor outstanding work and defects (as shall be listed in the Milestone Certificate); or<br><br>(b) reject the application, giving reasons and specifying the work required to be done and defects required to be remedied by the EPC Contractor to enable the Milestone Certificate to be issued.<br><br>The EPC Contractor shall then complete the work referred to in subparagraph (b) of this Sub-Clause before issuing a further Notice of application under this Sub-Clause.<br><br>If the Employer's Representative fails either to issue the Milestone Certificate or to reject the EPC Contractor's application within the above period of 28 days, and if the works of a Milestone are completed in accordance with the Contract, the Milestone Certificate shall be deemed to have been issued on the date which is 14 days after the date stated in the EPC Contractor's Notice of application.<br><br>If delay damages for a Milestone are stated in the Contract Data, and if the EPC Contractor fails to complete the works of the Milestone within the time for completion of the Milestone (with any extension under this Sub-Clause):<br><br>(i) the EPC Contractor shall, subject to Sub-Clause 20.1 [Claims], pay delay damages to the Employer for this default;<br><br>(ii) such delay damages shall be the amount stated in the Contract Data, for every day which shall elapse between the time for completion for the Milestone (with any extension under this Sub-Clause) and the date stated in the Milestone Certificate; |



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| | (iii) these delay damages shall be the only damages due from the EPC Contractor for such default; and<br><br>(iv) the total amount of delay damages for all Milestones shall not exceed the maximum amount stated in the Contract Data (this shall not limit the EPC Contractor's liability for delay damages in any case of fraud, gross negligence, deliberate default or reckless misconduct by the EPC Contractor)." |
| **Sub-Clause 5.1 General Design Obligations** | In the last paragraph, the provisions of sub-paragraph (d) are deleted in their entirety. |
| **Sub-Clause 5.2**<br><br>**EPC Contractor's Documents** | 5.2.2 <u>Review by Employer</u><br><br>Add the following para at the end:<br><br>If the Employer requires more time to review the EPC Contractor's documents, then he will notify the EPC Contractor of such additional time required by him before the expiry of review period. In such cases if the EPC Contractor suffers any delay, then the EPC Contractor may be entitled to request for Extension of Time under Sub- Clause 8.5. |
| **Sub-Clause 5.4**<br><br>**Technical Standards and Regulations** | The following is added as a second paragraph:<br><br>"If so, stated in the Employer's Requirements, the EPC Contractor shall:<br><br>(a) take to account climate change considerations in the design of structural elements of the Works and new buildings if any; and<br><br>(b) apply the concept of universal access to the design and construction of structures and new buildings if any (the concept of universal access means unimpeded access for people of all ages and abilities in different situations and under various circumstances.) |
| **Sub-Clause 6.1**<br><br>**Engagement of Staff and Labour** | On the first line, "Specification" is replaced with "Employer's Requirements".<br><br>The following paragraphs are added at the end of the Sub-Clause:<br><br>"The EPC Contractor shall provide the EPC Contractor's Personnel information and documentation that are clear and understandable regarding their terms and conditions of employment. The information and documentation shall set out their rights under relevant labor Laws applicable to the EPC Contractor's Personnel (which will include any applicable collective agreements), including their rights related to hours of |



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| | work, wages, overtime, compensation and benefits, as well as those arising from any requirements in the Employer's Requirements. The EPC Contractor's Personnel shall be informed when any material changes to their terms or conditions of employment occur.<br><br>The EPC Contractor is encouraged, to the extent practicable and reasonable, to employ staff and labour with appropriate qualifications and experience from sources within the Country." |
| **Sub-Clause 6.2**<br><br>**Rates of Wages and Conditions of Labor** | The following paragraphs are added at the end of this Sub-Clause:<br><br>"The EPC Contractor shall inform the EPC Contractor's Personnel about:<br><br>(a) any deduction to their payment and the conditions of such deductions in accordance with the applicable Laws or as stated in the Employer's Requirements; and<br><br>(b) their liability to pay personal income taxes in the Country in respect of such of their salaries, wages, allowances and any benefits as are subject to tax under the Laws of the Country for the time being in force.<br><br>The EPC Contractor shall perform such duties in regard to such deductions thereof as may be imposed on him by such Laws.<br><br>Where required by applicable Laws or as stated in the Employer's Requirements, the EPC Contractor shall provide the EPC Contractor's Personnel written notice of termination of employment and details of severance payments in a timely manner. The EPC Contractor shall have paid the EPC Contractor's Personnel (either directly or where appropriate for their benefit) all due wages and entitlements including, as applicable, social security benefits and pension contributions, on or before the end of their engagement / employment." |
| **Sub-Clause 6.5**<br><br>**Working Hours** | Delete the entire text and replace with the following:<br><br>Working hours shall be observed by the EPC Contractor as stipulated in the Labor Laws of Pakistan. However, when deemed necessary to expedite the Works, overtime, night time or holiday working may be allowed by the Employer upon the EPC Contractor's request. The EPC Contractor in these cases shall pay all the costs of Employer and his staff for such overtime, night time and holiday working at Site. |
| **Sub-Clause 6.6**<br><br>**Facilities for Staff and Labor** | The following is added as the last paragraph:<br><br>"If stated in the Employer's Requirements, the EPC Contractor shall give access to or provide services that accommodate the physical, social and cultural needs of the EPC Contractor's |



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| | Personnel. The EPC Contractor shall also provide similar facilities for the Employer's Personnel as stated in the Employer's Requirements." |
| **Sub-Clause 6.7**<br><br>**Health and Safety of Personnel** | In the second paragraph, replace "The EPC Contractor" with:<br><br>"Except as otherwise stated in the Employer's Requirements, the EPC Contractor…" |
| **Sub-Clause 6.8**<br><br>**EPC Contractor's Superintendence** | The following paragraph is added at the end:<br><br>If the EPC Contractor's superintending staff is not fluent in English language, the EPC Contractor shall make competent interpreters available during all working hours in a number deemed sufficient by the Employer. |
| **Sub-Clause 6.9**<br><br>**EPC Contractor's Personnel** | The Sub-Clause is replaced with:<br><br>"The EPC Contractor's Personnel (including Key Personnel, if any) shall be appropriately qualified, skilled, experienced and competent in their respective trades or occupations.<br><br>The Employer may require the EPC Contractor to remove (or cause to be removed) any person employed on the Site or Works, including the EPC Contractor's Representative and Key Personnel (if any), who:<br><br>(a) persists in any misconduct or lack of care;<br>(b) carries out duties incompetently or negligently;<br>(c) fails to comply with any provision of the Contract;<br>(d) persists in any conduct which is prejudicial to safety, health, or the protection of the environment;<br>(e) based on reasonable evidence, is determined to have engaged in Fraud and Corruption during the execution of the Works;<br>(f) has been recruited from the Employer's Personnel in breach of Sub-Clause 6.3 [Recruitment of Persons]; or<br>(g) undertakes behavior which breaches the Code of Conduct for EPC Contractor's Personnel (ES).<br><br>If appropriate, the EPC Contractor shall then promptly appoint (or cause to be appointed) a suitable replacement with equivalent skills and experience. In the case of replacement of the EPC Contractor's Representative, Sub-Clause 4.3 [EPC Contractor's Representative] shall apply. In the case of replacement of Key Personnel (if any), Sub-Clause 6.12 [Key Personnel] shall apply.<br><br>Subject to the requirements in Sub-Clause 4.3 [EPC Contractor's Representative] and 6.12 [Key Personnel], and notwithstanding any requirement from the Employer to remove or cause to remove any person, the EPC Contractor shall take immediate action as appropriate in response to any violation of |



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| | (a) through (g) above. Such immediate action shall include removing (or causing to be removed) from the Site or other places where the Works are being carried out, any EPC Contractor's Personnel who engages in (a), (b), (c), (d), (e) or (g) above or has been recruited as stated in (f) above." |
| **Sub-Clause 6.12**<br>**Key Personnel** | The following is inserted at the end of the last paragraph:<br>"If any of the Key Personnel are not fluent in this language, the EPC Contractor shall make competent interpreters available during all working hours in a number deemed sufficient by the Employer." |
| **The following Sub-Clauses 6.13 to 6.28 are added after Sub-clause 6.12.** | |
| **Sub-Clause 6.13**<br>**Foreign Personnel** | The EPC Contractor may bring into the Country any foreign personnel who are necessary for the execution of the Works to the extent allowed by the applicable Laws. The EPC Contractor shall ensure that these personnel are provided with the required residence visas and work permits. The Employer will, if requested by the EPC Contractor, use its best endeavors in a timely and expeditious manner to assist the EPC Contractor in obtaining any local, state, national or government permission required for bringing in the EPC Contractor's personnel.<br>The EPC Contractor shall be responsible for the return of these personnel to the place where they were recruited or to their domicile. In the event of the death in the Country of any of these personnel or members of their families, the EPC Contractor shall similarly be responsible for making the appropriate arrangements for their return or burial. |
| **Sub-Clause 6.14**<br>**Supply of Foodstuffs** | The EPC Contractor shall arrange for the provision of a sufficient supply of suitable food as may be stated in the Employer's Requirements at reasonable prices for the EPC Contractor's Personnel for the purposes of or in connection with the Contract |
| **Sub-Clause 6.15**<br>**Supply of Water** | The EPC Contractor shall, having regard to local conditions, provide on the Site an adequate supply of drinking and other water for the use of the EPC Contractor's Personnel. |
| **Sub-Clause 6.16**<br>**Measures against Insect and Pest Nuisance** | The EPC Contractor shall at all times take the necessary precautions to protect the EPC Contractor's Personnel employed on the Site from insect and pest nuisance, and to reduce the danger to their health. The EPC Contractor shall comply with all the regulations of the local health authorities, including use of appropriate insecticide. |
| **Sub-Clause 6.17**<br>**Alcoholic Liquor or Drugs** | The EPC Contractor shall not, otherwise than in accordance with the Laws of the Country, import, sell, give, barter or otherwise dispose of any alcoholic liquor or drugs, or permit or |



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| | allow importation, sale, gift, barter or disposal thereto by EPC Contractor's Personnel. |
| **Sub-Clause 6.18**<br><br>**Arms and Ammunition** | The EPC Contractor shall not give, barter, or otherwise dispose of, to any person, any arms or ammunition of any kind, or allow EPC Contractor's Personnel to do so |
| **Sub-Clause 6.19**<br>**Festivals and Religious Customs** | The EPC Contractor shall respect the Country's recognized festivals, days of rest and religious or other customs |
| **Sub-Clause 6.20**<br><br>**Funeral Arrangements** | The EPC Contractor shall be responsible, to the extent required by local regulations, for making any funeral arrangements for any of its local employees who may die while engaged upon the Works. |
| **Sub-Clause 6.21**<br><br>**Forced Labour** | The EPC Contractor, including its Subcontractors, shall not employ or engage forced labor. Forced labor consists of any work or service, not voluntarily performed, that is exacted from an individual under threat of force or penalty, and includes any kind of involuntary or compulsory labor, such as indentured labor, bonded labor or similar labor-contracting arrangements.<br><br>No persons shall be employed or engaged who have been subject to trafficking. Trafficking in persons is defined as the recruitment, transportation, transfer, harboring or receipt of persons by means of the threat or use of force or other forms of coercion, abduction, fraud, deception, abuse of power, or of a position of vulnerability, or of the giving or receiving of payments or benefits to achieve the consent of a person having control over another person, for the purposes of exploitation. |
| **Sub-Clause 6.22**<br><br>**Child Labor** | The EPC Contractor, including its Subcontractors, shall not employ or engage a child under the age of 14 unless the national law specifies a higher age (the minimum age).<br><br>The EPC Contractor, including its Subcontractors, shall not employ or engage a child between the minimum age and the age of 18 in a manner that is likely to be hazardous, or to interfere with, the child's education, or to be harmful to the child's health or physical, mental, spiritual, moral, or social development.<br><br>The EPC Contractor, including its Subcontractors, shall only employ or engage children between the minimum age and the age of 18 after an appropriate risk assessment has been conducted by the EPC Contractor with the Employer's consent. The EPC Contractor shall be subject to regular monitoring by the Employer that includes monitoring of health, working conditions and hours of work.<br><br>Work considered hazardous for children is work that, by its nature or the circumstances in which it is carried out, is likely to |



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| | jeopardize the health, safety, or morals of children. Such work activities prohibited for children include work:<br><br>(a) with exposure to physical, psychological or sexual abuse;<br>(b) underground, underwater, working at heights or in confined spaces;<br>(c) with dangerous machinery, equipment or tools, or involving handling or transport of heavy loads;<br>(d) in unhealthy environments exposing children to hazardous substances, agents, or processes, or to temperatures, noise or vibration damaging to health; or;<br>(e) under difficult conditions such as work for long hours, during the night or in confinement on the premises of the employer. |
| **Sub-Clause 6.23**<br><br>**Employment Records of Workers** | The EPC Contractor shall keep complete and accurate records of the employment of labour at the Site. The records shall include the names, ages, genders, hours worked and wages paid to all workers. These records shall be summarized on a monthly basis and submitted to the Employer. These records shall be included in the details to be submitted by the EPC Contractor under Sub-Clause 6.10 [EPC Contractor's Records]. |
| **Sub-Clause 6.24 Workers Organization** | In countries where the relevant labour laws recognize workers' rights to form and to join workers' organizations of their choosing and to bargain collectively without interference, the EPC Contractor shall comply with such laws. In such circumstances, the role of legally established workers' organizations and legitimate workers' representatives will be respected, and they will be provided with information needed for meaningful negotiation in a timely manner. Where the relevant labour laws substantially restrict workers' organizations, the EPC Contractor shall enable alternative means for the EPC Contractor's Personnel to express their grievances and protect their rights regarding working conditions and terms of employment. The EPC Contractor shall not seek to influence or control these alternative means. The EPC Contractor shall not discriminate or retaliate against the EPC Contractor's Personnel who participate, or seek to participate, in such organizations and collective bargaining or alternative mechanisms. Workers' organizations are expected to fairly represent the workers in the workforce." |
| **Sub-Clause 6.25**<br><br>**Non-Discrimination and Equal Opportunity** | The EPC Contractor shall not make decisions relating to the employment or treatment of EPC Contractor's Personnel on the basis of personal characteristics unrelated to inherent job requirements. The EPC Contractor shall base the employment of EPC Contractor's Personnel on the principle of equal opportunity and fair treatment, and shall not discriminate with |



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| | respect to any aspects of the employment relationship, including recruitment and hiring, compensation (including wages and benefits), working conditions and terms of employment, access to training, job assignment, promotion, termination of employment or retirement, and disciplinary practices.<br><br>Special measures of protection or assistance to remedy past discrimination or selection for a particular job based on the inherent requirements of the job shall not be deemed discrimination. The EPC Contractor shall provide protection and assistance as necessary to ensure nondiscrimination and equal opportunity, including for specific groups such as women, people with disabilities, migrant workers and children (of working age in accordance with Sub-Clause 6.22). |
| **Sub-Clause 6.26**<br><br>**EPC Contractor's Personnel Grievance Mechanism** | The EPC Contractor shall have a grievance mechanism for EPC Contractor's Personnel, and where relevant the workers' organizations stated in Sub-Clause 6.24, to raise workplace concerns. (other than those relating to SEA and/or SH, which shall be addressed under Sub-Clause 6.27 below). The grievance mechanism shall be proportionate to the nature, scale, risks and impacts of the Contract. The mechanism shall address concerns promptly, using an understandable and transparent process that provides timely feedback to those concerned in a language they understand, without any retribution, and shall operate in an independent and objective manner.<br><br>The EPC Contractor's Personnel shall be informed of the grievance mechanism at the time of engagement for the Contract, and the measures put in place to protect them against any reprisal for its use. Measures will be put in place to make the grievance mechanism easily accessible to all EPC Contractor's Personnel.<br><br>The grievance mechanism shall not impede access to other judicial or administrative remedies that might be available, or substitute for grievance mechanisms provided through collective agreements.<br><br>The grievance mechanism may utilize existing grievance mechanisms, providing that they are properly designed and implemented, address concerns promptly, and are readily accessible to EPC Contractor's Personnel. Existing grievance mechanisms may be supplemented as needed with Contract-specific arrangements." |
| **Sub-Clause 6.27** | The EPC Contractor shall provide appropriate training to relevant EPC Contractor's Personnel on ES aspects of the Contract, including appropriate sensitization on prohibition of |

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| **Training of EPC Contractor's Personnel** | SEA and SH, and health and safety training referred to in Sub-Clause 4.8.<br><br>As stated in the Specification or as instructed by the Employer's Representative, the EPC Contractor shall also allow appropriate opportunities for the relevant EPC Contractor's Personnel to be trained on ES aspects of the Contract by the Employer's Personnel.<br><br>The EPC Contractor shall provide training on SEA and SH, including its prevention, to any of its personnel who has a role to supervise other EPC Contractor's Personnel. |
| **Sub-Clause 6.28 Compliance by Subcontractors** | The EPC Contractor shall be responsible for compliance by his Subcontractors of the provisions of this Clause. |
| **Sub-Clause 7.1**<br><br>**Manner of Execution** | The following new paragraph is added at the end:<br><br>The EPC Contractor is encouraged, to the extent practicable and reasonable, to use Plant, Materials, Goods and EPC Contractor's Equipment from the sources located in the country of the Employer. However, in case any of the Plant, Materials, Goods or EPC Contractor's Equipment is not available in the Employer's country, that shall be imported from the eligible source countries. |
| **Sub-Clause 7.3**<br><br>**Inspection** | The following is added in the first paragraph after "Employer's Personnel" "(including the Employer's staff or consultants acting on the Employer's behalf, stakeholders and third parties, such as independent experts, local communities, or non-governmental organizations)"<br><br>The following is added as (b) (iv):<br><br>"(iv) carryout environmental and social audit, and" |
| **Sub-Clause 7.4**<br><br>**Testing by the EPC Contractor** | The second paragraph is modified to start as: "Except as otherwise specified in the Contract, the EPC Contractor shall…." |
| **Sub-Clause 7.7**<br><br>**Ownership of Plant and Materials** | The first paragraph is modified to start as: "Except as otherwise specified in the Contract, each item of …." |
| **Sub-Clause 7.9**<br><br>**Factory Acceptance Test** | Factory acceptance test shall be witnessed by the personnel of the Employer and the Employer's Representative. All cost in connection with witnessing of the factory acceptance tests by the Employer and the Employer's Representative shall be borne by the EPC Contractor. These Shall include costs of air travel (economy class) from Pakistan to place inspection / testing and back, hotel accommodation / boarding / lodging (as per actual), inland transportation and daily allowance (agreed |



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| | by the Employer) per day per person for inspection testing to be conducted outside and inside Pakistan for each visit of every person to witness these tests. |
| **Sub-Clause 7.10**<br><br>**Performance Guarantees** | The following sub clause 7.10 is added:<br><br>The EPC Contractor shall guarantee a rated output as per Appendix-A to the PCC - Part B (Performance Guarantees) on the generator terminals for rated net water head and rated water discharge in accordance with the technical specifications (“Guaranteed Output”).<br><br>In case the variation in the output on the generator terminals for rated net water head and rated water discharge is more than 2% of the specified technical specifications ("Guaranteed Output"), the EPC Contractor shall remove the defect, or replace the Hydro-generating unit or related parts at his own cost, so that the desired specified output is achieved.<br><br>(a) The Contract Price for each generator and/or turbine shall be reduced by US$ 90,000 Ninety Thousand for each one tenth of one percent (1/10 of 1%) or part thereof that the weighted average prototype efficiency as determined by test is less than the guaranteed weighted average efficiency.<br><br>(b) In any case the liquidated damages related to the output/production capacity shall not exceed ten percent (10%) of the Contract Value of the concerned turbine and generator Hydro-generating Unit. Liquidated damages for delayed completion, if any, shall be paid separately.<br><br>(c) In case the value of either weighted average efficiency or rated output is less than two percent (2%) of guaranteed values then<br><br>i) the Employer shall have the right to reject the generator and/or turbine; in which case the EPC Contractor shall design, model test, construct, supply and install free of charge to the Employer a new generator and/or turbine with satisfactory performance. Further, in this case the EPC Contractor shall carry out site efficiency tests of all units.<br>Or<br>ii). The Employer shall advise the EPC Contractor to remove the defect or repair/replace the Hydro-generating unit or concerned part at his own cost within a reasonable time ascertained by the Employer’s Representative. |



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| | If such attempts to improve or modify or rectify fails, then imposing of liquidated damages or rejection of the equipment as the case may be, shall be applied.<br><br>The Employer may, without prejudice to any other method of recovery, deduct the amount of such damages from any moneys due or to become due to the EPC Contractor. The payment or deduction of such damages shall not relieve the EPC Contractor from his obligation to complete the Works, or from any other of his obligations and liabilities under the Contract. |
| **Sub-Clause 8.1 Commencement of Works** | The sub-clause is replaced with the following:<br><br>"The Employer's Representative shall give a Notice to the EPC Contractor stating the Commencement Date, not less than 14 days before the Commencement Date." |
| **Sub-Clause 8.3**<br><br>**Programme** | Add the following para at the end:<br><br>Nevertheless, the approval of program shall not in any way relieve the EPC Contractor from any of his liability for timely completion of the Works, and unless otherwise revised/updated, such program shall be deemed to serve as a base line schedule for its contractual effects and for coordination of the Works between the Employer, the EPC Contractor and the Employer's Representative. |
| **Sub-clause 8.5**<br><br>**Extension of Time for Completion** | SCL Protocol 2017 governing guideline for determining EOT and EOT related cost claims |



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**Sub-Clause 10.1**

**Taking Over the Works and Sections**

The following text has been included as Sub Paragraph (iii)

The Works shall be divided into Five (05) Sections. One Unit consist complete turbine Generator Unit (s) including all associated Systems.

In order to render the Unit (s) fit for its purpose and capable to generate Electrical Output that can be dispatched through the Interconnection and Transmission Facilities to the Regional Grid/Load Centers.

| Section No. | E&M Works | Time for Completion |
|---|---|---|
| 1 | Execution of Successful Completion of First Unit and all Auxiliaries necessary, 132 kV Switchyard, fit for intended / Commercial Purpose. The Tests on Completion have also been satisfactorily completed | 37 Months from the Date of Commencement |
| 2 | Execution of Successful Completion of Second Unit and all Auxiliaries necessary, 132 kV Switchyard, fit for Intended/ Commercial Purpose. The Tests on Completion have also been Satisfactorily Completed. | 39 Months from the Date of Commencement |
| 3 | Execution of Successful Completion of the Third Unit and all Auxiliaries necessary, 132 kV Switchyard, fit for Intended/ Commercial Purpose. The Tests on Completion have also been Satisfactorily Completed. | 41 Months from the Date of Commencement |
| 4 | Power Intake and Sediment Flushing Intake Hydraulic Gates, Trash Racks, Stoplogs and their | 36 Months from the Date of Commencement |



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| | | Associated Equipment, HSS and Gantry Crane | |
| | 5 | Execution of successful Completion of remaining Balance Of Plant Mechanical Works including Bridge Cranes, Workshops, Fire Detection and Fire Fighting system (For Generators), Drainage and Dewatering system, Oil Filtration system, Compressed Air system, Complete 132 kV Switchyard and Balance of Plant for Electrical Works, SCADA System, Telecommunication System, DG Set and other Whole of the Works mentioned in Employer's Requirement. The Tests on Completion have also been Satisfactorily Completed on these Systems. | 42 Months from the Date of Commencement |

**Note:**

All the Prerequisites / Activities outlined in each Section for Powerhouse Electro-Mechanical Works shall be completed prior to the Issuance of the TOC (Taking Over Certificate) in accordance with the provisions of Sub-Clause 10.1 of GCC.

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| **Sub-Clause 13.4**<br><br>**Provisional Sums** | The following is inserted as the penultimate paragraph:<br><br>"The Provisional Sum shall be used to cover the Employer's share of the DAAB members' fees and expenses, in accordance with Clause 21. No prior instruction of the Employer shall be required with respect to the work of the DAAB. The EPC Contractor shall submit the DAAB members' invoices and satisfactory evidence of having paid 100% of such invoices as part of the substantiation of those Statements submitted under Sub-Clause 14.3." |
| **Sub-Clause 13.6** | Following is added at the end: |

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| **Adjustments for Changes in Laws** | Clause 13.6 does not deal with taxes. However, any subsequent change in tax laws may be proposed as under.<br><br>Any increase or decrease in the taxes due to subsequent legislation will be dealt as given below.<br><br>**a) Local Direct Taxes**<br>It is implied that the Proposer has taken all the risks into account while submitting the proposed price. The Employer (WAPDA) shall not be responsible for any present or future direct taxes (Income Tax/Corporate Tax, WHT, Turnover Tax, Super Tax etc.) payable by the Proposer, his/her experts and other employees.<br><br>Any increase or decrease in the rates of all local direct taxes or introduction of new tax on the income of the EPC Contractor, experts and other employees in connection with the performance of the contract will be the liability of the EPC Contractor as these taxes are levied on the income earned by the EPC Contractor from the contract and the Employer (WAPDA) will not compensate to the EPC Contractor.<br><br>**b) Local Indirect Taxes**<br>All local indirect taxes i.e. sales tax, custom duty, VAT, levies, other charges or similar taxes levied on the EPC Contractor's invoice, shall be borne and reimbursed by the Employer (WAPDA), subject to withholding Law, on the basis of actual amount of indirect taxes paid by the EPC Contractor at the prevailing tax rates supported by the documentary evidence of such payment of indirect taxes by the EPC Contractor. The indirect taxes shall be mentioned as separate line item on the EPC Contractor's invoice.<br>Information of the EPC Contractor's Tax obligations in the Employer's (WAPDA) country can be found from Federal Board of Revenue Pakistan (www.fbr.gov.pk) & relevant Provincial Tax Authority's website or from their relevant offices.<br>The following is added at the end of the Sub-Clause:<br><br>"Notwithstanding the foregoing, the EPC Contractor shall not be entitled to an extension of time if the relevant delay has already been taken into account in the determination of a previous extension of time and such Cost shall not be separately paid if the same shall already have been taken into account in the indexing of any inputs to the table of adjustment data in accordance with the provisions of Sub-Clause 13.7.1 [Adjustments for Changes in Cost]." |
| **Sub-Clause 13.7** | Refer to "Appendix to Proposal - Schedule of Cost Indexation" |

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| **Adjustments for Changes in Cost** | |
| **Sub-Clause 14.1(b)**<br><br>**The Contract Price** | For the purpose of Local Direct Taxes and Indirect Taxes it is amended as:<br><br>**a) Local Direct Taxes**<br>It is implied that the Proposer has taken all the risks into account while submitting the proposed price. The Employer (WAPDA) shall not be responsible for any present or future direct taxes (Income Tax/Corporate Tax, WHT, Turnover Tax, Super Tax etc.) payable by the Proposer, his/her experts and other employees.<br><br>Any increase or decrease in the rates of all local direct taxes or introduction of new tax on the income of the EPC Contractor, experts and other employees in connection with the performance of the contract will be the liability of the EPC Contractor as these taxes are levied on the income earned by the EPC Contractor from the contract and the Employer (WAPDA) will not compensate to the EPC Contractor.<br><br>**b) Local Indirect Taxes**<br>All local indirect taxes i.e. sales tax, custom duty, VAT, levies, other charges or similar taxes levied on the EPC Contractor's invoice, shall be borne and reimbursed by the Employer (WAPDA), subject to withholding Law, on the basis of actual amount of indirect taxes paid by the EPC Contractor at the prevailing tax rates supported by the documentary evidence of such payment of indirect taxes by the EPC Contractor. The indirect taxes shall be mentioned as separate line item on the EPC Contractor's invoice.<br>Information of the EPC Contractor's Tax obligations in the Employer's (WAPDA) country can be found from Federal Board of Revenue Pakistan (www.fbr.gov.pk) & relevant Provincial Tax Authority's website or from their relevant offices.<br><br>The following is added at the end of the sub-clause:<br><br>**<u>Withholding of Advance Income Tax</u>**<br>All payments (gross) as payable to the EPC Contractor/Subcontractor will be subject to Withholding Tax/Advance Tax at prescribed rate at the time of payment. The deduction of advance income tax from the gross payable bills shall be made in accordance with prevalent income tax laws of the Government of Pakistan. These deductions shall be deposited in the Government Treasury by the Employer to the account of the EPC Contractor within prescribed period. |

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| | The Employer shall within 28 days of making any such deduction provide to the EPC Contractor/ Consultant within prescribed period.<br><br>The Employer shall within 28 days of making any such deduction provide to the EPC Contractor a certificate of tax deducted and deposit in the Government Treasury.<br><br>**Provincial Sales tax on Services:**<br>Subject to the relevant provisions of the Provincial Sales tax Act on Services, all payments (gross) as payable to the EPC Contractor/Subcontractor in relation to Works/Services will be subject to withholding sales tax at the prevalent rates at the time of payment. |
| **Sub-Clause 14.2**<br><br>**Advance Payment** | Sub-Clause 14.2.1 "Advance Payment Guarantee"<br><br>– In the first paragraph delete the words "equal to the advance payment" from the first sentence and replace with : "equal to the total amount of advance"<br>– In the second paragraph before "the advance payment has been repaid" add the words : "the total amount of"<br>– In the third paragraph before "the advance payment has been repaid" add the words : "the total amount of"<br>– In sub-paragraph (a) before "the advance payment has been repaid" add the words: "the total amount of"<br>– In the last sentence, before "the advance payment", at the very end of sentence, add the words: "the first installment of"<br><br>The entity issuing the Advance Payment Guarantee and its form shall be as follows:<br><br>"The Advance Payment Guarantee shall be in the form of Bank Guarantee issued by (a) a Scheduled Bank in Pakistan or (b) a foreign bank duly counter-guaranteed by a Scheduled Bank in Pakistan. In case of Joint Venture, the Advance Payment Guarantee(s) shall be in the name of the Joint Venture or in the name of the Lead / Either firm of the JV or in ratio of shares of the individual JV Partners.<br><br>Sub-Clause 14.2.3 "Re-payment of Advance Payment"<br><br>Replace the text with the following:<br><br>"The Advance Payment shall be recovered in equal installments; first installment at the expiry of 4th month after the date of payment of Advance and last installment before the issuance of TOC of the Works as per Sub-Clause 10.1. The Advance Bank Guarantee may be reduced in proportion to the value of the Plant and Equipment delivered to the site, as evidenced in the shipping and delivery documents. |



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| **Sub-Clause 14.3**<br><br>**Application for Interim Payment** | The following is inserted at the end of (vi) after: *[Agreement or Determination]*: "any reimbursement due to the EPC Contractor under the Dispute Avoidance/ Adjudication Agreement. (Appendix General Conditions of Dispute Avoidance/ Adjudication Agreement)." |
| **Sub-Clause 14.12**<br><br>**Discharge** | On the seventh line of the first paragraph, replace "Sub-Clause 21.6 [Arbitration]" with "Clause 21 [Disputes and Arbitration]". |
| **Sub-Clause 14.4**<br><br>**Schedule of Payments** | The Foreign Currency Component Will be Paid in Equivalent Pak Rupee / Local Currency. The amount in Equivalent PKR / Local Currency shall be determined by applying TT&OD composite selling exchange rate published / authorized by State Bank of Pakistan (SBP) for the day 28 days prior to Contractor's IPC / FPC submission date.<br><br><u>Schedule No. 01: Supply of Plant from Abroad (Pre-Engineered Structures) including Fixtures and other Materials, Goods and Spare Parts (if any) (Schedule of Price Basis)</u><br><br>In respect of Plant and Equipment supplied from Abroad, the following Payments shall be made:<br><br>• Sixty five Percent (65%) of the total or Pro Rata CIP Amount (Quoted Amount) upon incoterm "CIP" upon Delivery to the Carrier within Forty-Five (45) Days after successful Factory Acceptance Tests (FAT) and Certificate by Employer's Representative and Receipt of Invoice and Shipping Document.<br><br>• Thirty Percent (30%) of the Total or Pro Rate CIP Amount (Quoted Amount) upon Incoterm "CIP (including all Costs of Logistics to site etc.)" after Delivery to Site (Attabad Lake HPP, District Hunza) within Forty-Five (45) days after receipt of Invoice mentioned.<br><br>• Two and a half Percent (2.5%) of the Total or Pro Rate CIP Amount (Quoted Amount), upon Issuance of the Taking Over Certificate, within Forty-Five (45) days after receipt of Invoice mentioned.<br><br>• Two and a half Percent (2.5%) of the Total or Pro Rate CIP Amount (Quoted Amount), upon Issuance of the Performance Certificate, within Forty-Five (45) days after receipt of Invoice mentioned.<br><br><u>Schedule No. 02: Supply of Plant from within the Employer's Country (Pre-Engineered Structures) including Fixtures and other Materials, Goods and Spare Parts (if any) (Schedule of Price Basis)</u><br><br>In respect of Plant and Equipment supplied from within the Employer's country, the following Payments shall be made:<br><br>• Sixty Five Percent (65%) of the Total or Pro Rate Quoted Amount upon Incoterm "EXW", after |



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| | successful Factory Acceptance Tests (FAT) and Certificate by Employer's Representative, within Forty-Five (45) days after receipt of Invoice mentioned.<br>• Thirty Percent (30%) of the Total or Pro Rate Quoted Amount upon after Delivery to Site (Attabad Lake HPP, District Hunza) within Forty-Five (45) days after receipt of Invoice mentioned.<br>• Two and a half Percent (2.5%) of the Total or Pro Rate Quoted Amount, upon Issuance of the Taking Over Certificate, within Forty-Five (45) days after receipt of Invoice mentioned.<br>• Two and a half Percent (2.5%) of the Total or Pro Rate Quoted Amount, upon Issuance of the Performance Certificate, within Forty-Five (45) days after receipt of Invoice mentioned.<br><u>Price Schedule No. 03: Design Services</u><br>The following payments shall be made:<br>• Twenty Five Percent (25%) of the Measured Value of Work performed by the Contractor, as identified in the said Program Level-I Design and other approved submittals, during the preceding month, as evidenced by the Employer's Authorization of the Contractor's Application, will be made Monthly within Forty-Five (45) days after receipt of Invoice mentioned.<br>• Seventy Percent (70%) of the Measured Value of Work performed by the Contractor, as identified in the said Program Level-II Design and other approved submittals, during the preceding month, as evidenced by the Employer's Authorization of the Contractor's Application, will be made Monthly within Forty-Five (45) days after receipt of Invoice mentioned.<br>• Two and a half Percent (2.5%) of the Total or Pro Rata Value of Design Services performed by the Contractor as evidenced by the Employer's Authorization of the Contractor's Monthly Applications, upon Issue of the Taking Over Certificate, within Forty-Five (45) days after receipt of Invoice mentioned.<br>• Two and a half Percent (2.5%) of the Total or Pro Rata value of Design Services performed by the Contractor as evidenced by the Employer's Authorization of the Contractor's Monthly Applications, upon Issue of the Performance Certificate, within Forty-Five (45) days after receipt of Invoice mentioned.<br><u>Price Schedule No. 04: Installation and All Other Services</u> |



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| | The following payments shall be made:<br>• Ninety Five Percent (95%) of the Measured or Pro Rata Value of Work performed by the Contractor, as identified in the Said Program of Performance, during the Preceding Month, as evidenced by the Employer's Authorization of the Contractor's Application, will be made Monthly within Forty-Five (45) days after receipt of Invoice mentioned.<br>• Two and a half Percent (2.5%) of the Total or Pro Rata Value of Installation Services Performed by the Contractor as evidenced by the Employer's Authorization of the Contractor's Monthly Applications, upon Issue of the Taking Over Certificate, within Forty-Five (45) days after receipt of Invoice mentioned.<br>• Two and a half Percent (2.5%) of the Total or Pro Rata Value of Installation Services performed by the Contractor as evidenced by the Employer's Authorization of the Contractor's Monthly Applications, upon Issue of the Performance Certificate, within Forty-Five (45) days after receipt of Invoice mentioned. |
| **Sub-Clause 14.6.2**<br>**Withholding (amounts in) an Interim Payment** | "and/or" from subparagraph (b) is deleted. |
| **Sub-Clause 14.8**<br>**Delayed Payment** | Delete the text 'compounded monthly' in the third line of first para and replace with the text:<br>"at the rate stated in the Contract Data"<br>Delete para two and three. |
| **Sub-Clause 15.1**<br>**Notice to Correct** | "and" is deleted from (b) and "." is replaced by: "; and" in (c).<br>The following is then added as (d)<br>"(d) specify the time within which the EPC Contractor shall respond to the Notice to Correct."<br>In the third para, "shall immediately respond" is replaced with: "shall respond within the time specified in (d)". Further, in the third para., "to comply with the time specified in the Notice to Correct." is replaced with: "to comply with the time specified in (c)." |
| **Sub-Clause 15.2** | In Sub-Clause 15.2.1, sub-paragraph (h) is replaced with the following: |



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| **Termination for EPC Contractor's Default** | "(h) is found, based on reasonable evidence, to have engaged in Fraud and Corruption as defined in paragraph 2.2 of Section VI - Fraud and Corruption, in competing for or in executing the Contract." |
| **Sub-Clause 17.7**<br><br>**Use of Employer's Accommodation/Facilities** | The following Sub-Clause is added as 17.7:<br><br>"The EPC Contractor shall take full responsibility for the care of the Employer-provided accommodation and facilities, if any, as detailed in the Employer's Requirements, from the respective dates of hand-over to the EPC Contractor until cessation of occupation (where hand-over or cessation of occupation may take place after the date stated in the Taking-Over Certificate for the Works)<br><br>If any loss or damage happens to any of the above items while the EPC Contractor is responsible for their care arising from any cause whatsoever other than those for which the Employer is liable, the EPC Contractor shall, at his own cost, rectify the loss or damage to the satisfaction of the Employer." |
| **Sub-Clause 18.1**<br><br>**Exceptional Events** | Sub-paragraph (c) is substituted with:<br><br>"(c) riot, commotion, disorder or sabotage by persons other than the EPC Contractor's Personnel and other employees of the EPC Contractor and Subcontractors;" |
| **Sub-Clause 19.3**<br><br>**Insurance Company** | Following new Sub-Clause is added.<br><br>The EPC Contractor shall be obliged to place all insurances relating to the Contract with an insurance company having at least A rating from PACRA/JCR as approved by the Employer. |
| **Sub-Clause 20.1 Claims** | In a): "any additional payment" is replaced with "payment". |
| **Sub-Clause 21.2**<br><br>**Failure to Appoint DAAB Member(s)** | For both (a) and (b): "by the date stated in the first paragraph of Sub-Clause 21.1 [Constitution of the DAAB]" is replaced with: "within 42 days from the date the Contract is signed by both Parties" |
| **Sub-Clause 21.6**<br><br>**Arbitration** | The word "international" is deleted in the sixth line of first paragraph. The text of sub-paragraph (a) is substituted with the following:<br><br>"the Dispute shall be finally settled under the Rules of Arbitration, specified in the Contract Data". |
| **Sub-Clause 21.8**<br><br>**No DAAB in Place** | The clause is amended as:<br>"References of disputes involving NOD prior to constitution of DAAB/period in which DAAB was not in place shall be referred to the DAAB within 42 days of constitution of DAAB/date on which the DAAB came into being. However, both parties to Contract with mutual consent may proceed for Sub-Clause |

| | |
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| | 21.5 (Amicable Settlement) and Sub-Clause 21.6 (Arbitration) in case the DAAB is not in place." |
| **The Following New Clause 22 is added.** | |
| **22. Integrity Pact** | If it is found and established at any stage that the EPC Contractor or any of his Subcontractors, agents or servants have violated or involved in violation of the Integrity Pact signed by the EPC Contractor then the Employer shall be entitled to:<br>(a) recover from the EPC Contractor an amount equivalent to ten times the sum of any commission, gratification, bribe, finder's fee or kickback given by the EPC Contractor or any of his Subcontractors, agent or servants;<br>(b) terminate the Contract; and<br>(c) recover from the EPC Contractor any loss or damage to the Employer as a result of such termination or of any other corrupt business practices of the EPC Contractor or any of his Subcontractors, agent or servants.<br>The termination under sub-paragraph (b) of this Sub-Clause shall proceed in the manner prescribed under Sub-Clause 15.1 to Sub-Clause 15.4 and the payment under Sub-Clause 15.4 shall be made after having deducted the amounts due to the Employer under sub-paragraph (a) and (c) of this Sub-Clause. |



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## Appendix A - Performance Guarantees

The EPC Contractor shall adjust technical details were required to suit the design of the Complex provided that the Performance Guarantees are equaled or exceeded.

The Complex shall consist of weir headrace channel, forebay, intakes, penstocks, powerhouse, tailrace and a switchyard. The installed plant capacity of the Complex at rated head shall not be less than 55.68 MW measured at generator terminals while the estimated net capacity of the Complex shall be not less than 55.12 MW, measured by the Metering System at transformer high voltage terminals.

The Complex shall include three (03) Units and shall use water from Hunza River, drawn from the intake and passed through one (01) penstock into the powerhouse. The projected powerhouse operating conditions shall be as follows (subject to confirmation by EPC Contractor):

**Table 8-1 Water Levels and Heads**

| Description | Levels |
|---|---|
| **Headwater Levels (m) above mean sea level** | |
| Maximum Operating Reservoir Level | 2412 |
| Minimum Operating Reservoir Level | 2410 |
| **Tailwater Levels (m) above mean sea level** | |
| Tailwater Level at 60 $m^3/s$ (Plant Rated Discharge) | 2301.86 |
| Tailwater Level at 20 $m^3/s$ (One Unit Rated Discharge) | 2301.25 |
| **Gross Heads (m)** | |
| Normal Maximum Gross Head | 110.75 |
| Rated Gross Head | 110.14 |
| Minimum Gross Head | 108.14 |
| Acceleration due to gravity (g), $m/sec^2$ | 9.8 |

The powerhouse shall contain three (03) Francis Turbines with associated generators and auxiliary equipment (each referred to as "Unit"). Each Unit shall have a capacity of 18.56 MW (measured at the generator terminals) at rated head. The other facilities and structures shall include but not be limited to, a control room, unit transformers and exterior switchyard.

Each Unit shall be designed to operate independently and together with other Unit in the Complex in parallel over a wide range of operating conditions within the Technical Limits.

The Complex shall be capable of operation within a voltage range of ±10% on the 11kV system and 132kV system, as the case may be. The generators shall be conventional synchronous type, air-cooled, and directly coupled to the Francis turbines. Pressurized air shall be circulated axially for cooling the windings.

The EPC Contractor may propose another rotational speed. Please note that the EPC Contract have been written for the case of 375 rpm, and will require adjustment in case another rotational speed is accepted. All parameters (including submergence) that may possibly need adjustment to accommodate a change in speed are subject to review and approval by the Employer and Employer's Representative.

**Table 8-2 Generator Rating**

| Item | Value |
|---|---|
| Rated Capacity (Installed) | 18.56 MW |
| Speed | 375 rpm |
| Power factor | 0.8 lagging to 0.9 leading |
| Frequency | 50 Hz |
| Voltage | 11 kV |
| Insulation | Class F |

Each generator shall be connected to 3-phase transformers on a unit basis, located outside of the power station, and a total of three (03) 3-phase transformers shall be provided for the Complex.

Such three-phase transformers shall have the following ratings (to be confirmed by EPC Contractor):

**Table 8-3 Transformer Rating**

| Item | Value |
|---|---|
| Rated capacity per a 3-phase unit | 20/26 MVA |
| Cooling | ONAN/ONAF |
| Frequency | 50Hz |
| Voltage ratio | ±8%×1.25% |
| Winding connection | YNd11 |
| Tap changer type | OLTC |

A common control room shall be provided to monitor and control the Complex through Distributed Control System (DCS). The plant control systems will include a Supervisory Control and Data Acquisition system (SCADA).

All permanent material, plant, equipment and machinery incorporated in the construction of the Complex shall be new and unused.

## A-1 Guaranteed Characteristics

The basic performance guarantees are for the performance of the entire turbine-generator unit, based on the power output at the generator terminals, the net head on the turbine, the tail water level and the turbine discharge.

Comparison of field-tested performance with guaranteed performance will provide for the usual turbine-test tolerances to be applied but with the power output defined as the generator power output not the turbine power output. The guaranteed performance of the turbine-generator unit shall be the guaranteed performance of the turbine multiplied by the generator efficiency that is derived from the table of generator efficiencies given below under section A-4 of this Appendix or from the generator site measured efficiencies if a generator efficiency test is done. This calculation shall use a straight-line interpolation of the guaranteed or measured generator efficiency at 0.8 pf lag to 0.9 pf lead, without adjustment for tolerance.

The EPC Contractor shall attach to their Proposal, copies of the model test results from which

the turbine performance guarantees are based on. These results shall include but not be limited to the following:

- Curves and an efficiency hill diagram of values of expected turbine performance showing efficiencies and discharge for a range of power output from approximately 20% to 100% of maximum power output under the net heads indicated in this Appendix. Cavitation limits for the tailwater elevations given in Section A-5, Turbine Operation Cavitation Limits, shall be indicated on the curves and on the efficiency hill diagram. The individual points shown on the calculated guaranteed average annual energy table shall be superimposed on the efficiency hill diagram.
- Model efficiency hill diagram and calculations showing step-up to prototype values and step-up calculations.
- Model cavitation test results including photos, sketches and cavitation break curves that form the basis of the turbine cavitation guarantees.

## A-2 Plant and Unit Net Capacity Requirements

The Complex is guaranteed to develop not less the outputs stated below (EPC Contractor to fill in the requested values):

**Table 8-4 Plant and Unit Net Capacity Requirements**

| Description | Unit | Guaranteed Value |
|---|---|---|
| Project Output Capacity Guarantee (measured at the high voltage terminals of the main Generator Step Up Transformer):<br><br>The Attabad Hydropower Plant is guaranteed to deliver not less than 55.68 MW at the Generators terminals, without exceeding the cavitation limits, with all units operating at the rated speed, at 60 $m^3/s$, at 0.8 power factor, with the reservoir at 2412 m, and with a tailwater level of _____ [m]. | MW | [ ] |
| Unit (Turbine-Generator) Output Capacity Guarantee (measured at the generator terminals):<br><br>Each of the Attabad Hydropower Plant generating units is guaranteed to deliver not less than 18.56 MW at the generator terminals, without exceeding the cavitation limits, with one unit operating at the rated speed, at 20 $m^3/s$, at 0.8 power factor, with the reservoir at 2412m and with a tailwater level of _____ [m]. | MW | [ ] |

## A-3 Turbine Capacity and Efficiency

The turbine is guaranteed to develop not less than the range of guaranteed power outputs and efficiencies stated below, without exceeding its cavitation limits, when operating at the rated speed under the indicated net heads, with tailwater elevations corresponding to the turbine discharge in accordance with the Tail Water levels in Table 8-1. (EPC Contractor to fill in the requested values).



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**Table 8-5 Turbine Capacity and Efficiency**

| Net Head (m) | Load** on Turbine | Guaranteed Turbine Output* (kW) | Turbine Discharge ($m^3/s$) | Guaranteed Turbine Efficiency (%) |
|---|---|---|---|---|
| Rated Net Head | 100% Rated Output | | | |
| | 90% Rated Output | | | |
| | 80% Rated Output | | | |
| | 70% Rated Output | | | |
| | 60% Rated Output | | | |
| | 50% Rated Output | | | |
| | 40% Rated Output | | | |

* Output measured at turbine shaft.

** Load in percent of the maximum guaranteed output for continuous normal operation at the indicated net head. The units shall be capable of operating down to at least 40% of 100% load on turbine.

### A-4 Turbine and Generator Guaranteed Weighted Average Efficiency

The turbine and generator weighted average efficiencies are guaranteed as indicated in the following table, when operating at rated speed under the indicated power output, power factor and net head (EPC Contractor to fill in the requested values). (The guaranteed generator efficiency values shall be taken from Section A-4 of this Appendix.

**Table 8-6 Turbine and Generator Guaranteed Weighted Average Efficiency**

| Net Head (m) | Load on Turbine** | Guaranteed Turbine Output* (kW) | Expected Turbine Discharge ($m^3/s$) | Weighting Factor (R) | Guaranteed Turbine Efficiency (E) (%) | Guaranteed Product R x E (%) | Guaranteed Generator Efficiency at 0.8 pf (G) (%) | Guaranteed Product R x G (%) |
|---|---|---|---|---|---|---|---|---|
| Rated | 100% | | | 0.59 | | | | |
| Rated | 80% | | | 0.20 | | | | |
| Rated | 60% | | | 0.12 | | | | |



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| Net Head (m) | Load on Turbine** | Guaranteed Turbine Output* (kW) | Expected Turbine Discharge ($m^3/s$) | Weighting Factor (R) | Guaranteed Turbine Efficiency (E) (%) | Guaranteed Product R x E (%) | Guaranteed Generator Efficiency at 0.8 pf (G) (%) | Guaranteed Product R x G (%) |
|---|---|---|---|---|---|---|---|---|
| Rated | 40% | | | 0.09 | | | | |
| Guaranteed Turbine Weighted Average Efficiency (%) sum of Products (R) × (E) | | | | | | | | |
| Guaranteed Combined Turbine-Generator Weighted Average Efficiency (%) sum of Products (R) × (E) × (G) | | | | | | | | |

*Output measured at turbine shaft.

**Load in percent of the maximum guaranteed output for continuous normal operation at the indicated net head.

Guaranteed Turbine weighted average efficiency shall be greater than 92.8%.

### A-5 Wicket Gate Leakage and Turbine Leakage Torque

Maximum rate of leakage through the wicket gate seals under a static head of [112.75] is guaranteed to not exceed (EPC Contractor to fill in the requested values): _____ $m^3/s$

Maximum hydraulic torque acting on the turbine shaft, resulting from the maximum wicket gate leakage with the wicket gates closed (with squeeze effect), under the maximum static head of [112.75] is guaranteed is guaranteed to not exceed

- At standstill: _____ kNm
- At 50% rated speed: _____ kNm

### A-6 Turbine Noise

Guaranteed maximum sound pressure level measured inside the pit at a distance of 1 to 1.5 m from the generator bearing and averaged from twelve (12) readings taken during operation within normal operating range of net heads and unit outputs (EPC Contractor to fill in the requested values).

SPL, Re .0002 microbar: _____dBA

Operating conditions during noise readings: _____

### A-7 Vibration

Guaranteed maximum vibration magnitude, RMS velocity (mm/s) measured on the generator bearing housing (EPC Contractor to fill in the requested values):



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**Table 8-7 Generator Bearing Housing Vibration Levels at Various Operating Ranges**

| At a net head of 104m Operating Range | Max RMS velocity "x" (mm/s) | Max RMS velocity "y" (mm/s) | Max RMS velocity "z" (mm/s) |
|---|---|---|---|
| Speed no load to 20% rated Q | | | |
| 20% to 40% rated Q | | | |
| 40% to 60% rated Q | | | |
| 60% to 70% rated Q | | | |
| 70% to 80% rated Q | | | |
| 80% to 90% rated Q | | | |
| 90% to 100% rated Q | | | |



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**Metrics for Regular Reporting**

a. Environmental incidents or non-compliances with contract requirements, including contamination, pollution or damage to ground or water supplies;
b. Health and safety incidents, accidents, injuries that require treatment and all fatalities;
c. Interactions with regulators: identify agency, dates, subjects, outcomes (report the negative if none);

d. Status of all permits and agreements:
   (i) Work permits: number required, number received, actions taken for those not received;
   (ii) Status of permits and consents:
   - List areas/facilities with permits required (quarries, asphalt & batch plants), dates of application, dates issued (actions to follow up if not issued), dates submitted to resident engineer (or equivalent), status of area (waiting for permits, working, abandoned without reclamation, decommissioning plan being implemented, etc.);
   - List areas with landowner agreements required (borrow and spoil areas, camp sites), dates of agreements, dates submitted to resident engineer (or equivalent);
   - Identify major activities undertaken in each area in the reporting period and highlights of environmental and social protection (land clearing, boundary marking, topsoil salvage, traffic management, decommissioning planning, decommissioning implementation);
   - For quarries: status of relocation and compensation (completed, or details of activities and current status in the reporting period).

e. Health and Safety Supervision:
   (i) Safety officer: number days worked, number of full inspections & partial inspections, reports to construction/project management;
   (ii) Number of workers, work hours, metric of PPE use (percentage of workers with full personal protection equipment (PPE), partial, etc.), worker violations observed (by type of violation, PPE or otherwise), warnings given, repeat warnings given, follow-up actions taken (if any);

f. Worker Accommodations:
   (i) Number of expats housed in accommodations, number of locals;
   (ii) Date of last inspection, and highlights of inspection including status of accommodations' compliance with national and local law and good practice, including sanitation, space, etc.;
   (iii) Actions taken to recommend/require improved conditions, or to improve conditions.

g. Health services: provider of health services, information and/or training, location of clinic, number of non-safety disease or illness treatments and diagnoses (no names to be provided);
h. Gender (for expats and locals separately): number of female workers, percentage of workforce, gender issues raised and dealt with (cross-reference grievances or other Sections as needed);



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i. Training:
   (i) Number of new workers, number receiving induction training, dates of induction training;
   (ii) Number and dates of toolbox talks, number of workers receiving occupational health and safety (OHS), environmental and social training;
   (iii) Number and dates of communicable diseases (including stds) sensitization and/or training, no. Workers receiving training (in the reporting period and in the past); same questions for gender sensitization, flag person training.
   (iv) Number and date of sea and sh prevention sensitization and/or training events, including number of workers receiving training on code of conduct for EPC Contractor's personnel (in the reporting period and in the past), etc.

j. Environmental and Social Supervision:
   (i) Environmentalist: days worked, areas inspected and numbers of inspections of each (road section, work camp, accommodations, quarries, borrow areas, spoil areas, swamps, forest crossings, etc.), highlights of activities/findings (including violations of environmental and/or social best practices, actions taken), reports to environmental and/or social specialist/construction/site management;
   (ii) Sociologist: days worked, number of partial and full site inspections (by area: road section, work camp, accommodations, quarries, borrow areas, spoil areas, clinic, HIV/AIDS centre, community centres, etc.), highlights of activities (including violations of environmental and/or social requirements observed, actions taken), reports to environmental and/or social specialist/construction/site management; and
   (iii) Community Liaison Person(s): days worked (hours community centre open), number of people met, highlights of activities (issues raised, etc.), reports to environmental and/or social specialist /construction/site management.

k. Grievances: list new grievances (e.g., number of allegations of SEA and SH) received in the reporting period and number of unresolved past grievances by date received, complainant's age and sex, how received, to whom referred to for action, resolution and date (if completed), data resolution reported to complainant, any required follow-up (Cross-reference other sections as needed):
   (i) Worker grievances;
   (ii) Community grievances

l. Traffic, Road Safety and Vehicles/Equipment:
   (i) Traffic and road safety incidents and accidents involving project vehicles & equipment: provide date, location, damage, cause, follow-up;
   (ii) Traffic and road safety incidents and accidents involving non-project vehicles or property (also reported under immediate metrics): provide date, location, damage, cause, follow-up;
   (iii) Overall condition of vehicles/equipment (subjective judgment by environmentalist); non-routine repairs and maintenance needed to improve safety and/or environmental performance (to control smoke, etc.).

m. Environmental Mitigations and Issues (what has been done):
   (i) Dust: number of working bowsers, number of watering/days, number of complaints, warnings given by environmentalist, actions taken to resolve; highlights of quarry dust control (covers, sprays, operational status); % of rock/ spoil lorries with covers, actions taken for uncovered vehicles;



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(ii) Erosion control: controls implemented by location, status of water crossings, environmentalist inspections and results, actions taken to resolve issues, emergency repairs needed to control erosion/sedimentation;
(iii) Quarries, borrow areas, spoil areas, asphalt plants, batch plants: identify major activities undertaken in the reporting period at each, and highlights of environmental and social protection: land clearing, boundary marking, topsoil salvage, traffic management, decommissioning planning, decommissioning implementation;
(iv) Blasting: number of blasts (and locations), status of implementation of blasting plan (including notices, evacuations, etc.), incidents of off-site damage or complaints (cross-reference other sections as needed);
(v) Spill clean-ups, if any: material spilled, location, amount, actions taken, material disposal (report all spills that result in water or soil contamination;
(vi) Waste management: types and quantities generated and managed, including amount taken offsite (and by whom) or reused/recycled/disposed on-site;
(vii) Details of tree plantings and other mitigations required undertaken in the reporting period;
(viii) Details of water and swamp protection mitigations required undertaken in the reporting period.

n. Compliance:
(i) Compliance status for conditions of all relevant consents/permits, for the Work, including quarries, etc.): statement of compliance or listing of issues and actions taken (or to be taken) to reach compliance;
(ii) Compliance status of C-ESMP/ESIP requirements: statement of compliance or listing of issues and actions taken (or to be taken) to reach compliance
(iii) Compliance status of SEA and SH prevention and response action plan: statement of compliance or listing of issues and actions taken (or to be taken) to reach compliance
(iv) Compliance status of Health and Safety Management Plan re: statement of compliance or listing of issues and actions taken (or to be taken) to reach compliance
(v) Other unresolved issues from previous reporting periods related to environmental and social: continued violations, continued failure of equipment, continued lack of vehicle covers, spills not dealt with, continued compensation or blasting issues, etc. Cross-reference other sections as needed.



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## SECTION X - CONTRACT FORMS

### Declaration of Ultimate Beneficial Owners Information for Public Procurement Contracts

1. Name:
2. Father's Name/Spouse's Name:
3. CNIC/NICOP/Passport no.:
4. Nationality:
5. Residential address:
6. Email address:
7. Date on which shareholding, control or interest acquired in the business:
8. In case of indirect shareholding, control or interest being exercised through intermediary companies, entities or other legal persons or legal arrangements in the chain of ownership or control, following additional particulars to be provided:

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|
| Name | Legal form (Company/Limited Liability Partnership/Association of Persons/Single Member Company/Company/Partnership Firm/Trust/Any other individual, body corporate (to be specified) | Date of incorporation / Registration | Name of Registering Authority | Business Address | Country | Email Address | Percentage of shareholding, control or interest of BO in the legal person or legal arrangement | Percentage of shareholding, control or interest of legal person or legal arrangement in the Company | Identity of Natural Person who ultimately owns or controls the legal person or arrangement |
| | | | | | | | | | |
| | | | | | | | | | |



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9. Information about Board of Directors (details shall be provided regarding number of shares in the capital of the company as set opposite respective names)

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|
| **Name and surname *(In Block Letters)*** | **CNIC No. *(in case of foreigner, Passport No)*** | **Father's / Husband's Name in Full** | **Current Nationality** | **Any other Nationality (ies)** | **Occupation** | **Residential address in full or the registered / principal office address for a subscriber other than natural person** | **Number of shares taken by each subscriber *(in figures and words)*** |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | Total Number of Shares taken *(in figure and words)* | | | | |

10. Any other information incidental to or relevant to Beneficial Owner(s).

Name & Signature
*(Person authorized to issue notice ion behalf of the company)*

.



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## Letter of Acceptance

*[letterhead paper of the Employer]*

*[date]*

To: *[name and address of the EPC Contractor]*

This is to notify you that your Proposal dated *[date]* for execution of the *[name of the Contract and identification number, as given in the Contract Data]* for the Accepted Lump-sum Turnkey Contract Amount *[amount in numbers and words] [name of currency]*, as corrected and modified in accordance with the Instructions to Proposers, is hereby accepted by our Agency.

You are requested to furnish

the additional information on beneficial ownership in accordance with **ITP 53.1** within eight (08) Business days using the Beneficial Ownership Disclosure Form, included in **Section X (Contract Forms)** of the RFP/EPC Bidding Documents.

Authorized Signature: _____

Name and Title of Signatory: _____

Name of Agency: _____

**Attachment:** Contract Agreement



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## Contract Agreement

THIS AGREEMENT made the _____ day of _____, _____, between _____of _____ (hereinafter "the Employer"), of the one part, and _____ of _____ (hereinafter "the EPC Contractor"), of the other part:

WHEREAS the Employer desires that the Works known as _____ should be executed by the EPC Contractor, and has accepted a Proposal by the EPC Contractor for the execution and completion of these Works on EPC/Turnkey basis and the remedying of any defects therein,

The Employer and the EPC Contractor agree as follows:

1. In this Agreement words and expressions shall have the same meanings as are respectively assigned to them in the Contract documents referred to.
2. The following documents shall be deemed to form and be read and construed as part of this Agreement. This Agreement shall prevail over all other Contract documents.
   (a) the Contract Agreement
   (b) the Letter of Acceptance
   (c) the Letter of Proposal
   (d) the Particular Conditions Part A - Contract Data
   (e) the Particular Conditions Part B - Special Provisions
   (f) the General Conditions (GC)
   (g) the Employer's Requirements
   (h) Preamble to Schedule of Price
   (i) the Schedule of Prices
   (j) the Completed Schedules
   (k) the Proposal
   (l) the JV Agreement (if the EPC Contractor is a JV), and
   (m) any other document forming part of the Contract.
      i. Code of Conduct for EPC Contractor's Personnel (ES).
      ii. Sexual Exploitation and Abuse (SEA), and/or Sexual Harassment (SH) Declaration
3. In consideration of the payments to be made by the Employer to the EPC Contractor as specified in this Agreement, the EPC Contractor hereby covenants with the Employer to execute the Works and to remedy defects therein in conformity in all respects with the provisions of the Contract.
4. The Employer hereby covenants to pay the EPC Contractor in consideration of the execution and completion of the Works and the remedying of defects therein, the Contract Price or such other sum as may become payable under the provisions of the Contract at the times and in the manner prescribed by the Contract.

IN WITNESS whereof the parties hereto have caused this Agreement to be executed in accordance with the laws of _____ on the day, month and year specified above.

Signed by _____ (for the Employer)

Signed by _____(for the EPC Contractor)

**Schedule1:** Schedule of Payments

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## Schedule 1 - Schedule of Payments

*[**Note**: Payments will be based upon the actual progress achieved by the EPC Contractor in executing the Works, which necessitates careful definition of the payment milestones by the Proposer. Accordingly, as brought out in **Section VIII (Particular Conditions), Part B (Special Provisions) Sub-Clause 14.4 (Schedule of Payments),** the instalments quoted in the Schedule of Payments shall be treated as the estimated contract values, and the Employer's Representative may proceed to agree or determine revised instalments, and the revised instalments shall take account of the extent to which progress differs from that on which the Schedule of Payments was based.]*

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## DAAB Agreement

Name and details of the Contract _____

This Agreement made the _____day of _____ [*month*], _____ [*year*], between

Name and contact details of the Employer _____ (name)
_____(*address*)
_____(*telephone*)
_____(*email / other contact details*);

Name and contact details of the EPC Contractor _____ (name)
_____(*address*)
_____(*telephone*)
_____(*email / other contact details*);

Name and contact details of the DAAB Member _____ (name)
_____(*address*)
_____(*telephone*)
_____(*email / other contact details*);

("**DAAB Agreement**")

Whereas:

A. the Employer and the EPC Contractor have entered (or intend to enter) into the Contract;

B. under the Contract, the "**DAAB**" or "**Dispute Avoidance/Adjudication Board**" means the sole member or three members (as stated in the Contract Data of the Contract) so named in the Contract, or appointed under Sub-Clause 21.1 [*Constitution of the DAAB*] or Sub-Clause 21.2 [*Failure to Appoint DAAB Members*] of the Conditions of Contract;

C. the Employer and the EPC Contractor desire jointly to appoint the above-named DAAB Member to act on the DAAB as:

   a. the sole member of the DAAB, and where this is the case, all references to the "Other Members" do not apply; or

   b. one of three members / chairman [*delete the one which is not applicable*] of the DAAB and, where this is the case, the other two persons are:

| | |
|---|---|
| _____ *(name)* | _____ *(name)* |
| _____ *(address)* | _____ *(address)* |
| _____*(telephone)* | _____*(telephone)* |
| _____*(email/ other contact details)* | _____ *(email/other contact details)* |

the "**Other Members**"; and

D. the DAAB Member accepts this appointment.

**The Employer, EPC Contractor and DAAB Member jointly agree** as follows:

1. The conditions of this DAAB Agreement comprise:
   (a) Clause 21 [*Disputes and Arbitration*] of the Conditions of Contract, and any other provisions of the Contract that are applicable to the DAAB's Activities; and
   (b) the "General Conditions of Dispute Avoidance/Adjudication Agreement", which is appended to the General Conditions of the "Conditions of Contract for Construction" Second Edition 2017 published by FIDIC ("GCs"), as amended and/or added to by the following provisions.



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2. [Details of amendments to the GCs, if any. For example:
In the procedural rules annexed to the GCs, Rule _ is deleted and replaced by: " … "]
3. The DAAB Member shall be paid in accordance with Clause 9 of the GCs. The currency of payment shall be _____.
In respect of Sub-Clauses 9.1 and 9.2 of the GCs, the amounts of the DAAB Member's monthly fee and daily fee shall be:
monthly fee_____ per month, and
daily fee of_____ per day
(or as otherwise set under Sub-Clause 9.3 of the GCs).
4. In consideration of the above fees, and other payments to be made to the DAAB Member in accordance with the GCs, the DAAB Member undertakes to act as DAAB Member in accordance with the terms of this DAAB Agreement.
5. The Employer and the EPC Contractor shall be jointly and severally liable for the DAAB Member's fees and other payments to be made to the DAAB Member in accordance with the GCs.
6. This DAAB Agreement shall be governed by the law of _____ (if not stated, the law that governs the Contract under Sub-Clause 1.4 of the Conditions of Contract).

| | | |
|---|---|---|
| SIGNED by:_____<br>Print name:_____<br>Title: _____<br>for and on behalf of the Employer<br>in the presence of<br>Witness:_____<br>Name:_____<br>Address:_____<br>_____<br>Date:_____ | SIGNED by:_____<br>Print name:_____<br>Title:_____<br>for and on behalf of the EPC Contractor<br>in the presence of<br>Witness:_____<br>Name:_____<br>Address:_____<br>_____<br>Date:_____ | SIGNED by:_____<br>DAAB Member<br>Title:_____<br>in the presence of<br>Witness:_____<br>Name:_____<br>Address:_____<br>_____<br>Date:_____ |



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## Performance Security

**Guarantee No**._____
**Executed on** _____
**Expiry date** _____

*[Letter by the Guarantor to the Employer]*

**Name of Guarantor with address:** _____

**Name of Principal (EPC Contractor) with address:**_____

**Penal Sum of Security (*express in words and figures*)** _____

**Letter of Acceptance No**. _____ **Dated** _____

KNOW ALL MEN BY THESE PRESENTS, that in pursuance of the terms of the Bidding Documents and above said Letter of Acceptance (hereinafter called the Documents) and at the request of the said Principal we, the Guarantor above named, are held and firmly bound unto the _____ (hereinafter called the Employer) in the penal sum of the amount stated above for the payment of which sum well and truly to be made to the said Employer, we bind ourselves, our heirs, executors, administrators and successors, jointly and severally, firmly by these presents.

THE CONDITION OF THIS OBLIGATION IS SUCH, that whereas the Principal has accepted the Employer's above said Letter of Acceptance for _____ _____ (*Name of Contract*) for the _____ _____ (*Name of Project*).

NOW THEREFORE, if the Principal (EPC Contractor) shall well and truly perform and fulfill all the undertakings, covenants, terms and conditions of the said Documents during the original terms of the said Documents and any extensions thereof that may be granted by the Employer, with or without notice to the Guarantor, which notice is, hereby, waived and shall also well and truly perform and fulfill all the undertakings, covenants terms and conditions of the Contract and of any and all modifications of said Documents that may hereafter be made, notice of which modifications to the Guarantor being hereby waived, then, this obligation to be void; otherwise to remain in full force and virtue till all requirements of Clause11, Defects After Taking Over, of Conditions of Contract are fulfilled.

Our total liability under this Guarantee is limited to the sum stated above and it is a condition of any liability attaching to us under this Guarantee that the claim for payment in writing shall be received by us within the validity period of this Guarantee, failing which we shall be discharged of our liability, if any, under this Guarantee.

We, _____ (the Guarantor), waiving all objections and defense under the Contract, do hereby irrevocably and independently guarantee to pay to the Employer without delay upon the Employer's first written demand without cavil or arguments and without requiring the Employer to prove or to show grounds or reasons for such demand any sum or sums up to the amount stated above, against the Employer's written declaration that the Principal has refused or failed to perform the obligations under the Contract which payment will be effected by the Guarantor to Employer's designated Bank & Account Number.

PROVIDED ALSO THAT the Employer shall decide, whether the Principal (EPC Contractor) has duly performed his obligations under the Contract or has defaulted in fulfilling said obligations and the Guarantor shall pay without objection any sum or sums up to the amount



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stated above upon first written demand from the Employer forthwith and without any reference to the Principal or any other person.

IN WITNESS WHEREOF, the above-bounden Guarantor has executed this Instrument under its seal on the date indicated above, the name and corporate seal of the Guarantor being hereto affixed and these presents duly signed by its undersigned representative, pursuant to authority of its governing body.

**Guarantor**

(Scheduled Bank/ Insurance Company)

**WITNESS:**

Signature _____

1. _____

Name _____

_____

Title _____

Corporate Secretary (Seal)

Corporate Guarantor (Seal)

2. _____

_____

Name, Title & Address



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## Form of Mobilization Advance Guarantee / Bond

**Guarantee No**._____ **Date** _____

WHEREAS _____ *(hereinafter called the 'Employer')*

has entered into a Contract for _____
*(Particulars of Contract)*
with _____(hereinafter called the "EPC Contractor').

AND WHEREAS, the Employer has agreed to advance to the EPC Contractor, at the EPC Contractor's request, an amount of Rupees _____ (Pak. Rs _____) which amount shall be advanced to the EPC Contractor as per provisions of the Contract.

AND WHEREAS, the Employer has asked the EPC Contractor to furnish Guarantee to secure the mobilization advance for the performance of his obligations under the said Contract.

AND WHEREAS, _____ (*hereinafter called the "Guarantor")*

at the request of the EPC Contractor and in consideration of the Employer agreeing to make the above advance to the EPC Contractor, has agreed to furnish the said Guarantee.

NOW, THEREFORE, the Guarantor hereby guarantees that the EPC Contractor shall use the advance for the purpose of above-mentioned Contract and if he fails and commits default in fulfilment of any of his obligations for which the advance payment is made, the Guarantor shall be liable to the Employer for payment not exceeding the aforementioned amount.

Notice in writing of any default, on the part of the EPC Contractor, of which the Employer at his discretion of making decision, shall be given by the Employer to the Guarantor, and on such first written demand, payment shall be made by the Guarantor of all sums then due under this Guarantee without any reference to the EPC Contractor and without any objection.

This Guarantee shall remain in force until the advance is fully adjusted against payments from the Interim Payment Certificates of the EPC Contractor or until _____whichever is earlier.
*(Date)*

The Guarantor's liability under this Guarantee shall not in any case exceed the sum of PKR _____ (Pakistani Rupees _____ _____).

This Guarantee shall remain valid up to the aforesaid date and shall be null and void after the aforesaid date or earlier if the advance made to the EPC Contractor is fully adjusted against payments from Interim Payment Certificates of the EPC Contractor provided that the Guarantor agrees that the aforesaid period of validity shall be deemed to be extended if on the above-mentioned date, the advance payment is not fully adjusted.

Guarantor

(*Scheduled Bank/ Insurance Company*)

WITNESS:

Signature _____

1. _____

Name _____

_____

Title _____

Corporate Secretary (Seal)

Corporate Guarantor (Seal)

2. _____

_____

Name, Title & Address

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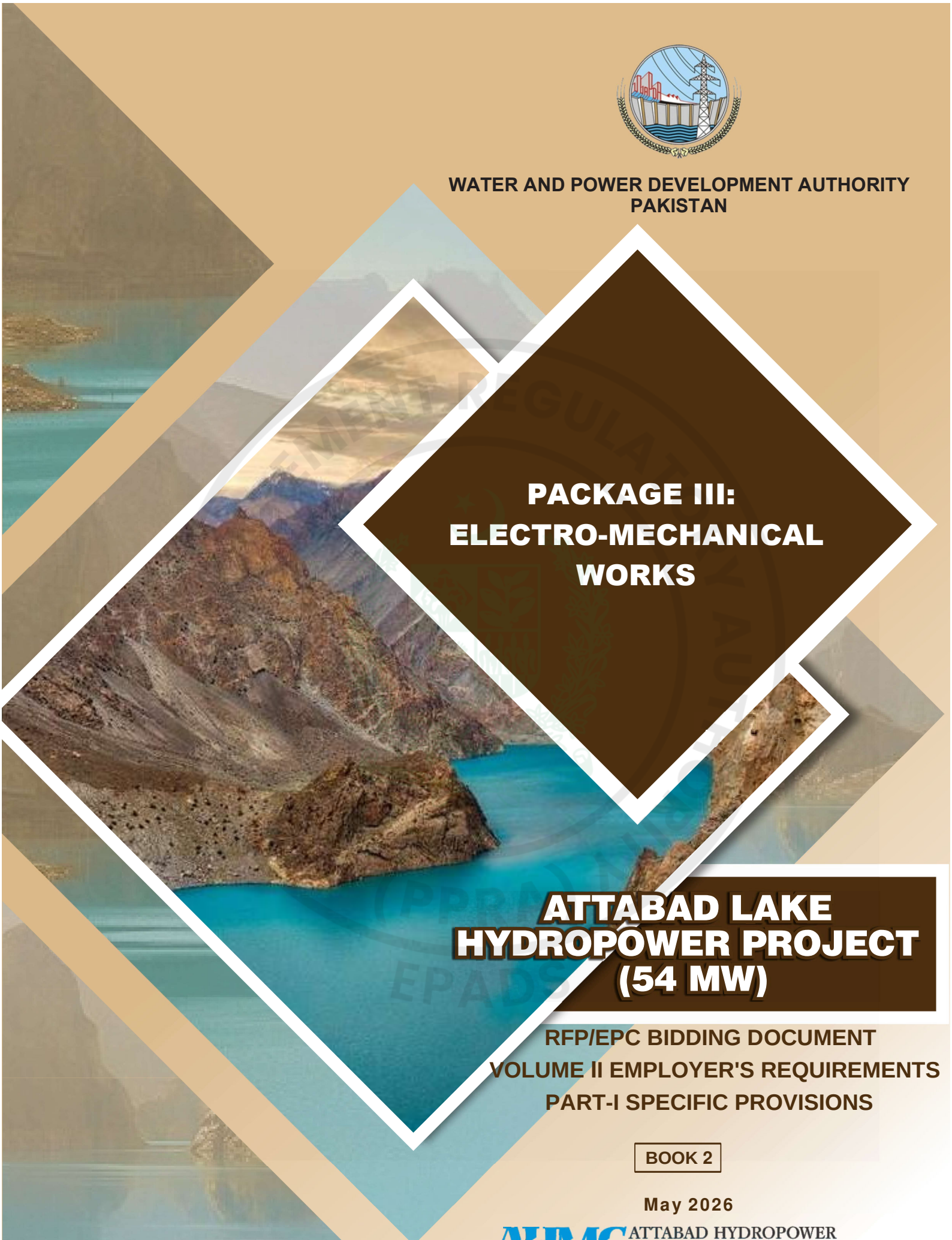
WATER AND POWER DEVELOPMENT AUTHORITY
PAKISTAN



# PACKAGE III: ELECTRO-MECHANICAL WORKS

# ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

## RFP/EPC BIDDING DOCUMENT
## VOLUME II EMPLOYER'S REQUIREMENTS
## PART-I SPECIFIC PROVISIONS

BOOK 2

May 2026

AHMC ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

DOLSAR ENGINEERING

DOCUMENT NO:
BD-ALHPP-03 (V2-I)

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# EPC BIDDING DOCUMENTS OF
# ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

## PACKAGE-III: ELECTRO-MECHANICAL WORKS

## INDEX TO BIDDING DOCUMENTS


VOLUME-I: BIDDING PROCEDURES AND CONDITIONS OF CONTRACT

Part-I: Bidding Procedures

Part-II: Conditions of Contract and Standard Forms

VOLUME-II: EMPLOYER'S REQUIREMENTS

**Part-I: Specific Provisions**

Part-II: Technical Provisions

Part-III: Conceptual Drawings

VOLUME-III: ADDITIONAL INFORMATION

Part-I: Feasibility Study Report (2021)

Part-II: Feasibility Review Report (2022)

Part-III: Topographic Survey Map Book (2023)

Part IV: Updated Environmental Impact Assessment (EIA) Report (2023)


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**EPC BIDDING DOCUMENTS OF**
**ATTABAD LAKE HYDROPOWER PROJECT (54 MW)**

**PACKAGE-III: ELECTRO-MECHANICAL WORKS**

**TABLE OF CONTENTS**

**LIST OF ABBREVIATIONS ..... IV**

**SECTION 1 SCOPE OF WORK ..... 1-1**

1.1 GENERAL ..... 1-1
1.2 PROJECT COMPONENTS ..... 1-2
1.3 DETAILED DESIGN AND PLANNING OF THE WORKS ..... 1-4
1.4 QUALIFICATION EXPEREINCE REQUIREMENT FOR DESIGN FIRM FOR ENGINEERING OF E&M PLANT EQUIPMENT ..... 1-6
1.5 QUALIFICATION EXPERIENCE REQUIREMENT FOR E&M PLANT AND EQUIPMENT ..... 1-7
1.6 PROVISION OF FIELD CAMPS AND OFFICES AND OPERATING FACILITIES ..... 1-7
1.7 QUALITY ASSURANCE/QUALITY CONTROL ..... 1-11
1.8 ENVIRONMENTAL COMPLIANCE ..... 1-15
1.9 DOCUMENTARY FILM ..... 1-16
1.10 JOINT OPERATION AND DEFECT NOTIFICATION PERIOD ..... 1-16
1.11 MOBILIZATION AND DEMOBILIZATION ..... 1-17
1.12 PROPOSAL SUBMISSIONS ..... 1-17
1.13 CONTRACTOR SUBMITTALS AND RESPONSIBILITIES ..... 1-18
1.14 GENERAL DESIGN CRITERIA FOR ELECTROMECHANICAL WORKS AND HYDRAULIC STEEL STRUCTURES ..... 1-34
1.15 TESTING AND COMMISSIONING AND VERIFICATION OF PERFORMANCES AND GUARANTEES ..... 1-36
1.16 CONSTRUCTION AND ERECTION REQUIREMENTS ..... 1-44

**SECTION 2 GENERAL HYDROMECHANICAL AND HYDRAULIC STEEL STRUCTURES REQUIREMENTS ..... 2-1**

2.1 GENERAL HYDROMECHANICAL REUIREMENTS ..... 2-1
2.2 GENERAL HYDRAULIC STEEL STRUCTURE ..... 2-37
2.3 GENERAL ELECTRICAL REQUIREMENTS ..... 2-47
2.4 GENERAL CONTROL AND INSTRUMENTATION REQUIREMENTS ..... 2-67

**SECTION 3 BASIC DESIGN CRITERIA ..... 3-1**

3.1 GENERAL ..... 3-1

**SECTION 4 USE OF SITE AND ENVIRONMENTAL ASPECTS ..... 4-1**

4.1 USE OF SITE ..... 4-1
4.2 ENVIRONMENT, SOCIAL, HEALTH AND SAFETY REQUIREMENTS ..... 4-3

**ANNEX A TO SECTION 4.2: PROPOSER HSE MANAGEMENT SYSTEM QUESTIONNAIRE ..... 4-16**

**ANNEX B TO SECTION 4.2: HAZARD WARNING SIGNS/MARKING ..... 4-25**

**ANNEX C TO SECTION 4.2: BILL OF QUANTITIES (BOQ) ..... 4-26**



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## LIST OF TABLES

**Table 1-1: Schedule of Design and Construction Submittals** ..... 1-19
**Table 2-1: Standards** ..... 2-2
**Table 2-2: Normal Design Condition Stress Limits** ..... 2-7
**Table 2-3: Maximum Allowable Flow Velocity in Pipes** ..... 2-28
**Table 2-4: Use of Parallel Slide and Gate Valves** ..... 2-29
**Table 2-5: Radiating Surface Vibration Limits** ..... 2-33
**Table 2-6: Gates Material Standards** ..... 2-39
**Table 2-7: Stoplog Material Standards** ..... 2-39
**Table 3-1: Reference Standards** ..... 3-2
**Table 4-1: Contractor's Staff for ESHS** ..... 4-4
**Table 4-2 Recommended Personal Protective Equipment According to Hazard** ..... 4-14

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| AASHTO | American Association of State Highway and Transportation Officials |
| AC | Alternating Current |
| ACI | American Concrete Institute |
| ACSR | Aluminum Conductor Steel Reinforced |
| AHMC | Attabad Hydropower Management Consultants |
| AIDS | Acquired Immunodeficiency Syndrome |
| AIS | Air Insulated Substation |
| ALHPP | Attabad Lake Hydropower Project |
| AR | Arterial Road |
| ASME | American Society of Mechanical Engineers |
| ASTM | American Society of Testing Materials |
| BOQ | Bill of Quantities |
| C&D | Construction and Demolition |
| CCTV | Closed Circuit Television |
| CD | Compact Disc |
| CE | Construction Earthquake |
| COVID-19 | Coronavirus Disease 2019 |
| CPM | Critical Path Method |
| CT | Current Transformer |
| DBE | Design Basis Earthquake |
| DC | Direct Current |
| DCS | Distributed Control System |
| DISCOs | Distribution Companies |
| DNP | Defect Notification Period |
| DR | Direct Road |
| DSHA | Deterministic Seismic Hazard Analysis |
| E&M | Electro-Mechanical |
| EIA | Environmental Impact Assessment |
| EMP | Environmental Management Plan |
| EOT | Electrically Operated Travelling |
| EPA | Environmental Protection Agency |
| EPABX | Electronic Private Automatic Branch Exchange |
| EPC | Engineering, Procurement, and Construction |
| ERT | Electrical Resistivity Tomography |
| ESHS | Environmental, Social, Health and Safety |
| EZ-FRISK | Computer Software |
| FEMA | Federal Emergency Management Agency |
| GCBs | Generator Circuit Breakers |
| GLOF | Glacier Lake Outburst Flow |
| GoGB | Government of Gilgit Baltistan |



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| | |
|---|---|
| GPS | Global Positioning System |
| GPS | Global Positioning System |
| GSI | Geological Strength Index |
| HEC-RAS | Computer Software |
| HIV | Human Immunodeficiency Virus |
| HSS | Hydraulic Steel Structure |
| HT | High Tension |
| HVAC | Heating, Ventilation and Air Conditioning |
| ICOLD | International Commission on Large Dams |
| ISO | International Organization of Standardization |
| LT | Low Tension |
| MCE | Maximum Credible Earthquake |
| MCM | Million Cubic Meters |
| MDE1 | Maximum Design Earthquake (Stress) |
| MDE2 | Maximum Design Earthquake Stability |
| MV/LV | Medium and Low Voltage |
| MW | Mega Watts |
| NCR | Non-conformance Reporting |
| NDT | Non-Destructive Testing |
| NOC | No Objection Certificate |
| NTDC | National Transmission and Dispatch Company |
| NWD | Nation Wide Dialing System |
| O&M | Operation and Maintenance |
| OBE | Operating Basis Earthquake |
| OBE | Operational Basis Earthquake |
| P&ID | Piping and Instrumentation Drawings |
| PAS | Public Address System |
| PCM | Pulse Code Modulation |
| PCS | Plant Control System |
| PGA | Peak Ground Acceleration |
| PMF | Probable Maximum Flood |
| PSHA | Probabilistic Seismic Hazard Analysis |
| PVC | Polyvinyl Chloride |
| QA | Quality Assurance |
| QC | Quality Control |
| REFLEXW3 | Computer Software |
| RMR | Rock Mass Rating |
| SAS | Substation Automation System |
| SCADA | Supervisory Control and Data Acquisition |
| SEE | Safety Evaluation Earthquake |
| SLOPE/W | Computer Software (Geo-Slope) |
| SMR | Slope Mass Rating |



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| | |
|---|---|
| SOPs | Standard Operating Procedures |
| SPC | Stored Program Control |
| SRS | Seismic Refraction Survey |
| SSEMP | Site-Specific Environmental Management Plan |
| SSHSMP | Site Specific Health and Safety Management Plan |
| TDM | Time Division Multiplexing |
| TOC | Taking Over Certificate |
| ToRs | Terms of Reference |
| UBC | Uniform Building Code |
| UPS | Uninterruptible Power Supply |
| USACE | United States Army Corps of Engineers |
| USBR | United States Bureau of Reclamation |
| VA | Volt-Amps |
| VR | Village Road |
| VT | Voltage Transformer |
| WAPDA | Water and Power Development Authority |

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# SECTION 1 SCOPE OF WORK

## 1.1 GENERAL

The Contractor shall Design, Procure the necessary Equipment and Materials, Construct, Install, Test and Commission the Power Plant according to the scope of work as defined in forthcoming sections. This Section describes the Scope of Work, to be performed by the Contractor under a lump sum, fixed price EPC Contract for delivering the Employer with fully Commissioned and Operative 54MW Hydropower Project Attabad including Joint Operation and Defect Notification Period of one (02) year, for Electro-mechanical works from Commercial Operation Date. The Contractor shall plan and co-ordinate his activities with those being undertaken by the civil contractor under Package-I - Civil and Auxiliary Services Works.

For equipment supplied under EM Contract all built in steel work, holding down bolts, liner tubes, nuts, washers, any embedment's and packing shall be installed by the Contractor. The Civil Works contractor will provide such openings, holes, plinths and subsidiary foundations as may be necessary for the work under EM Contract.

The Civil Contractor shall make application to the Employer for the date by which embedment's to be installed by E&M Contractor. If sufficient information and the necessary materials, templates and embedment's etc. are not installed within such time, any alterations or additions to such foundations, walls, floor ducts, pipes and trenches etc. resulted will be made by Civil Works contractor at the expense of the E&M Contractor.

The Contractor shall provide in accordance with a schedule to be agreed early in the Contract period all loads that his equipment will impose upon the civil structure and other equipment already existing or to be provided as part of the Project.

The Contractor shall plan and co-ordinate his activities with those being undertaken by the Civil contractor under Package-I Civil Works. The E&M Contractor shall liaise with the Employer's to ensure that their plant erection is well coordinated with related component activities of the Contractor for Civil Works. As there is a single contract for E&M plant the interfaces between the turbine, generator and other electromechanical equipment shall be the responsibility of the E&M contractor.

The Employer shall liaise with the civil works contractor with regard to the interface with the civil works. No contractor shall be deemed to have fulfilled his obligation insofar as the commissioning of the Plant is concerned until complete end-to-end tests have been carried out to the satisfaction of the Employer.

The Contractor shall be responsible for all aspects of Design and Construction of the Project in accordance with the Design Criteria and Specifications furnished herein, and in accordance with additional and supplementary Design Criteria and Specifications prepared by the Contractor and accepted by the Employer.

The scope of work to be carried out by the Contractor will include, but not be limited to:

a. Preparation of all "Detailed Design Criteria, Design Analysis, Design Calculations, Technical Specifications, E&M installation and Erection & assembly drawings, Detailed Construction and Shop Drawings, Quality Control Procedures, and Environmental Management Plans necessary for the complete Construction of the Project together with Operation and Maintenance (O&M) Manuals, Baseline Study Report and As Built Record Drawings";



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b. Layout of individual Project Components including Equipment Layout in the Powerhouse, Switchyard, Intake and other ancillaries;

c. Preparation of Detailed Construction Drawings, necessary Shop Drawings, Schedules etc. for Erection Sequence Drawings for E&M Equipment;

d. Ancillary and Environmental Protection Works necessary during implementation of the Project;

e. Telecommunication and Internet Facility;

f. Quality Plan and Quality Assurance System;

g. Health and Safety Measures Plans;

h. Preparation of Construction Program and Method Statements;

i. Fabrication, Delivery to site, Erection, Testing and Commissioning of specified Plants;

j. Provision of Operation and Maintenance (O&M) Manuals in English language;

k. Inspection testing plan

l. As-Built Record Drawings;

m. Training of Employer's O&M staff;

## 1.2 PROJECT COMPONENTS

Feasibility Project Layout, Alternative Project Layout or any other more Feasible / Applicable Project Layout(s) shall be reviewed and evaluated by Contractor during Bidding Stage.

As a result of evaluation of the Feasibility Project Layout and evaluations during the Site Visit, another appropriate / applicable Project Layout i.e. "Modified Alternative 1-A" comprising of the following main Electromechanical Components as defined by the Management Consultants. The Conceptual Drawings describing this Project Layout is provided in Part-III of this Volume-II.

### 1.2.1 Electro-Mechanical Components

#### 1.2.1.1 Powerhouse

a. Three (3) Vertical Shaft Francis Turbines of 18.94 MW each including all associated Ancillaries and Auxiliary Equipment, Instrumentation and Controls.

b. Three (3) Turbines Acoustic Flow Meters.

c. Three (3) Speed Governors including all Allied and Auxiliary Equipment.

d. Three (3) Turbine Main Inlet Valves with Hydraulic Operators and all Auxiliary Equipment.

e. Powerhouse Mechanical Auxiliary Systems i.e. Cooling Water System, Dewatering and Drainage Systems, Compressed Air System, Oil Purification Systems, Fire Detection and alarm System for Generators and Transformers

f. One (1) Electrically Operated Traveling (EOT) Overhead Bridge Crane of Tentative Capacity 70 Ton for Powerhouse Machine Hall Erection.

g. Mechanical Workshop Equipment.



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h. One (1) Electrically Operated Traveling Powerhouse Passenger Elevator with lifting capacity of 1000 kg or (13) persons.

i. Three (3) Alternating Current Vertical Shaft Synchronous Generators of 18.56 MW (23.20 MVA) each complete with Ancillary Equipment.

j. Three (03) Static Excitation System along with complete Protection and Three Phase Dry Type Transformers.

k. Three (03) Segregated Phase Bus between Generators and Generator Step-Up Transformers at Switchyard.

l. Four (4) Generator Step-Up Transformers with rating of 20/26 MVA each including one spare Transformer.

m. Three (03) Generator Circuit Breakers of Capacity of 1600 A each shall be part of Medium Voltage Switchgear along with Compartments provided for connection with Segregated Phase Bus.

n. The entire Plant shall include the following Protections:

   i. Three (3) sets of complete Generator Protection System.
   ii. Three (3) sets of complete Generator Step-Up Transformers Protection Systems.
   iii. Three (3) sets of complete Protection Systems for the Auxiliary Transformers.

o. Plant Control System (PCS).

p. Telecommunication System.

q. One (1) set of 220V DC System and UPS system.

r. Four (04) Station Auxiliary Transformers (11/0.4kV), Rating of 630kVA each, Dry Type including one spare Station Auxiliary Transformer.

s. One (01) Set Low Voltage Switchgear, Earthing System (For Equipment Protective Earthing Connections) and Cables etc.

t. One (01) Set of Emergency Diesel Generator of Rating 500 kVA for powerhouse.

u. One (01) Set of Medium and Low Voltage (MV/LV) Power Supply and Distribution Networks

**1.2.1.2 Power Intake**

a. Two (2) sets of Trash rack.
b. One (1) set of Stoplogs.
c. Two (2) Fixed Wheel Gates.
d. One (1) Gantry Crane.
e. One (1) Set of Trash rack Cleaning Machine.
f. Two (02) Auxiliary Transformers at Intake (11/0.4kV), Rating of 400kVA, Oil Type including one spare Transformer.
g. One (1) set of 220V DC System and UPS system
h. One (01) Emergency Diesel Generator with Rating of 100 kVA for Intake.
i. One (1) set of Medium and Low Voltage (MV/LV) Power Supply and Distribution Networks, Earthing & Bonding System for E&M equipment and structures



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#### 1.2.1.3 Flushing Intake

a. (1) Guard Gate (Fixed Wheel Type).
b. One (1) Service Gate (Fixed Wheel Type).
c. One (1) set of Stoplogs (Optional).

#### 1.2.1.4 Draft Tube

a. Three (3) Bulkhead Gates (Fixed Wheel Type).
b. One (1) Gantry Crane for Draft Tube Gates.

#### 1.2.1.5 132kV AIS Switchyard

a. 132 kV AIS Switchyard shall consist of Three (03) Transformer Bays (Generator Step Up Transformers), One (01) Power Transformer Bay and Three (03) 132 kV Transmission Line Bays. The 132 kV Transmission Line Bays shall be arranged in a One-and-a-Half Circuit Breaker Scheme.
b. One (01) 132/11.5 kV Power Transformer with a Rating of 10/13 MVA.
c. One (01) Emergency Diesel Generator Set with a Rating of 200 kVA.
d. One (01) Set of 110V DC System and UPS system complete with Batteries and Chargers.
e. MV/LV Switchgear.
f. Protection System.
g. Substation Automation System (SAS)
h. SCADA and Telecommunication System.
i. Equipment Protective Earthing connections, complete in all respect.
j. The specifications mentioned in the Employer's Requirements in respect of Goods and Materials to be provided and considered in the Works shall be new, unused, of the most recent or current models and shall incorporate all recent improvements in Design and Materials.

### 1.3 DETAILED DESIGN AND PLANNING OF THE WORKS

The Contractor shall perform Engineering Services pertinent to planning and Detailed Design of the Works in accordance with accepted International Standards. In addition, the Contractor shall establish a Quality Control/Quality Assurance Program to verify that the Work performed by the Contractor is in accordance with the requirements of the Contract.

The Electro-Mechanical and any other Designs included in the Feasibility Report and Conceptual Drawings in Part-III of Volume-II, Employer's Requirement, are only for the information of the Proposers to understand the Project. The Proposer shall review all such designs and may firm up their Proposal level Designs and Drawings in view of the Employer's Requirements, Standards and Specifications to fulfill their responsibility as a Contractor.

The Contractor shall prepare a Basic Design as part of preparation of its proposal for construction of Works. The Contractor shall be fully responsible to develop the detailed design for implementation of the Project, including consideration of all requirements stated Volume-II. Any details or information shown in the Basic Design shall be confirmed by the Contractor before incorporation in the Detailed Design of the Works. Any deviations from the



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requirements stated in Volume-II, Part-I, Part-II and Part-III shall be brought to the attention of the Employer in writing and shall be subjected to Employer's approval.

The Contractor shall prepare and execute all the site investigations and surveys necessary for the detailed design and project execution with the prior approval of Employer.

The Contractor shall provide the entire Works to be fully equipped, ready for operation with spare parts and consumables required for the operation for the specified period in Volume-II Part-II (Technical Provisions) to the Employer. If the EPC Contractor shall operate the Works, either for a "trial period" in accordance with sub-clause 9.1 or as directed by the Employer.

### 1.3.1 Detailed Design

All Designs shall be performed in accordance with the requirements given in the following Section 2, Basic Design Criteria. The Design responsibilities of the Contractor shall be as follows but not limited to:

a. The Contractor shall carry out the Detailed Design and prepare Construction Drawings of the Permanent Works to be performed under this Contract and the site investigations, all analysis deemed necessary for detailing the design. These analyses will include, but will not limited to the analysis listed below.
    - Stability Analysis;
    - Head Loss Calculations of complete waterways and Turbine setting to minimum Tailwater Level;
    - Annual Energy Calculations (in tabulated form) considering Average Daily Flows and Actual Plant Efficiencies;
    - Using Computer Simulation Modelling, carry out Hydraulic Transient Analysis to determine speed & pressure rise values and flywheel effect ($GD^2$) keeping in mind that the Power Plant will be required to stably operate in isolated mode;
    - The hydraulic complete design shall be vetted by the Turbine's Manufacturer;
    - Structural Design Calculations and Drawings of Hydraulic Steel Structures (HSS) including Gates, Stoplogs, Trash rack along with their Service / Support Structures;
    - Detailed Piping and Instrumentation Diagrams (P&ID) for the Mechanical Auxiliary Systems along with System Description, Design Data, Calculations and Design Briefs.
    - Using computer simulation modelling, carry out surging analysis in the waterways considering applicable cases of load rejection and load acceptance to verify if the maximum upsurge and down surge in the surge chamber are within safe operating limits against worst case scenario.
b. The Contractor shall prepare the Detailed Design and Drawings of the necessary Temporary Works to be performed under this Contract;
c. The Contractor shall prepare Construction Method Statements and an Execution and Implementation Plan;
d. The Contractor shall prepare the Detailed Design and Connection Shop Drawings of the Hydro-Mechanical and Electro-Mechanical Equipment to be installed under this Contract;
e. The Contractor shall prepare the Detailed Design Drawings and Shop Drawings of 132 kV Switchyard and Connection Facilities including Grid Connection after Site Investigation / Testing if necessary.



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f. In the event that any unforeseen underground or overhead utility lines or services are encountered during the course of the project, the Contractor shall be responsible for identifying and proposing suitable alternatives or modifications to the design during the detailed design stage. All such alternatives must be submitted for review and approval by the Engineer/Employer prior to implementation, ensuring minimal disruption to existing services and project timelines.

The activities to be performed under the Detailed Design are outlined as follows but not limited to:

- Review the work done and prepare Summary of all Tests and Investigations planned to be carried out in connection with the Detailed Design;
- Design Memoranda;
- Detailed Design Calculations;
- Providing and/or incorporating Manufacturer's Drawings;
- Manufacturing and Delivery Schedule for Major Equipment;
- Detailed information of Site Offices and Camp Facilities;
- Quality Control and Quality Assurance plans and Procedures for Construction;
- Environmental Management Plan including measures for rehabilitation of work areas;
- Construction Security, Health and Safety plans; and
- Basic Outline of the Operation and Maintenance Manuals, and proposed Training Program.

The Contractor shall prepare Detailed Design Documentation to include as a minimum for the review of Employer:

- Review of Assumptions and Design Procedures adopted, Design Criteria, Loads, Load Cases used and the Safety Factors;
- Short Description of each Method of Analysis, Computer Programs and Software etc. used;
- Calculations and Principal Results of the Detailed Design Analysis;
- Detailed Design Drawings and Specifications for Construction;
- Manufacturer's Shop Drawings;
- All other information necessary for Construction/Completion of Works.

## 1.4 QUALIFICATION EXPEREINCE REQUIREMENT FOR DESIGN FIRM FOR ENGINEERING OF E&M PLANT EQUIPMENT

If the Proposer has an experience of design and manufacturing of E&M Equipment as a Manufacturer and sub-Contractor only, then for E&M Plant Engineering like Hydraulic Transient Analysis, Power System Studies, Earthing Design, BOP Design, AC/DC System Design, Control & Protection Schemes Design etc., the proposer shall engage the services of reputed international design firm having design experience of at least successfully completed two Projects of similar nature and complexity of E&M Plant Engineering of Hydro power Plant.

All design activates shall be carried out after approval of design firm by the Employer Representative.

Following information is needed to evaluate the design capability of the design firm:



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- Experience/Performance Certificates/ Documentary Proof of at least two Hydropower Projects clearly mentioning design activities of E&M Plant Engineering of Hydropower Plant, carried out by the Design Firm for those Projects like Transient Analysis, Power System Studies, Earthing Design, BOP Design etc.

- CVs of Key Design Experts showing relevant skills/experience in specific design activities

- List of design software and tools, which are used by the Design Firm for similar design activities for design of E&M Plant Engineering.

## 1.5 QUALIFICATION EXPERIENCE REQUIREMENT FOR E&M PLANT AND EQUIPMENT

During execution stage, the following minimum criteria shall be applied to all Suppliers/Sub-Contractors/Manufacturers, which are intended to be used by the Contractor.

a) The proposed Supplier/Sub-Contractor/Manufacturer must demonstrate at least five (05) years of business on international projects outside their home countries according to international standards.

b) The proposed Supplier/Sub-Contractor/Manufacturer must have supplied the equipment to at-least one (1) similar project in Pakistan or outside the home country of the Sub-Contractor/Supplier/Manufacturer during last 10 years.

c) Similar type of equipment as offered for the Project must have been in satisfactory commercial operation for at least three (03) years proven by the reference documentation.

## 1.6 PROVISION OF FIELD CAMPS AND OFFICES AND OPERATING FACILITIES

### 1.6.1 General

Provision of field camps and office, accommodations complete with all facilities for their own staff shall be made by the Contractor positively within three (03) months of issuance of notice to proceed in accordance with Employer's prior approval and requirements. If the Contractor fails to complete this activity within three (03) months of issuance of notice to proceed, all the expenses as a result of alternate offices residences and other facilities for their own staff, shall be deducted from the invoices claimed by the Contractor.

The Contractor shall design, install, operate, provide all consumable items, spares, replacements etc.; and shall maintain throughout the execution of the work all camp and office facilities required for the Works.

The Contractor shall provide, maintain and operate suitable capacity diesel generators along with lubricants, fuels, filters and spares; one (01) for accommodation for their own till completion of the project.

The Contractor shall be responsible for ensuring that, during the construction period, there should be no adverse impact on the operations of any structures owned by government of Pakistan and Gilgit Baltistan and Private sector.

During the entire construction period and Defect Notification Period, the Contractor shall be responsible for the maintenance of the entire telephone system and cellphones facilities inclusive of rental, call and data charges.



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The Contractor shall make available canteen and catering facilities for his own needs. The capacity shall be adjusted to the peak manpower requirement at Site. Canteen facility (lunch and tea) should be made available in field office free of cost. These facilities shall be able to serve hygienic meals at all times of the day to the Contractor and Employer's Staff. Adequate recreational facilities shall be provided.

Possession of the Project land will be taken from the Government of Gilgit Baltistan (GoGB) which will be handed over by the Employer for construction of the permanent project components.

Contractor shall provide appropriate number of security guards for effective and vigilant watch and ward around the clock for the project area along with all necessary security equipment and tools as mentioned in sub-clause 1.4.8.

### 1.6.2 Temporary Site Installations

The Contractor shall design, install and maintain throughout the execution of the Works all temporary facilities, such as, but not limited to, Survey control points, foundations for construction plant, workshops, offices, site laboratory (to carry out all necessary tests) and stores etc. required for the Work.

On completion of the Project, the Contractor shall remove all temporary facilities, including their foundations that are not handed over to the Employer, and restore the area to a level acceptable to the Employer.

### 1.6.3 Temporary Facilities to be handed over to the Employer

At the Completion date, selected temporary facilities or part thereof shall be handed over to the Employer if and as the Employer requires. These facilities shall be handed over to the Employer at no additional cost in good and serviceable conditions so that these can be utilized by the Employer without any further treatment or renovation.

### 1.6.4 Construction Power and Water Supply

The Contractor shall be responsible for the design and provision of temporary power supply for all sites during construction of the works (if small Micro/Mini Hydro Generators). Such facilities shall be handed over to the Employer at no additional cost in good and serviceable conditions so that these can be utilized without any further treatment or renovation by the Employer.

The Contractor shall be responsible for the supply of potable water as well as treatment/ disposal of waste water as well as appropriate disposal of solid waste for their own staff and to be acceptable to the Employer.

### 1.6.5 Water Distribution System

The water distribution system shall be designed and installed by the Contractor and shall be maintained during the entire duration of the Project Construction, Defect Liability Period and Period during which the Contractor rectifies the defects.

Prior to execution, the Contractor shall submit all necessary layouts and detailed drawings to the Employer for approval.



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### 1.6.6 Sewerage and Pollution Disposal System

The Contractor shall design sewerage and pollution disposal system according to national and international standards. The design shall be approved by Employer. The Contractor shall execute and maintain sewerage system for all of his site installations staff.

The sewerage system shall be in accordance with the sufficient required capacity of the sewerage system comprising sewer pipes in all dimensions, manholes, complete sewage treatment plants and all other installations and civil works to put the complete system into operation.

The treated wastewater shall be discharged downstream of Tailrace Channel located in the vicinity of the site area. The sanitary drainage and sewerage treatment system shall be provided with a suitable capacity of sewerage treatment compact pumping station, Septic Tank, Leach Field, Chlorine Contact Chamber, piping, power supplies, Valves and other accessories as per requirement of the project.

At all workshops and other areas where losses of lubrication oil can occur, the Contractor shall provide oil traps, oil separators or other measures to avoid environmental pollution. The oil shall be properly disposed at location and method approved by the relevant authorities.

### 1.6.7 Contractor's Site Office

a. The Contractor shall establish the site office and its facilities which he requires for the Project.
b. The Contractor is foreseen to have one main office.
c. The Contractor shall establish site office on temporary land at his own cost.
d. Unless otherwise instructed by the Employer, at the end of the Construction period, all site office buildings and storage buildings (including the foundations), electric services, buried utilities, and fencing shall be removed and the site restored to the condition found before the camp was developed.

### 1.6.8 Contractor's Camp

#### 1.6.8.1 General

The Contractor camp shall be constructed by the Contractor in accordance with the requirements the project construction. The Contractor will be responsible for development and operation & maintenance of the Contractor Camps for its own requirement.

Overall development of the Contractor Camp for their own staff is the responsibility of the Contractor. Contractor camp will be established on Temporary Land which will be arranged by the Contractor at his own cost.

#### 1.6.8.2 Boundary Wall, Fencing and Watch Towers

Proper Boundary wall (3.5 m high) around construction camp along with barbed wire and razor wire fencing and appropriate number of search light towers for proper surveillance by security staff will be provided by Contractor.


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### 1.6.8.3 Camp Security

Security inside the perimeter of the Contractor camp shall be the responsibility of the Contractor for the duration of the Works. In addition to premises security, storage buildings, all work and office areas shall be provided with security to prevent loss of materials as well as maintaining the stored equipment.

Contractor shall arrange the security equipment and security guards which includes but not limited to:

a. Walkie-Talkies.
b. Walk through gates.
c. Metal Detector.
d. Search Lights for security surveillance.
e. Installation of CCTV cameras
f. Barracks for security guards and GB police personnel will also be provided by the Contractor.
g. Necessary arms and ammunition.
h. Pop-up barriers.

### 1.6.8.4 Security Field Cabins and Barracks

Contractor will provide, establish and maintain appropriate number of field security cabins and barracks with all accessories and utilities over the duration of project and defect notification period. Cost shall be included in the Contract Price.

Security outside of the premises of the Employer camp and Contractor camp shall be provided by the GB police which will be arranged by the Contractor.

### 1.6.8.5 Removal of the Camp

Unless otherwise instructed by the Employer, at the end of the Construction period, all camp buildings and storage buildings (including the foundations), electric services, buried utilities, and fencing shall be removed and the site restored to the condition found before the camp was developed.

### 1.6.8.6 First Aid Facilities

a. A first aid station shall be provided to serve all personnel at the site. The first aid station (Dispensary) shall be equipped as required by applicable Pakistani and Gilgit Baltistan laws.

b. A qualified emergency medical officer shall be on duty at the first aid station (Dispensary) on each working shift and day.

c. One Ambulance with driver fully equipped to handle the emergency shall be on duty at site for working day.

d. The Contractor shall furnish proof to the Employer that he has a continual arrangement with an approved hospital and Medicare arrangements for the emergency evacuation and admittance at any time and subsequent medical and hospital care for injured employees.



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### 1.6.9 Temporary Electrical Facilities

#### 1.6.9.1 Scope of Work

The Contractor shall be responsible for complete installations, earthing, testing and commissioning of the power supply networks, Distribution Transformers, along with allied hardware's, consisting of but not limited to all material, labor, tools and accessories etc. or (unless specifically stated otherwise) required for proper completion shall be included in the Contractor's Scope of Works.

a. The Contractor will construct his own power supply network from Diesel Generator set to various parts of the works including his offices, equipment, construction areas, testing areas, workshops, plant, and all other needed facilities.

b. Diesel generator set as a main power supply for the various parts of the works including Contractor offices, equipment, work areas, workshops, plant.

c. Lighting and small power system (indoor/outdoor) for various parts of the works for their own facilities

The Contractor shall remain responsible for site clearance, removal of defects detected in the works for achieving satisfactory operation/ functioning/ service of the works. The contract shall include furnishing of all construction equipment, tools, labor, supervisory staff, plants, transport, power, testing apparatus/arrangements and all construction materials as shall be required for satisfactory completion of works strictly in accordance with DISCO's technical specifications & Standards. The cost of the aforementioned scope including tariff cost of electricity bill, diesel etc. shall be borne by the Contractor.

### 1.6.10 Site Communication

a. The Contractor shall furnish and completely install a telephone system as communication facility for his own requirements.

### 1.6.11 Project Vehicles

The contractor shall provide three (03) brand-new Double Cabin Four-Wheel Drive vehicles and three (03) brand-new Jimny Jeeps for the Employer. Additionally, the contractor shall provide two (02) brand-new Double Cabin Four-Wheel Drive vehicle and one (01) brand-new Jimny Jeep for the Attabad Hydropower Management Consultants. The contractor shall be responsible for all costs related to registration, licensing, insurance, operation, and maintenance, including fueling and dedicated drivers, throughout the project duration, including the Defect Notification Period. Upon project completion, all project vehicles shall be handed over to the Employer.

### 1.6.12 Project Working Scale Physical Model

Contractor shall prepare project working scale physical model of size 1.2m x 0.8m along with stands and associated features.

## 1.7 QUALITY ASSURANCE/QUALITY CONTROL

### 1.7.1 General

a. The Proposer is required to demonstrate by documentation his proven capability to design, manufacture, supply, install and commission all equipment specified herein.



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b. The documentation shall be based upon the requirements set forth in ISO 9001:2015, "Quality systems, Model for quality assurance in design/development, production, installation and servicing". Copy of current certificate shall be presented to the Employer.

c. The Contractor shall be completely responsible for implementing a Quality Assurance Plan covering all the Works contained in the Contract. The Quality Assurance Plan will be prepared by the Contractor and reviewed and authorized by the Employer and will be implemented by the Contractor. Specifically, it will be managed by the Contractor's Quality Assurance Manager. The Contractor's Quality Assurance Plan is the means by which the Contractor ensures the control and quality of all design functions, all fabrications by the suppliers and Sub-contractors and all construction activities carried out by Contractor's forces and the Sub-contractors, all work by equipment installation engineers and the testing and commissioning activities associated with all the mechanical and electrical equipment.

### 1.7.2 Contractor's Quality Assurance Plan

The Contractor's Quality Assurance Plan shall meet all the requirements of ISO 9001- 2015. As appropriate the Contractor will impose on his designers, suppliers, fabricators and sub-Contractors the requirements of ISO 9002, ISO 9003 and ISO 9004. The Quality Assurance Plan will be prepared and presented in three different volumes namely:

Volume 1 Quality Plan;
Volume 2 Quality Assurance Procedures; and
Volume 3 Quality Control Procedures

Collectively the three Volumes shall comprise the Contractor's Quality Assurance Plan (PLAN). Each volume will address the issues enumerated in the following articles of this Section. The Quality Assurance Plan shall recognize and include the potential necessity for revision during the project at which time reauthorization shall be sought from the Employer. Within thirty (30) days of the date of the Letter of Acceptance, the Contractor shall produce and submit to the Employer an outline of the Plan. Within a further 30 days of the above submittal date, the Contractor will submit the detailed Plan incorporating the comments made by the Employer. The authorized detailed Plan will be supplemented by comprehensive details for specific work activities at least 28 days prior to their commencement. The Contractor's Quality Assurance Plan will be managed and directed by a dedicated Quality Assurance (QA) Manager who will be physically present on the Project Site throughout the implementation, and will report directly to both the Contractor 's Site Project Manager and independently and directly to the Contractor 's Home Office Senior Management. The QA Manager shall represent and be authorized by the company to manage quality assurance activities and to implement the Contractor s QA system.

### 1.7.3 Volume 1 "Quality Plan"

This section of the Contractor 's Quality Assurance Plan will address the following topics:

a. Purpose and Scope;
b. Policy;
c. Organization and Responsibilities;
d. Project Manager Review;
e. Applicable Standards; and



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f. Definitions.

The purpose, scope and policy sections will establish the general philosophy and parameters that the Contractor ’s Senior Management requires for the Quality Assurance Plan. Organization and Responsibilities will clearly present the detailed Contractor ’s Organization as it pertains to Quality Assurance and Quality Control activities. A description of assigned responsibilities is required. Project Management Review will address the Contractor ’s procedures for addressing quality issues raised by the Quality Manager to the Site Project Manager and Head Offices Senior Management. The standards that will be used to support the Contractor ’s Quality Assurance Plan are required to be listed. These will include all applicable industry codes, standards and practices and specifically those referenced in the Contract Documents and the Technical Specifications. For clarification in the use of the Contractor ’s Quality Assurance Plan document by Contractor ’s personnel it is required that a glossary of specific terms used in the documents be itemized (Definitions).

**1.7.4 Volume 2 “Quality Assurance Procedures”**

This Volume will present clearly the Quality Assurance (QA) procedures developed by the Contractor to provide a planned and disciplined approach for the achievement of project quality objectives. The procedures, in general, require the prompt detection and correction of deviations, which are or may be, detrimental to quality or safety and generate documentation necessary to provide objective evidence of achievement of quality and safety objectives during design, fabrication, construction and commissioning phases of the project. As a minimum the QA procedures will include but not limited to:

- Contractor ’s quality statement;
- Contractor ’s organization structures including quality control organization;
- Contractor ’s quality procedures addressing requirements of ISO 9001;
- Principal staff and its tasks and responsibilities;
- Contractor ’s plant management procedures;
- Construction program management;
- Progress reporting procedures;
- Contractor ’s design procedures;
- Contractor ’s procedures for selecting and appointing sub-Contractors and Suppliers including independent testing laboratories;
- Contractor ’s procedures for obtaining, reviewing and approving sub-Contractors and Suppliers quality procedures and for quality auditing of sub-Contractors and Suppliers;
- Contractor ’s risk assessments and method statements reporting in detail the proposed safe methods of working and measures to reduce risks or hazards to as low as reasonably practicable;
- Control of construction procedures with emphasis on Materials control and approval; and Method statements, including transportation and handling of materials;
- Verification, testing and reporting procedures for design, equipment, materials and workmanship in the office, factory or on site;
- Document control procedure;
- Health and safety procedures;
- Environmental Management plan;
- Site operational control procedures;
- Contractor ’s internal quality audit control procedures;



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- Non-conformance reporting (NCR) procedures;

**1.7.5 Closing out NCR for the Taking-Over procedures;**

- Training procedures;
- Interim measurements and payment procedures;
- Final measurement procedures;
- As-built information and operation and maintenance manuals; and
- Change control of project quality procedures.

The plan shall include organization charts illustrating the main task and their sub-division, the reporting structure and:

- Interface between the Contractor and the Employer;
- Interface within the Contractor ’s internal project team;
- The Contractor ’s coordination with local and statutory authorities; and
- The Contractor ’s internal quality management arrangement including quality assurance and auditing personnel.

The QA Procedures are the requirement for the Quality Assurance Manager to formulate an audit plan, designate organizational elements subject to audits and establish a schedule for providing regular auditing activities. The Contractor ’s internal quality audit control procedures will be written and submitted to the Employer for review and approval and as a minimum will contain the following items:

- Audit title and number;
- Organization affected;
- Purpose;
- Scope;

Activities to be audited;

- Performance standards;
- Audit team members overall schedule;
- Any interfaces;
- Review and approval authority; and
- Schedule of audits.

The Contractor ’s internal quality audit control procedures and schedule of audits will be forwarded to the Site Project Manager and other key members of his organization. Employer shall have the right to require revision of the Contractor ’s internal quality audit control procedures during the project.

**1.7.6 Volume 3 “Quality Control Procedures”**

a. This volume will present the procedures and systems that the Contractor will perform to maintain an effective Quality Control (QC) program. In general, the Contractor will perform sufficient checks, inspection and tests on all items of the Work including:

    - Design Engineers;
    - Suppliers;
    - Sub-Contractors; and
    - Contractor ’s site work activities.



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b. The Contractor shall ensure conformity with respect to the design, materials, workmanship, construction, finish and functional performance. The Quality Control Plan shall include adequate provision for access by the Employer to inspect any and all facilities of the project and facilities such as laboratories etc. required to implement the plan. Specifically, Volume 3 will address the following items as a minimum:

- The QC organization;
- The number and qualifications of personnel to be used;
- Authority and responsibility of QC personnel;
- Methods and procedures of QC control for all the work including design, suppliers and sub-Contractors;
- Inspection and Testing Plan;
- Details of the site laboratory including the physical layout and proposed on-site testing equipment;
- Details of any off-site laboratory testing;
- Details of the physical site tests and laboratory tests proposed for all the construction materials with emphasis on cement, concrete, soils and rock testing. Frequency of testing shall be included;
- Off-site testing of manufactured items and type testing;
- Procedures that will ensure that the latest applicable Drawings, shop drawings, the Employer's Requirements and instructions required by the Contract Documents, as well as authorized changes, are used for fabrication, construction, inspection and testing.

c. Procedure for the issuance, tracking and closeout of Non-Conforming Reports (NCR's) and Deviation Reports (DR's). This procedure shall prioritize the NCR's and ensure the closeout of such matters in a timely manner to the satisfaction of the Employer.

## 1.8 ENVIRONMENTAL COMPLIANCE

The Contractor shall comply with all applicable national and local environmental regulations and guidelines. The Contractor shall also comply with the Environmental Impact Assessment (EIA) Report and the conditions that will be laid down in "No Objection Certificate (NOC)" that will be issued by the GoGB, Environmental Protection Agency (EPA).

Reference is made to the environmental requirements given in;

a. The Laws and Regulations of Government of Pakistan and Government of Gilgit Baltistan, and relevant International standards;
b. GB Environmental Protection Act, 2014 and other applicable environmental rules and standards and good engineering practices and guidelines related to ESHS;
c. Employer's Requirements regarding ESHS given in subsequent Sections of Bidding Documents (refer Section 1.11.13 and sub clause 4.2 respectively);
d. Sub-clauses of General Condition of Contract and any other clause or sub-clause having any relevance to Environment;
e. The Contractor shall within one month of receipt of Notice to Proceed, appoint ESHS Personnel as specified under Section 4.2 of Special Provisions, whose broad responsibilities are to guide the construction personnel on ESHS matters, to communicate and to make liaison with the Employer, local stakeholders, relevant departments such as GB EPA, Fisheries Department, Wildlife Department and other relevant departments;



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f. The Contractor shall (a) establish an operational system for managing ESHS impacts and risks, (b) carry out all the monitoring and mitigation measures set forth in the EIA and Environmental Management Plan (EMP) for the project, and (c) allocate the budget required to ensure that such measures are carried out, and all cost for the implementation of such measures shall be borne by the Contractor in letter and spirit. The Contractor shall submit to the Employer, monthly and quarterly environmental reports on the carrying out of such measures as identified in the EIA, EMP, NOC and Contract;

g. The EPC Contactor needs to prepare the Site-Specific Environmental Management Plan (SSEMP) and Site-Specific Health and Safety Management Plan (SSHSMP) and other plans as suggested in the EIA Report;

h. The Contractor will be responsible to update the EIA including EMP based on the final design and submit to the Employer for review and approval; and

i. The Contractor shall apply for the operational stage NOC after the completion of the Construction works with GB EPA.

The detailed requirements with regards to the environmental provisions are provided in Section 4.2.

### 1.9 DOCUMENTARY FILM

The Contractor will prepare a documentary film showing all important events of construction, sub-assemblies and erection, testing and commissioning assemblies, of all the equipment. The documentary will provide a commentary giving full details of events. Three (3) copies of the documentary Film will be provided to the Employer before completion of the Project. The Contractor will present the Employer the updated documentary film on three (3) month basis for the review and approval of Employer.

### 1.10 JOINT OPERATION AND DEFECT NOTIFICATION PERIOD

The E&M Works Contractor shall successfully complete the joint operation of Electro-mechanical works for a period of two (02) years, which shall run concurrently with the Defect Notification Period (DNP).

Upon successful testing and commissioning, the Contractor shall assist in the joint operation of facilities for training the Employer's staff.

The Contractor shall deploy qualified personnel for the operation, maintenance, and rectification of any defects related to Electro-mechanical works during this period.

The Contractor shall remain responsible for rectifying defects within its scope during the Defect Notification Period.

The Contractor shall coordinate with the Civil Works Contractor to ensure seamless integration and operation of systems requiring both civil and E&M inputs.

Any defect requiring joint coordination between Civil and E&M Contractors shall be addressed through Employer, ensuring timely resolution.

Upon successful completion of the Defect Notification Period, the Contractor shall formally handover all related works to the Employer.

The final acceptance shall be subject to the satisfactory performance of all components



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and compliance with contractual requirements.

## 1.11 MOBILIZATION AND DEMOBILIZATION

a. The Contractor shall also furnish all the labor, materials, equipment and shall perform all work required for mobilization to and demobilization from the project site.

b. Mobilization shall include, but not be limited to, moving personnel, plant, and equipment to the Site; arranging for necessary Site utilities; establishing camps, shops, offices and administrative facilities; and obtaining all required permits, licenses, and other regulatory authorizations required by the Contractor for the construction of the project.

c. Demobilization shall include, but shall not be limited to, removing all plant, equipment, and temporary facilities from the Site; disconnecting temporary utilities; relocating personnel from the Site; cleaning-up and restoring all areas occupied by the Contractor; closing out permits, licenses, and other regulatory authorizations; and disposal of all waste materials and excess construction materials which are not the property of the Employer.

d. Cost of mobilization and demobilization shall be deemed to cover in overall Contract Price.

## 1.12 PROPOSAL SUBMISSIONS

### 1.12.1 General

The following documents are to be submitted with the Proposal for the purpose of evaluation.

#### 1.12.1.1 General

a. Completely filled schedules & data sheets.
b. Letter of Technical Proposal along with schedules.
c. Complete list of any Technical or Commercial Deviations.
d. Price and Payment schedule.
e. Comprehensive list of drawings to be submitted by the Contractor during detailed engineering.
f. Outline of Test and commissioning Plan for tests on Completion.
g. Outline of Training Program.

#### 1.12.1.2 Technical

a. Hydraulic Design and Head loss Calculations.
b. Power & Energy Studies.
c. Proposal Design Report covering basic design of E&M Plant.
d. Proposal Drawings for E&M works.
e. Construction Specifications.
f. The Proposer shall submit the necessary calculations, documents, and drawings as part of the Proposal to enable the Employer to assess the technical conformance of the proposed process. However, the Hydraulic Analysis shall be submitted during the Level-1 Design stage.



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### 1.12.2 Proposal Design

The Proposer shall submit as a minimum to define his offer, Drawings, Design Criteria, Data and Design Briefs and Construction Specifications. The Design Briefs shall be intended to represent the type and quantity of information required to evaluate the Proposals and to highlight:

a. Design parameters and Methodology.
b. Design Criteria.
c. Head Loss Calculations.
d. Power and Energy Calculations.
e. Construction Work Schedule.
f. Operating characteristics of the Project and its component parts.

### 1.12.3 Proposal Drawings for Electrical and Mechanical Equipment

As a minimum the following drawings shall be necessary to define the project Hydro-Mechanical and Electro-Mechanical equipment;

a. Drawings showing the general arrangement of the equipment including single line diagrams.
b. Plans.
c. Elevations.
d. Sections. (including principal dimensions).

### 1.12.4 Schedule Requirements

a. The Contractor shall plan and execute the Works to achieve the time for completion of the Section or the Works given in Contract.
b. An integrated project schedule shall be provided to demonstrate that Time for Completion given in Contract could be achieved. The integrated project schedule shall provide schedule dates for all Milestone Dates and will be used to monitor the Contractor's progress with reference to completion of the Works.

### 1.12.5 Contractor's Staff

a. Contractor will be responsible to arrange a strong state of the art design team or at least produce an MOU with some reputed Engineering Consulting Firm.
b. The Contractor shall assign a qualified Project Manager acceptable to the Employer and adequate staff with sufficient relevant experience. The Project Manager should have relevant construction experience of 15 years and should have managed at least two (02) similar projects of US$ 40 million value each.

## 1.13 CONTRACTOR SUBMITTALS AND RESPONSIBILITIES

### 1.13.1 General

The Contractor shall submit Contractor's Documents for review as specified. Unless otherwise specified in the Contract, the Contractor shall provide each Design and Construction Document to the Employer as per details specified in Table 1-1 included at the end of this Section.



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Notwithstanding the time periods listed in Table 1-1, the Contractor shall submit all documents as early as reasonably practical to mitigate any possibility of delays arising from review by the Employer or by third parties.

The Employer's review period and provision to comment shall be to assure the Engineer of the Contractor's compliance with the Contract. It is intended that Employer shall have a review and comment opportunity for each construction document, for each submittal or resubmittal.

Prior to the Commencement Date, the Contractor shall prepare and submit a "Design Management Plan" outlining the procedures to be used for control of design activities, schedule for design, coordination of the main Project design with the activities of sub-Contractors, design quality control procedures, authorizations for review and approval of design, description of design documents such as design criteria, design memoranda, and design reports, and other information necessary to demonstrate that the Contractor can effectively manage the design of the Works.

All Project documentation and submittals shall be in English Language.

All specifications, drawings, reports, design calculations and other essential data are subject to the Employer's review. Comments shall be given in writing by the Employer within twenty-eight (28) days after receipt of such documents, unless otherwise stipulated. Any work carried out prior to such approval shall be at the Contractor's own risk and expense. The number of drawings and documents to be submitted for information or approval shall be limited to the required minimum for the purposes of the Employer. The exact number and mode of distribution for drawings and documents will be agreed upon between the Contractor and Employer at the Commencement Date.

The Contractor shall submit a drawing schedule, which will be subject to the review by the Employer. The drawing schedule shall be consistent with the Contractor's integrated project schedule. The drawing schedule shall show design phase, structure, drawing number, titles, status, schedule dates and other relevant information. At four (04) week intervals, the Contractor shall submit copies of the revised drawing schedule showing the actual status of the drawings, i.e. preliminary, reviewed by Employer, approved for construction by Contractor, for information only, or as-built, and the date for completion of each phase of the drawings.

The Contractor shall submit a document control schedule, which will be subject to the review by the Employer. The document control schedule shall be consistent with the Contractor's integrated project schedule. The document control schedule shall show the number, titles, status, schedule dates and other relevant information. At four (04) week intervals, the Contractor shall submit copies of the revised document control schedule showing the actual status of the documents, i.e. preliminary, reviewed by Employer, approved for construction by Contractor, for information only, or as-built, and the date for completion of each phase of documentation.

The construction documents shall comprise the documents described in this Section in addition to other documents specified in the Contract.

### 1.13.2 Procedure

a. The Contractor's Documents to be submitted to the Employer for review as defined in Conditions of Contract.

**Table 1-1: Schedule of Design and Construction Submittals**



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| Description | Review Period | No of Copies for Review | No of Copies for Final Issue | Digital Copy |
|---|---|---|---|---|
| List of Design Documents for Review, Approval & Information | 28 days | 4 | 6 | 2 |
| Design Criteria & Basic Design (Level-1 Design) | 28 days | 4 | 6 | 2 |
| Detailed Design Criteria & Detailed Design (Level-2 Design) | 28 days | 4 | 6 | 2 |
| Detailed Design (Level-2) | 28 days | 4 | 6 | 2 |
| Detailed Design Specifications | 28 days | 4 | 6 | 2 |
| Construction drawings | 28 days | 4 | 6 | 2 |
| Manufacturer's shop drawings | 28 days | 4 | 6 | 2 |
| Inspection and Test Plans | 28 days | 4 | 6 | 2 |
| O&M Manuals | 28 days | 10 | 10 | 2 |
| Erection & Testing manuals | 28 days | 4 | 6 | 2 |

b. The sequence in which documents are submitted shall follow a logical progression such that all information is available to the Employer to facilitate review of each submittal when it is received. The program for detailed design shall allow the required time for review by the Employer.

c. All submittals shall include one copy in Digital form as well as the prescribed number in hard copy. In general design submittals shall be in:

   i. MS Word format for all text and reports.
   ii. AutoCAD version as advised for all drawings.
   iii. MS Excel for all calculations.

d. The Contractor shall provide on each submittal a clear space for the Employer's review stamps and comments.

e. Drawings and all supporting data, catalogs, or similar information shall be prepared by the Contractor or his suppliers and sub-Contractor, but shall be submitted as instruments of the Contractor.

f. The Employer will review submittals only for conformance with the design concept of the Project and for compliance with the contract. Contractor shall make any and all corrections required.

g. After Employer has performed his review of submittals, Employer will return one print to the Contractor with one of the following notations:

   i. Approved. (A)
   ii. Approved Except as Noted. (AEN)
   iii. Revise and Resubmit. (RC)

h. When submittals are returned marked with (ii), the Contractor shall make such revisions and/or corrections and resubmit the drawings or other material in the same



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manner as specified in submittals schedule. Construction works can be undertaken under category (ii) after incorporating comments.

i. When submittals are marked with (iii), the Contractor shall make new submission as directed by Employer for review and approval.

j. When drawings and submittals are returned with authorization to proceed with the work, Contractor shall provide the number of prints or copies of drawings as is required for field distribution.

### 1.13.3 Design Documents

a. Design Documents means documents of a technical nature provided by the Contractor under the Contract. Design Documents shall include but not be limited to:

   i. Equipment layout plans
   ii. Sections at different elevations
   iii. Embedment details required for civil works
   iv. Calculations, analyses and designs.
   v. Site investigation plans, reports, memoranda
   vi. Construction and manufacturing drawings.
   vii. Model test reports.
   viii. Hydraulic Model Test Reports.
   ix. Transient analysis report and calculations.
   x. Design briefs and design reports.
   xi. Technical specifications and performance curves.
   xii. Parts and components list.
   xiii. Circuit diagrams
   xiv. Wiring diagrams
   xv. Equipment outlines diagrams
   xvi. P&ID Diagrams

b. The Contractor shall provide the Employer with all necessary Design Documents and any other document or information as may be relevant to the performance, operation and maintenance of the Project and Employer's operating and maintenance activities and transfer obligations and to satisfy Employer's Requirements under the Contract.

c. The Design Documents shall be submitted in four basic stages and shall include the following:

   i. Stage-I, Basic Design Documents.
   ii. Stage-II, Detailed Design Documents.
   iii. Stage-III, Construction and Erection Design Documents.
   iv. Stage-IV, As Built Documents.

#### 1.13.3.1 Stage-I: Basic Design Documents

The Contractor shall provide Basic Design Documents to demonstrate that the design complies with the Contract. Basic Design Documents to be routinely submitted for non-objection during this phase shall include:

a. Basic Design Report



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b. Design basis memoranda for each work package
c. Detailed design criteria.
d. Calculations and Reports.
e. Manufacturer's turbine model test report.

The model acceptance tests report shall cover at a minimum, the following items:

Specifications of the model test equipment and instruments, drawings of model, sample calculations, turbine efficiency and output characteristics, cavitation limits and characteristics, hydraulic thrust and counterthrust (steady state and calculated transient characteristics), runaway speed and accompanying discharge, wicket gate torque and turbine runner characteristics, the pressure fluctuations, aeration tests, and flow-index pressure differentials.

a. General arrangement and outline drawings.
b. Architectural drawings.
c. Preliminary construction specifications.
d. Design Certification in respect of the design of each work package.
e. All other Design Documents as scheduled for submission under the Contractor's "Design Management Plan".

The Employer may at any time request Design Documents to a greater level of detail than that provided by the above documents. The Contractor shall respond promptly to any such request and, when appropriate, shall submit Design Documents for non-objection showing the requested details. The basic design of the Works shall be submitted together with any agreed modifications incorporated in the Contract Agreement. The detailed designs shall comprise development of the Basic Design to the level of detail, necessary for fabrication and construction.

**1.13.3.2 Stage-II: Detailed Design Documents**

Engineering/Detailed designs shall be submitted to the Employer for review prior to construction including:

a. Detailed Design Report
b. Summary of all tests and investigations planned to be carried out in connection with the detailed design
c. Design memorandum
d. Detailed design, Model Testing and NOC
e. Hydraulic model testing
f. Construction drawings and as built drawings
g. Manufacturer's Shop drawings to the extent necessary for the Employer's design review and operation and maintenance
h. Plan of the methods of achieving the construction requirements
i. Report on construction methods to be used for all major works
j. Principal items of construction plant to be used
k. Detailed information of site offices and camp facilities
l. Quality Control and Quality Assurance procedures for construction
m. Site Specific Environmental Management Plan (SSEMP) including measures for rehabilitation of work areas



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n. Site Specific Health and Safety Management Plan (SSHSMP)
o. Construction Security Plans; and
p. Basic outline of the Operation and Maintenance Manuals, and proposed Training Program
q. Manufacture's turbine model test report. If the efficiency of the turbine during turbine model test is lower than required efficiency the Employer have right to reject the test.

If in the opinion of the Employer, the engineering designs do not comply with the basic design documents for which the Employer's non-objection was given; the Employer can request further details of the engineering designs. The Contractor shall provide such details and shall justify or rectify any such non-compliance.

**1.13.3.3 Stage-III: Construction and Erection Design Documents**

Final detailed design shall be submitted to the Employer for information prior to the start of construction of work. Documents to be submitted at this stage include:

a. Method statements.
b. Inspection and Test Plans.
c. Designs and drawings of Temporary Works.
d. Fabrication details.
e. Project data.
f. Embedment details
g. Equipment erection plans, procedures, drawings and details.

The Contractor shall prepare and submit Method Statement for the review and approval of Employer prior to the execution of any permanent works at site after the approval of detail design. The Method Statement shall describe activity process to be carried out at site with the resource description deployed for the same. The resources to be inducted by the Contractor shall include Manpower resources, Equipment Resources and Material Resources. The Method Statement shall also describe the relevant standards and reference drawings to be employed during the execution of works. The ESHS requirements involved in the execution of the works will also be a part of Method Statement. The Method Statement shall require formal approval from Employer prior to the commencement of works at site. The Contractor shall follow the approved Method Statement for works during the execution otherwise the Contractor shall be subjected to Non-Conformance as per the QA/QC Standards.

The Contractor shall prepare and submit the Inspection and Test Plan for the review and approval of Employer prior to the execution of any works at site. The Inspection and Test Plan shall have Review point, Witness Point, Hold Point and Surveillance Point for each activity of the works and Contractor shall specify applicable points for the approval of Employer for each activity The Inspection and Test Plan shall be approved prior to the commencement of works and shall be followed at site otherwise Contractor will be subjected to Non-Conformance as per the QA/QC standards.

If in the opinion of the Employer the final designs for construction do not comply with the Basic Design Documents for which the Employer's non-objection was given, the Employer can request further details of the final designs. The Contractor shall provide such details and shall justify or rectify any such non-compliance.



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### 1.13.3.4 Stage-IV: As Built Documents

A final report shall be submitted to describe the As Built condition of the Works. Documents to be submitted at this stage include:

a. Final Design Report updated to include the As Built condition of the Works
b. As Built Construction drawings
c. Project data
d. Operation and Maintenance Procedures
e. Operating constraints and limitations that could affect the use of the Project

The Contractor shall provide six (6) copies of detailed "as-built" drawings for the entire Project, including all Mechanical, and Electrical general arrangements, and shop drawings of major equipment. These are to be based on the Contractor's “approved shop” drawings and field information.

Both E&M and Civil Works contractors shall coordinate to ensure consistency and accuracy in interface areas. A consolidated set of as-built drawings shall be jointly prepared, ensuring proper alignment between E&M and Civil works prior to final submission.

All drawings shall be provided in hard copy on Mylar, and the Contractor shall use his best efforts to provide "AutoCAD" files, as advised version, on computer hard disk or compact disk.

If in the opinion of the Employer the as built designs do not comply with the Basic Design Documents for which the Employer’s non-objection was given or with the Contract, the Employer can request further details of the as built designs. The Contractor shall provide such details and shall justify or rectify any such non-compliance.

### 1.13.4 Design Liability

Notwithstanding any review carried out by the Employer, the Contractor shall accept full responsibility for all aspects of the design, procurement, construction and commissioning of the Project.

### 1.13.5 Program

The Contractor shall submit the proposed program for the design and execution of the Works in accordance with Clause 12.1 of the Conditions of Contract in a format and media approved by the Employer. The proposed program shall be in two (02) levels of details as follows:

a. The Overall Program which shows the major work items of the Works.
b. The Detailed Working Program which shows further breakdown of the major work items into activities involved in the sub-items.

The Contractor shall identify critical activities and key dates and shall present the program in bar chart form indicating activities and dates critical to completion of the Work on time.

The Contractor shall submit an explanatory report covering any aspect of the chart or network that the Contractor cannot show on the chart. The Contractor shall agree with the Employer on the work section, activities, sub-activities, interface and other critical dates, which the Contractor has to identify in the programs. Upon agreement by the Employer, the proposed Overall Program shall become the Overall Works Program based on which the Contractor



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shall complete the Works on time. This Overall Works Program shall not be changed unless agreed with the Employer.

The Detail Working Program shall contain the items, which are breakdowns of the major items, such that no activity shall have a duration not exceeding 30 days. The program shall identify any interface requirements affecting the work, the main quantities of material and other agreed relevant information.

### 1.13.6 . Progress Reports

Each month the Contractor shall report on a day in a format and media approved by the Employer, the progress and financial status of the Works of the previous month. The report shall accurately estimate the work completed on each activity including the design activities shown on the accepted Overall Works Program and the Working Program. The Contractor's progress report shall include relevant progress photographs. The Contractor shall agree with the Employer and shall implement progress control procedures.

The Contractor’s execution of the construction work shall not deviate from the sequence shown in the approved overall Work Program without prior written permission from the Employer.

### 1.13.7 Fortnightly Progress Meetings

Fortnightly progress meetings will be held with the Employer. Bottlenecks will be discussed and resolved. Special meetings will be held as and when required.

The Fortnightly Detailed Working Program shall be submitted to the Employer for approval fortnightly and must show at least previous Fortnightly progress and the future two (2) Fortnightly planned works.

### 1.13.8 Photographic Records

The Contractor shall take progress photographs in digital camera during progress of work, which shall be attached to the monthly progress report. Each of these photos shall be submitted in 3-fold as paper copies in color. The sizes of the photos shall be 10 x 15cm. Every month at least twenty (20) color photos for each report shall be supplied.

The Contractor shall also prepare movie up to international standard of all the activities occurred on the project, from date of starting to end of the project.

### 1.13.9 Project Meetings

Monthly Project management meeting shall be held at site to review the Monthly Progress Report with the Employer. The Contractor shall present his report verbally at the meeting.

Weekly Site management meetings shall be held with the Employer to review site progress and procedures.

### 1.13.10 Integrated Project Schedule

Prior to the Commencement Date, Contractor shall submit an Integrated Project Schedule, including engineering, procurement, manufacturing, fabrication, transportation, construction, and start-up activities. The Project schedule shall be presented in electronic format acceptable to the Employer as well as hardcopy.



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The Employer shall review and comment on the schedule to ensure that his plan meets the schedule requirements and does not conflict with any Employer obligations. The schedule shall be binding on the Contractor.

The Contractor shall utilize the Primavera Software, or other construction planning software acceptable to the Employer, for the Critical Path Method (CPM) of planning and scheduling to produce the Integrated Project Schedule.

The Contractor shall develop a detailed construction plan covering the entire scope of the work. Each task shall consider relevant information, such as construction design schedule, description and duration, work relationships, material or equipment deliveries, access limitations, interfaces, and other details that affect the sequence and duration of the works. Negative lags and constraining dates shall not be allowed.

The Monthly Progress Reports shall include a schedule update and progress tracking to compare the actual status of the Project with the scheduled baseline progress. Actual status shall be measured and reported using Earned Value techniques approved by the Employer.

The Employer may require the Contractor to modify any portion of his schedule and work plan, judged impractical, unfeasible, unreasonable, or not in compliance with the Contract.

The Contractor shall coordinate with all equipment and material suppliers of the Works to get the relevant information in order to fulfill its obligations relating to the preparation of Integrated Project Schedule under this Section.

### 1.13.11 Construction Specifications

The Contractor shall prepare specifications for the complete Works to incorporate any and all provisions arising from the Design. Contractor shall submit to Employer for review six (6) copies of all specifications issued by the Contractor to suppliers for procurement of materials or sub-Contract services, conformed for purchase.

### 1.13.12 Drawings for Construction

The Contractor shall provide six (6) printed copies and one (1) electronic copy, of documents issued by Contractor for construction, as required in Design Documents and Construction Drawings, of the Project Design Requirements.

### 1.13.13 Environment, Social, Health and Safety (ESHS) Components

a. Contractor should place prime importance on environment, social, health and safety (ESHS) issues and requires that Contractor subscribe to and actively pursue the highest standards of ESHS performance;

b. Contractor should perform the Work in full compliance with the provisions, which is relevant for the Work, for the duration of the work;

c. Contractor should implement ESHS routines, which will ensure that all Personnel are fully aware of the existence, content and expectations of the ESHS;

d. Contractor will be responsible for ensuring that all Personnel understand and operate in accordance with the principles and requirements of ESHS provisions;

e. The Contractor shall submit to the Employer, monthly and quarterly environmental reports on the carrying out of such measures as identified in the EIA, EMP, NOC and Contract;



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f. Contractor shall ensure each work group has at least one (01) Person present at all times who is fluent in both the primary language of the Worksite and the language of the workers; and

g. Within thirty (30) days after Commencement date, the Contractor shall provide an ESHS Program including SSEMP, SSHSMP and associated working instructions and procedures i.e. Standard Operating Procedures (SOPs), establish systems such as Log in and Tag Out, Work Permits etc. as modified to be applicable to the Project.

The detailed requirements with regards to the Health and Safety provisions are provided in Section 4.2 of Special Provisions.

**1.13.14 Quality Control and Quality Assurance Plan**

a. Within thirty (30) days after Commencement Date, Contractor shall provide a Quality Control and Quality Assurance Plan in accordance with Section 1.6 of Special Provisions. A Quality Control and Quality Assurance Plan shall be prepared by the Contractor to his Quality Assurance Manual and in accordance with ISO Standard.

b. The Contractor's Quality Control and Quality Assurance Plan shall comprise procedures for quality control and quality assurance. The Employer will audit the Contractor's quality assurance on the basis of the quality control and quality assurance plan.

c. The Contractor's Quality Control and Quality Assurance Manuals (QC/QA Manual), as modified to be applicable to this Contract, shall be submitted to the Employer for review.

d. The QC/QA Manual shall define and document the Contractor's commitment to and policy for quality. The Contractor shall ensure that the policy and the associated procedures are understood, implemented and maintained at all levels in his organization, including all sub-Contractors. The Contractor's Quality Control and Quality Assurance Plan shall be based on well-established principles and proven performance.

e. The parts and components produced and the services provided in fulfilling the requirements of the specifications shall be performed in accordance with the requirements of the Contractor's Quality Assurance Program. The Contractor's Quality Assurance Program shall be documented in sufficient detail to assure the Employer that the Contract requirements will be met during the design assembly and test of the materials and components. The Contractor's Quality Assurance Program, as a minimum, shall provide the implementing details to address to the Employer requirements as given hereinafter.

f. The Contractor shall monitor and approve his own work using the QC/QA Manual. The Employer will monitor the Contractor's ability to follow approved plans and procedures throughout the entire Project. The Contractor shall provide copies of review reports and test reports to the Employer on a monthly basis. The Employer may audit the Contractor's records at any time to verify that sufficient reviews, checks, and tests are being performed.

g. The Quality Control and Quality Assurance Plan shall describe Contractor's Quality Assurance organization and delineate the responsibility and authority of the various personnel and groups involved. The Quality Assurance Department's relationships



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with other departments shall be defined and their independence of engineer, construction cost, and scheduling shall be stated. An organization chart shall be included with lines of authority and communication.

h. The Quality Control and Quality Assurance Plan shall contain provisions for the development, implementation and maintenance of training and certification programs as required to maintain acceptable quality control personnel. The programs shall comply with such codes and standards as required in the Contract Document or common industry usage.

i. The Quality Control and Quality Assurance Plan shall provide assurance that the Plant Characteristics Project Design Requirements are correctly translated into and included in the Contractor's documents and Drawings. The QA/QC Program shall further ensure that the latest approved documents (including changes) are available to and used by the required manufacturing, inspection and test personnel. The review shall be performed by individuals other than those involved in the original design and that the review is documented.

j. The Contractor's procurement process shall ensure that purchased items, whether purchased directly or through his sub-Contractors comply with the "Employer's Requirements". This assurance shall be provided by the inclusion of the quality requirements into the Contractor's procurement documents and adequate inspection of the material at its source or upon receipt.

k. The Quality Control and Quality Assurance Plan shall provide assurance that procured and subsequently processed material meets the specification requirements. Material identification shall be provided and maintained throughout the manufacturing cycle. Controls shall be provided for the documentation and disposition of nonconforming material, parts or components, and their subsequent rework or repair and re-inspection. The program shall also provide for the prior notification to the Employer of proposed rework or repair on nonconformance, for this evaluation and approval.

l. Special processes such as welding, soldering, brazing, heat treatment, cleaning, nondestructive examination etc., shall be performed in accordance with documented process procedures and by quality personnel. The procedure shall describe the process sequence and methods, process pre-requisites, equipment, qualification of personnel and equipment, and acceptance criteria. The procedures shall also describe the preparation and retention of documents used to record the results of special processes.

m. Non-Destructive Testing (NDT) shall be done to written procedures. The current edition of American Society of Mechanical Engineer (ASME), Section V shall be used as a guide for the NDT procedures.

n. The Quality Control and Quality Assurance Plan shall provide for the in-process and final inspection of items and activities to assure compliance with the requirements of the specifications. Examination or measurements shall be performed at each applicable work operation. Inspection activities shall be performed by qualified individuals other than those who performed the activities being inspected.

o. Procedures shall be established to assure that test and measuring devices used to test, inspect, or accept material or components are calibrated at specified intervals to maintain the proper accuracy. Devices used shall be of the proper range, type, and



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sensitivity to reliably measure the parameters being evaluated. The calibration of such devices shall be documented and shall be performed using certified measurement standards.

p. The Contractor's test program shall be suitably documented to assure that the required component or sub-component testing is properly performed. The test program shall address pertinent test pre-requisites, such as test instrumentation selection and calibration, acceptance criteria, documentation of test results, and evaluation of test results by qualified personnel.

q. The level of quality control applied by the Contractor shall be adjusted to the importance of the items in terms of cost of repairs personnel safety and loss of production if applicable.

r. During construction, after each assessment or measurement of quality, cases of non-conformity identified by the Employer or by the Contractor's quality control supervisors or by the personnel in charge of execution will be divided into four categories:

- NC-1: Minor defects which will be repaired immediately, then recorded on standard follow-up documents.
- NC-2: Defects which can be repaired according to a pre-established procedure. The repairs will be carried out immediately and recorded on a special document.
- Defects which cannot be repaired according to a pre-established procedure.
- The decision to repair, modify or rebuild or re-manufacture the item shall be proposed by the Contractor for the Employer's approval.
- Main defects on critical items.

The Contractor shall propose a solution to the Employer. The Employer will be responsible for making the final decision on the proposal.

s. The Quality Control and Quality Assurance Plan shall provide for audits of Contractor's and his sub-Contractors operations by his Quality Assurance Manager during the course of the Work. The audits shall be used to determine the organization's compliance to Contract requirements and to the Quality Plan procedures.

t. The Quality Control and Quality Assurance Plan shall include a system to ensure that the documentation necessary to attest the completion of fabrication, erection, and installation; use of correct material; completion of required inspections and tests; and acceptability of results are generated, reviewed, maintained and turned over to the Employer at the required time.

u. The system shall ensure that such documentation is reviewed by Contractor for legibility, completeness, validity of data, trace-ability of document to activity or equipment and acceptability of results.

v. Documentation to be generated and maintained shall include, as a minimum:

- Mill test reports for raw material.
- Weld and weld repair procedure.
- Inspection and test procedures.
- Inspection and test reports (vendor and site).

- Vendor surveillance reports (Contractor).
- Heat treatment records.
- Final inspection reports (vendor, Contractor).
- Certificates of compliance (vendor).

w. The Contractor shall coordinate with the suppliers of the equipment to get the relevant parts of Quality Control and Quality Assurance Plan in order to fulfill its obligations relating to the preparation of consolidated Quality Control and Quality Assurance Plan under this Section.

**1.13.15 Training Program Plan**

At least 180 days prior to tests on completion, the Contractor shall provide a plan to train the Employer's O&M personnel.

**1.13.16 Insurance and Construction Consents**

At least ten (10) days before the start of construction, the Contractor shall submit evidence demonstrating that the Contractor has obtained all material permissions and Consents for the start of construction.

On or before the start of construction, the Contractor shall certify that all conditions required by the Contractor to implement the Contractor's All Risk and Marine Cargo Insurance have been fulfilled.

**1.13.17 Purchase Orders**

Unpriced purchase orders shall be submitted by the Contractor for all purchased materials and any sub-Contracted services. Every thirty (30) days the Contractor shall update and submit four (4) copies of the purchase order log.

**1.13.18 Geotechnical Surveys**

If the Contractor determines that additional geotechnical investigations are required specifically for the installation of Electro-Mechanical equipment, the Contractor shall conduct such Investigations and submit six (6) copies of the results, reports, or recommendations to the Employer.

However, any geotechnical investigations related to overall site stability, civil structures, or foundations shall remain the responsibility of the Civil Works Contractor.

**1.13.19 Shop Inspection and Test Reports**

Six (6) copies of all shop inspection and test reports for Materials shall be submitted to Employer for review.

**1.13.20 Quality Control Reports**

The Contractor shall submit four (4) copies of quality control records related to E&M works, including but not limited to pump alignment, motor mounting, continuity wiring checks, and stress relieving where applicable.
Additionally, structural steel bolting and weld inspections (visual and non- destructive testing) shall be documented for E&M equipment supports and associated structures.



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To ensure seamless integration at interface areas, the E&M Contractor shall coordinate with the Civil Works Contractor, particularly for quality control processes related to embedded steel, equipment foundation tolerances, and alignment of interfacing components.

Both Civil and E&M Contractors shall participate in joint inspections and provide verification reports to maintain a harmonized approach.

### 1.13.21 Project Procedures

Where structural or embedded works interface with E&M installations, the Civil Works Contractor shall coordinate with the E&M Contractor to ensure alignment of quality control processes.

Joint inspections and verification of critical interfaces, such as equipment foundation tolerance`s and embedded steel elements, shall be conducted to ensure compliance with the project specifications.

### 1.13.22 Special Requirement for Site Installation

a. The Contractor shall submit, with his relevant stage drawings showing the overall layout of the proposed special site installations. This layout shall be compatible with the general layout included in the Conceptual Drawings. The final layout of site installation shall be agreed with the Employer prior to award of the Contract.
b. The Contractor shall present at least twenty-one (21) calendar days in advance of the starting date of the works, drawings and specifications sufficiently detailed to enable the Employer to check the suitability of the proposed construction and installation and their conformity with this Specification.

### 1.13.23 Training Program

After successful testing & commissioning, the Contractor will maintain and jointly operate the plant on commercial basis for training of the Employer’s staff during one (02) year defect Notification period.

The Basic O&M Program shall primarily explain the provisions and procedures related to electro-mechanical works as contained in the E&M Works O&M manuals. In addition to the various manuals, the class materials will include Drawings, Technical Specifications and other technical and educational material necessary for the complete training of O&M Personnel.

The Contractor Basic Training Program shall cover O&M manuals written for all equipment components, particularly all E&M equipment, gates and gate handling equipment. The classroom training will be supplemented by visits to the project facilities to facilitate the transfer of information and know-how.

The Contractor shall provide a training program in operation and maintenance for the Employer's O&M personnel. The training program will consist of following two (02) main components:

a. On-the-job Training.
b. Formal O&M Training Seminars.

Under both programs, training shall cover Operation and Maintenance of the entire Project (Electro-Mechanical works).



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### 1.13.23.1 On-the-job Training

The Employer shall assign staff to monitor construction activities at the various work fronts. The Contractor shall provide informal, On-The-Job training as it relates to the O&M of the entire Project (Electro-Mechanical Works).

a. Electrical and Mechanical Equipment

During the electrical and mechanical equipment erection, assembly and installation the Contractor shall provide informal on-the-job training that will cover aspects of equipment maintenance and operation. The informal training program shall be led by representatives from equipment manufacturers and shall be based on Design Memoranda, Technical Specifications, Drawings and other informational materials necessary for the adequate training and orientation of Employer's O&M personnel. The informal training program shall be conducted during the erection, and testing of all Project equipment, including but not limited to turbines, generators, excitation system, control, protection, transformers, MV and LV switchgear, governors, valves and switches, gates and gate handling equipment etc.

### 1.13.23.2 Formal O&M Training Seminars

Formal Training shall include a Basic O&M Program. The Training Programs shall be conducted in a classroom setting, in the Project offices at the construction site. The formal training will incorporate a Quality Control Program within the Formal Training program, including written testing, to ensure that the O&M Personnel are suitably trained and capable of operating and maintaining the Project after it is turned over to the Employer. At least four (04) months prior to initiation of the Formal Training Program, the Contractor shall submit a written plan and schedule for the Program, for Employer's review and approval. Such plan shall include course outlines, Curriculum Vitae of the proposed Training Instructors, and a detailed schedule. To initiate the Formal Training, the O&M Manuals must be a minimum of 90 % complete. The official language for all type of trainings must be English.

The Contractor shall train a total of up to ten (10) people in the Basic O&M Program. The Trainees shall generally include Employer's staff who participated in the monitoring of the project construction, and are familiar with the works. In general, the Basic O&M Program shall take approximately five (05) days and a total of six (06) hours per day, comprising two three-hour sessions, separated by a two (02) hour break.

### 1.13.23.3 Electrical and Mechanical Equipment Factory Acceptance Tests

At least three (03) representative of the Employer/ Employer representatives will inspect/witness the manufacturing and factory testing of electrical & mechanical equipment and workshop facilities at manufacturer’s shop for a period of approximately seven (07) days each trip. The Contractor shall give at least twelve (12) weeks’ notice to the Employer for all important Factory Acceptance Tests of major plant equipment (i.e. turbines, inlet valves, cranes, HPU for governors/inlet valves, generator, exciter, digital governor, control & protection, switchgears, transformers, DC system, SAS, telecom equipment, etc.). All expense regarding witnessing of factory acceptance tests (i.e. visa process, travel, boarding lodging and daily allowance @ 200 US$/day for one person for foreign inspections and @ 15,000 PKR/day for one person for local inspections) shall be considered in the price of respective equipment.

### 1.13.23.4 Commissioning Reports

Within one month after the Completion Date the Contractor shall issue to the Employer the Commissioning report including copies of all test records.

### 1.13.23.5 Operation and Maintenance Manuals

Three (3) Months prior to scheduled commissioning of the Project, the Contractor shall provide detailed manuals with drawings and schematics, setting out the Operations and Maintenance Procedures, in English language, for all the Electrical and Mechanical works and equipment, including Specifications, Equipment Data Sheets, Vendor Data and Shop Drawings.

The Contractor shall provide Operation and Maintenance Manuals, for all Electro-Mechanical Equipment/Systems, which must be in English language.

The Contractor shall provide to the Employer tools and spare parts sufficient for five (05) years of operation together with a recommended priced list of spare parts. The foreseen mandatory spares are tentatively listed in subsequent sections which the Contractor shall revise in its Proposal as per estimated essential requirements. The Contractor shall construct proper and sufficient storage facilities for such tools and spare parts.

All instruction manuals shall be issued in two volumes, one containing all operating information required including drawings and the other containing maintenance instructions. Ten (10) hard copies and one (1) electronic copy of each volume of instruction manuals shall be furnished along with of the reproducible original one copy drawings/sketch forming part of manuals.

If after the commissioning and initial operation of the plant, the instruction manuals require any modifications/additions/changes, the same shall be incorporated and the updated final instruction manuals in the form of one (1) set of electronic files as CD and ten (10) copies shall be submitted by the Contractor to the Employer. All manuals shall also be provided in electronic version (Microsoft Word and pdf formats).

The submission of Operation and Maintenance Manuals as well as other documents shall be made in the English language.

## 1.13.24 Project Records

Contractor shall maintain one (01) record copy of:

a. Contract Drawings
b. Specifications
c. Addenda
d. Change Orders and Other Modifications to the Contract
e. Approved Shop Drawings, Product Data and Samples
f. Approved Construction Drawings & Erection Sequence Drawings for E&M Equipment.
g. Approved control, protection and instrumentation Drawings
h. Field Test Records
i. Inspection Certificates
j. Manufacturer's Certificates

Record Documents and samples shall be stored in Contractor’s Field Office apart from documents used for construction. Files, racks, and secure storage for Record Documents and samples shall be provided.

Record Documents shall be maintained in a clean, dry and legible condition. Record Documents shall not be used for construction purposes.

Record Documents and samples shall be available for inspection by Employer.

### 1.13.24.1 Submittals

On completion of works, Contractor shall deliver Record Documents to Employer including the Contracts Drawings in reproducible ink-on-mylar sheets that match the contract documents (size. sheet content and title block).

Accompany submittal with transmittal letter, in duplicate, containing:

- Date
- Project title and number
- Contractor's name and address
- Title and number of each record document
- Certification that each document as submitted is complete & accurate
- Signature of Contractor, or his authorized representative

## 1.14 GENERAL DESIGN CRITERIA FOR ELECTROMECHANICAL WORKS AND HYDRAULIC STEEL STRUCTURES

### 1.14.1 General

The plant and equipment shall be designed according to the latest version of international standards relevant to the particular section of works. The completed work shall be safe, durable and adequate for intended purpose under most severe loading conditions where there are differences between the various standards; the most stringent standards shall be adopted. Contractor must make available two hard copies of applicable standards in English language. If other standards shall be chosen, the Contractor shall supply copies of those standards in English language only, clearly identifying or referring to the particular chapters or sections that shall be applied. The approval for adoption of such standards must be necessary from the Employer.

For the dimensioning, design and layout of the various plant components and installations, consider the following features and aspects:

- The ambient conditions at the project site;
- Ratings to safely cope with all normal and fault conditions, avoiding any overstressing of material and equipment;
- Altitude correction factor above 1,000 masl as per IEC;
- Equipment to be of standard design, providing highest degree of safety, reliability, availability and ease of operation;
- Equipment arrangements to consider adequate space and access for transport, installation, commissioning, operation and maintenance.

### 1.14.2 Compliance with Local Regulations

In addition to the general design criteria, the design shall also conform to the requirements of all relevant local, state and federal authorities where approvals for that section of works is needed from the relevant authorities specially, in case of interconnection and interfacing the


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relays and metering should be in accordance with prevailing Employer/Employer's Representative standards/ quality and of the same manufacturers as installed in the Employer/Employer's Representative system. Type test for electrical equipment shall be carried out according to Employer/Employer's Representative standards from STL approved lab. Cost of such tests shall be included in the cost of relevant equipment. No additional payment shall be made to carry out and witness type tests in case of unavailability of valid type report from STL approved lab.

### 1.14.3 Equipment Standards

All equipment and parts related to engineering design concerning choice of materials, main dimensions and function should conform to latest international standards. However, for Grid Station/Switchyard Equipment, Contractor is bound to fully comply with relevant Employer/Employer's Representative standards and STL approved type test reports shall be mandatory. All equipment of the project including Protection and SCADA equipment shall comply with the reference standards mentioned in relevant sections.

The equipment and materials furnished under this Contract shall conform to the requirements of the Specification and to the designated Standards.

### 1.14.4 Employer/Employer's Representative Approvals

During design review and prior to start of manufacturing, Employer/Employer's Representative review/approval shall be required at least but not limited for the following equipment;

- 132kV Switchyard Equipment
- Type and Range of Transformer Tap Changer
- Telecommunication Equipment
- Protection and Control (SCADA) Equipment
- Tariff Metering Equipment
- Key Single Line Diagrams
- Protection and Metering Single Line Diagrams
- SCADA Signal List

The Contractor will provide all the required information, technical data/test reports as per Employer/Employer's Representative requirements.

### 1.14.5 Inspection and Test Plans

Inspection and test plans shall be submitted for factory Tests and Tests on Completion for approval of the Employer. Tests on Completion shall be carried out in two stages: Dry tests followed by wet testing, commissioning and reliability tests.

### 1.14.6 WPS & WQR, Fabrication & Installation Schedules

Welding procedure specifications, welders' qualification records, fabrication and installation schedules shall be submitted prior to commencement of any welding, fabrication and installation work.


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### 1.14.7 Erection and Testing Manuals

Detailed erection and testing procedures shall be submitted along with instructions regarding handling and storage of all equipment at least two (02) months before the start of erection of the first unit.

### 1.14.8 Operation and Maintenance Manuals

Three (03) months prior to scheduled commissioning of the Project, the Contractor shall provide detailed manuals (in English) with drawings and schematics setting out the operations and maintenance procedures for all mechanical and electrical works and equipment, including specifications, equipment data sheets, vendor data and shop drawings.

### 1.14.9 As-Built Drawings

The Contractor shall provide five (05) copies of detailed "as-built" drawings for the entire Project, including all mechanical, and electrical general arrangements, concrete outlines, and shop drawings of major equipment. These are to be based on the Contractor's “approved shop” drawings and field information.

The Contractor shall also furnish to the Employer one mylar polyester base full size reproducible of each As-built and other Drawing, which, in the opinion of the Employer, may be required for operation, maintenance, dismantling and reassembly, for identification of parts; and for ordering replacement parts and materials. The mylar shall be 0.1 mm thick, double matte film, wash off film, printed on the front. The Contractor shall use his best efforts to provide "AutoCAD" files, version as advised, on portable hard drive.

### 1.14.10 Commissioning Reports

Within one (01) month after the Completion Date the Contractor shall issue to the Employer the Commissioning reports including copies of all test records.

## 1.15 TESTING AND COMMISSIONING AND VERIFICATION OF PERFORMANCES AND GUARANTEES

### 1.15.1 General

The Contractor shall prepare a detailed testing and commissioning plans for the works and submit to the Employer for approval. The plan shall include inspection and testing at the factory and verification testing at site.

Testing and commissioning shall comprise factory and field-testing designed to verify the performance of the Project. The Contractor shall prepare testing and commissioning plans and procedures to verify performances of the complete Project including tests prior to synchronization, reliability run test, commercial operations test, demonstration of energy from the Project, and system performance.

Except as otherwise specified, all tests shall be performed in accordance with relevant standards from ASME, IEEE, IEC, and ISO.



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### 1.15.2 Tests at Site

Tests on Project, equipment, systems and facilities at Site shall be carried out, by the Contractor, and passed prior to taking over of the Works by the Employer, and shall comprise main stages of testing as follows:

#### 1.15.2.1 Preliminary Tests

Which are tests prior to rotation of, energizing at normal voltage, or admission of air, water or oil at normal pressures to the main or auxiliary Project under test.

#### 1.15.2.2 Test on Completion

Which are tests to progressively prove the correct operation of all Project, equipment, systems and facilities.

#### 1.15.2.3 Test after Completion

Which are tests to be undertaken periodically to confirm continued compliance of the Project, equipment, systems and facilities with the performance guarantees specified in the Contract.

The Contractor shall use calibrated testing instruments for site testing. These instruments shall be calibrated before the measurements at site are carried out. The Master Calibration device itself shall be calibrated and tested not longer than 5 years ago by either an independent Authority or the original Manufacturer. Appropriate documentation shall be supplied.

Test results shall be recorded for the Site tests conducted on the Project, equipment, system and facilities. The test results shall be in the form of test certificates or test reports. Comprehensive testing and commissioning reports shall be prepared for all Project, equipment, system and facilities.

The Contractor shall be responsible for testing and operation of all Project, equipment, systems and facilities until an associated Taking over Certificate is issued. Before taking over and prior to issuing the Taking over Certificate, the Contractor shall at the request of the Employer, open-up or dismantle any part of the Works for inspection by the Employer.

### 1.15.3 Testing and Verification of Performance and Guarantees

#### 1.15.3.1 General

The Contractor shall provide the Employer on an on-going basis with relevant information regarding its program for testing the Project. Not less than ninety (90) days prior to the commencement of such test program, the Contractor will deliver in writing the final program for testing the Project, including the expected duration of the start-up testing program and a tentative schedule for conducting all tests required by the contract. The Contractor shall advise in writing of any changes in its final schedule for the testing program not less than thirty (30) days prior to the commencement of the tests. If the schedule for any test is adjusted after the Contractor has provided the final testing program schedule, then the Contractor shall advise not less than seventy-two (72) hours prior to the commencement of any such test.

On each day beginning with the day on which testing commences, the Contractor shall provide a schedule of the tests to be conducted on the following day or days (if such test will continue for more than one (1) day). All testing of the Project shall satisfy the commissioning and test criteria provided in the Contract.

The Contractor shall at his own expense provide all such personnel, equipment and instruments etc. as required to carry out the testing and commissioning of the works, and prepare complete reports with all the records and findings to be submitted to the Employer.

### 1.15.3.2 Preliminary Tests

Preliminary tests are tests conducted prior to rotation of, energizing at normal voltage, admission of air, water or oil at normal pressures to the Project, equipment, systems or facilities of the Works under test.

Preliminary tests shall be conducted on all Project, equipment, systems and facilities and shall comprehensively demonstrates readiness for commencement of the Tests on Completion for such Project, equipment, systems and facilities Site preliminary tests shall include following.

a. Non-destructive tests of welds and welded components
b. Hydrostatic pressure tests
c. Leakage and deflection tests
d. Voltage withstands tests
e. Insulation resistance tests
f. Conductivity tests
g. Proof of phasing and/or polarity of power supplies and circuits
h. Operation of all mechanical, electrical and control equipment to prove freedom of movement and correct operation, including timing checks, power consumption etc.
i. Functional and operational checks on Project, equipment, components and systems (including control, protection and SCADA systems)
j. Demonstration of sensitivity and operation of all monitoring, control, protection and alarm devices to the nominated settings
k. Tests of all indications, displayed quantities and device output signals
l. Check all protective devices for correct ratings (fuses, miniature circuit breakers etc.)
m. Tests of automatic voltage regulator setting and adjusting in stand-still condition and with the generator running at no load
n. Turbine governor control checks, including a turbine over speed test
o. Open circuit tests on the generator
p. Short circuit saturation characteristics tests on the generator
q. Verification of the protection level settings for the following:
    i. Stator earth fault
    ii. Negative phase sequence
    iii. Generator transformer over current and earth fault; and
    iv. High voltage bus bar protection

Results in details of the proposed preliminary tests shall be submitted to the Employer.

### 1.15.4 Prior to Commencement of Tests

The following systems and facilities shall be commissioned and in service prior to the commencement of tests on each generating unit:

a. All work on or near the unit shall be substantially finished.



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b. Tests on Completion shall be satisfactorily completed for all directly related main, auxiliary and ancillary Project, equipment, systems and facilities. All such plant, equipment, systems and facilities shall be operational and in service.

c. The monitoring, control, protection, SCADA and communication systems relating to the unit being tested and the associated grid station and transmission facilities shall be fully operational.

d. All tests without water shall be finished.

e. The cooling system shall be in operation.

f. The transmission lines shall be in operation and phase tests shall be completed satisfactorily.

g. All gate and stop log operating systems and associated hoists shall be tested, proven and in service.

### 1.15.5 Tests Prior to Synchronization of units

The Contractor shall carry out the following tests for each Unit prior to synchronizing with the power system:

a. Automatic voltage regulator setting and adjusting in stand-still condition and with the generator running at no load.

b. Turbine governor control checks, including a governor over speed test.

c. Open and short circuit tests on the generator.

d. Functional testing and timing of high voltage switchgear in the switchyard of the Project.

The protection level settings shall be approved by the Employer for following systems.

a. Stator earth fault.

b. Negative phase sequence.

c. Generator transformer over current and earth fault.

d. High voltage bus bar protection.

e. Calibration of under-frequency relay used for load shedding.

Voltage phasing checks will be carried out between the switchyard of the Project, and the Grid system. All inter-tripping circuits between the Project and the Power Purchaser equipment will be proved.

### 1.15.6 Tests on Completion of Units

Tests on Completion are tests to progressively prove the correct operation, output and efficiency of complete auxiliary systems, main Project items, and the generating units. Tests on Completion shall be carried out for each Section of the Project.

Tests on Completion shall be conducted on all equipment, systems and facilities and shall comprehensively demonstrate correct, reliable and safe operation of such Section and the Project, equipment, systems and facilities. Tests on Completion shall include:

a. The tests required by the design standards.

b. Such other inspection and tests as may be necessary to demonstrate compliance with the Contract.



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c. Any other test deemed necessary by the Employer.

Details of the proposed Tests on Completion shall be submitted to the Employer for review and approval.

### 1.15.6.1 Unit Tests on Completion

Tests on Completion shall be carried out as necessary to demonstrate that the performance criteria established in the Contract are satisfied and that the Section of the Project, as the case may be. All tests shall confirm with requirements established by the Grid code. The tests on Completion for each of the generating units shall, as a minimum, including the following:

#### 1.15.6.1.1 Step 1: Rotation Test without Voltage

- Initial spinning test by manual start
- Brake test
- Test of bearings
- Alignment, balance, vibration and other mechanical tests
- Over speed test
- General inspection
- Generator insulation tests
- Governor test / adjustment
- Emergency shutdown test

#### 1.15.6.1.2 Step 2: Rotation Test with Voltage

- Excitation of the generator and check of excitation equipment
- Primary test of signaling and protection devices
- Commissioning of voltage regulator and demonstration that the Automatic Voltage Regulator Droop can control generator voltage over the range of ±10% or rated voltage with a droop characteristic of ±0.5%
- Short circuit characteristics test
- Operation of the turbine governor
- Test of specific generator data (residual voltage, shaft voltage, voltage waveform, open circuit test, phase sequence, and start, stop and emergency stop functions)

#### 1.15.6.1.3 Step 3: Test with Connected Network

- Initial load test by taking up load in predefined steps up to full load
- Load increasing / decreasing test (MW/minute, ramp rates, step loads
- Testing and adjusting governor parameters at successive steps as per contract
- Governor primary, secondary and high frequency response, limited high frequency response and output at reduced system frequency tests
- Servomotor test (closing force and characteristics)
- Unit start/stop automatic sequence control tests and checks
- Unit loading/unloading rate adjustment checks
- Test to demonstrate capability of the Project to operate at rated voltage and frequency at the system power factors and reactive power conditions provided in the contract document



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- Reactive power load rejection tests
- AVR, automatic voltage regulator droop, and power system stabilizer tests
- Minimum load continuous stability tests
- Unit capability tests
- Active power load rejection test (25%, 50%, 75%, 100% load)
- Unit temperature stability tests (heat run)
- Unit Reliability Run Tests, including:

(i) Stable and reliable operation for at least 24 hours at varying outputs between the maximum possible and minimum allowable capacity of the unit without any failure or interruption and with no more than 2 start/stop cycles.

(ii) within a continuous 72-hour period, at least 10 successive cycles of starting (i.e. including synchronizing and loading to the dispatch level) and stopping (i.e. including unloading from the dispatch level down to no load and stopping to standstill).

(iii) A reliability run for a period of seven hundred and twenty (720) hours and including one hundred and sixty-eight (168) continuous hours at maximum continuous rating. The output during the remaining hours of the test will be as requested by the Employer; provided that in no event shall the requested output be outside the technical limits. The test shall have been satisfactorily completed only if it continues without interruption for not less than 720 hours.

(iv) The successful reliability test shall be a condition for issuing the Handing/Taking over Certificates.

### 1.15.7 Efficiency/ Performance Tests

The efficiency/performance tests at Site shall be carried out after the units have been satisfactorily put into commercial operation and within the specified period of guarantee of the turbines and governors. Efficiency/performance tests shall be conducted on at least one turbine. The test includes the following:

a. Unit efficiency tests (including continuous running of the Unit at predefined outputs) as per IEC 60041.

b. Runaway Speed Test shall be made to demonstrate that all parts of the turbine shall successfully withstand the stresses incidental to its operation at the no-load runaway speed. The unit shall be operated at this speed for a period of not more than five minutes.

### 1.15.8 Contractor's O&M Staff during Testing and Commissioning

The Employer shall engage an O&M Staff to operate the Project. Reference to the O&M Staff may be construed as reference to the Employer, as the context requires.

Nominated personnel of the O&M Staff shall attend commissioning and testing of the Project as counterpart for the training purposes. The Contractor shall include the O&M Staff in the Contractor's commissioning teams responsible for all commissioning, testing, stage-up and trial operation of Project.

During commissioning, the O&M Staff are required to participate the activities associated with commissioning under supervision of the Contractor. The participation of the O&M Staff in the Contractor's commissioning teams shall be arranged to ensure that the skills, knowledge and

documentation acquired by the O&M Staff will be sufficiently focused and targeted to prepare them for the task of operating the Project. The O&M Staff shall only take an active part in commissioning at the Contractor's entire responsibility.

During reliability run tests the O&M Staff is required to operate the facilities under supervision of the Contractor.

### 1.15.9 Spare Parts

All mandatory spare parts for the equipment shall be provided as mentioned in the relevant sections of these specifications. However, the Proposer shall submit list of any other spare parts (which in the opinion of the Contractor) necessary for plant as per recommendation of the equipment supplier(s).

All spares furnished shall be new and interchangeable with the corresponding original parts. They shall also be of the same material and workmanship, and shall have all the features and provisions of the corresponding original parts. Second-hand spare parts shall be rejected.

All spares are to be suitably treated and packed for long storage under conditions prevailing at the Site. Each spare shall be clearly marked or labelled on the outside of its packing with description and purpose, and, when more than one spare is packed in a single case, box or container, an inventory is to be shown on the outside of same, and a detailed list enclosed inside. All cases, containers, boxes and other packages shall be suitably marked and numbered for purposes of identification.

The Contractor shall manufacture the spare parts and deliver them to Site at the same time as the rest of the Plant. Spares shall be handed over to the Employer not later than at the date 30 days prior to the start of the Tests upon Completion.

Spare parts catalogues and/or necessary drawings with item lists shall be supplied giving all necessary data for ordering spare parts directly from the manufacturers. The spare parts catalogues shall include data on complete modules and assemblies as well as sub-modules, sub-assemblies and individual components. The drawings shall show the location, main dimensions and the ways of disassembly or assembly of the various spare parts.

Additionally, the Contractor shall propose recommended spare parts with itemized prices. The Employer shall have the option of ordering or omitting any of the spares listed

### 1.15.10 Consumable Goods

All consumable goods needed for completing the installation as well as for maintaining and operating the Work for at least three (3) years or the period mentioned in relevant sections in technical provisions after Taking Over shall be furnished and included in the Contract Price, and shall be handed over to the Employer not later than at the date 30 days prior to the start of the Tests upon Completion. Such consumables shall be separately packed and shall include oil, grease, paint, electrodes (if required), solvents, filters, electrical articles, fuses and any other goods as required for normal maintenance and operation.

### 1.15.11 Erection & Testing Equipment and Maintenance Tools

The Contractor shall provide Erection and Testing Equipment and Maintenance Tools in new and unused condition, as specified in Schedule of Prices. The special erection equipment shall be of the type not normally available and re necessitated by the design of the Plant and is required or convenient for the erection, testing and commissioning of Plant ready for operation.



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The list of equipment shall include description and use, as well as quantity of each items and the unit rates and prices for the total quantity proposed for each item.

The Contractor shall furnish, suitably boxed, complete set of tools, including wrenches, spanners, other special tools etc. as listed in the Schedule of Prices, and which are necessary or convenient for operation maintenance or replacement of any part of Plant under the Contract. Complete lists of all such tools and equipment shall be submitted to the Employer before delivery of the tools. Shipment containers shall become the property of the Employer and shall be suitable for permanent storage of the tools.

Each tool or appliance shall be clearly marked with its size/or purpose, shall not be used for erection and shall be handed over in new condition. Copies of its certificates for lighting appliances shall be handed over at the time of Taking Over of Unit 1.

Each set of maintenance tools and appliances shall be suitably arranged in boxes of mild steel construction, the number of boxes being determined in relation to the layout of the equipment in question. If the weight of any box and its content should be such that it cannot conveniently be carried (maximum 25kg), its shell be supported on steer able rubber-tire wheels.

Each box shall be painted, fitted, with a lock and clearly marked in white letters with the name of the item of equipment for which the tools and appliance contained are intended to be use.

The tools & appliances with the appropriate boxes shall be handed over to the Employer at the time of issue of the Taking-Over of Unit 1.

### 1.15.12 Access for Operation and Maintenance

Where safe and easy plant operation and maintenance cannot be arranged from provided floor levels, the Contractor shall supply and erect all platform galleries, stairways, access ways and ladders necessary for providing safe and easy access to the plant items. The Contractor shall ensure that the whole of the access ways is of uniform design and pattern throughout the Works. Where access is required for operation then standard design stairways must be provided, but if infrequent access for maintenance only is required then provision of vertical ladders will be considered as long as appropriate safety guards are provided.

The design of all stairways, access ways etc. shall conform to the requirements of this Specification.

### 1.15.13 Interlocks

A complete system of interlocks and safety devices shall be provided so that the following requirements and any other condition necessary for the safe and continuous operation of the plant are provided:

a. Safety of personnel engaged in operational or maintenance work on the plant.
b. Correct sequence of operation of the plant during start up and shut down periods.
c. Safety of the plant when operating under normal or emergency conditions.
d. Interlocks shall be preventive, as distinct from corrective in operation.

Where plant supplied under this Contract forms the whole or a part of a system for which one or more interlocking schemes are required, the Contractor shall be responsible for all interlocking schemes. General descriptions of interlocking requirements are given in the Specifications but the Contractor shall include for any other additional interlocks he considers necessary.



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### 1.15.14 Guards

All moving parts, shafts, couplings, flywheels, bare conductors and hot or cold surfaces shall be adequately and securely guarded in accordance with good industry practice and the legislation prescribed in Pakistan to afford complete safety for all personnel.

### 1.15.15 Locks, Padlocks and Key Cabinets

The Contractor shall provide padlocks, locks, chains or other locking devices for the locking of all equipment cubicles, electrical isolating switches, selector switches, valves, etc.

All locking devices and chains shall be manufactured from corrosion resistant material. All mechanisms shall be provided with a cover to minimize entry of water or dust.

Certain locks may be required to conform to a master keying feature to be agreed with the Project Manager for groups of equipment. It is the Contractor's responsibility to discuss details of the master keying system with the Employer prior to installation.

All locks shall have individual high integrity locks and shall be provided with three (3) set keys. Each key shall be provided with a label.

The Contractor shall supply and fit key cabinets equipped with labelled hooks, each identified with its appropriate key. Every cabinet shall be provided with a nameplate identifying the cabinet with its respective item or items of plant. Sufficient cabinets shall be provided to store all keys supplied under this Contract.

The Contractor shall provide comprehensive lock and key schedules to permit identification readily with equipment and doors. Such schedules are not required for loose padlocks.

## 1.16 CONSTRUCTION AND ERECTION REQUIREMENTS

### 1.16.1 GENERAL

The descriptions given in forthcoming sub-sections are outlined descriptions only. Such descriptions do not include or give full description of all materials or other items to be supplied or all Works and services to be executed by the Contractor in order to fulfil its obligations in compliance with the Contract. Once completed the Works shall include all that is necessary to satisfy the Project Requirements, or is implied by the Contract and all Works (which although not mentioned in the Contract) are necessary for stability or for the completion, or safe and proper operation, of the Works suitable and fit for the purposes for which Works are intended as set out in the Contract.

### 1.16.2 ELECTROMECHANICAL WORKS

#### 1.16.2.1 Mechanical Equipment (Powerhouse)

##### 1.16.2.1.1 Operating conditions

a. The generating units shall have to work mainly under seasonal varying head and discharge with respect to the variations in flow in the source River.
b. The Electrical Energy generated shall be evacuated to the Grid System through the proposed 132 kV Transmission Line to the 132/66 kV Aliabad Regional Grid Station and through the proposed 132/11 kV Sost Grid Station, respectively.

c. In case of load rejection, the water hammering/discharge/flow of the power plant is to be released by specially designed surge chamber.

d. Special starting operation of the turbines is required to control and limit the hydraulic transients considering the inertia of the water column in the tunnel.

e. The turbine operating criteria shall be based on the following values of head water levels (HWL) and tail water levels (TWL).

**1.16.2.1.2 Head**

- Headrace water level: 2412.0 masl
- Tailrace water level: 2301.86 masl
- Gross head: 110.14 m
- Rated net head: 104 m

**1.16.2.1.3 Net Head Variation**

- Maximum at the maximum level: 104.14 m
- Minimum at the minimum level: 102.14 m

**1.16.2.1.4 Turbines**

**1.16.2.1.5 Key Technical Parameters of Turbines**

| Description | Unit | Data |
|---|---|---|
| No of Units | No. | Three (03) |
| Type of Turbine | Type | Vertical Shaft Francis Turbines |
| Rated Turbine Output at Shaft | MW | 18.94 |
| Rated Net Head | m | 104.0 |
| Rated Turbine Speed (n) | rpm | 375 |
| Turbine Runaway Speed (nr) | rpm | 655 |
| Unit Discharge (Qunit) | m3/sec | 20.0 |
| Runner Diameter | m | 1.68 |
| Min. Turbine Efficiency (η) | % | 93 |

**1.16.2.1.6 Inlet Valve**

The following parts of each valve shall be supplied.

a. Butterfly Valve (Internal Diameter 1.8m)

b. Bypass Valves Assembly

c. Extension Pipes

d. Dismantling Joint

e. Counter Weight

f. Hydraulic Operator

g. Associated Piping

**1.16.2.1.7 Governor System**

The governor shall operate with a hydraulic pressure supply system and remote control. The governor system shall set the turbine speed and servomotors positions smoothly and gradually, no harmful oscillations should occur at all electrical loadings and load rejections.



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The governor system shall provide stable operation of the turbine for all operating conditions and shall cope with worst condition on full load rejection. The stabling of frequency must be as per international Standards.

#### 1.16.2.1.8 Powerhouse Crane

The powerhouse crane shall serve all normal requirements for lifting and moving of heavy components during installation, maintenance work and operation. The lifting capacity of the main hoist shall be determined by Contractor with appropriate factor of safety. The Powerhouse overhead crane shall cover the entire Powerhouse length. It shall have an auxiliary hoist of 10Tons. The traveling and hoisting speeds shall conform to those given in the feasibility report. The design shall conform to FEM standard.

#### 1.16.2.1.9 Auxiliary Mechanical Systems

Auxiliary systems to be provided shall include but not be limited to the following main facilities:

Cooling water system, dewatering and drainage systems, compressed air system, oil purification systems, fire detection & alarm and firefighting system for Generators.

The design of the auxiliary systems shall be carefully considered to ensure a well-functioning, easy to operate and easy to maintain power plant. The layout and location of auxiliary installation (such as compressor, strainer and pumps) shall be considered with respect to performance considerations and maintenance access. Air intakes for compressors shall minimize introducing dust and moisture into the compressed air. Strainers shall be arranged so that the baskets may be withdrawn readily without losing the entrapped material.

### 1.16.2.2 Hydraulic Steel Structures

Hydraulic Steel Structures to be provided shall include but not be limited to the following main facilities.

a. Power Intake: Trash rack, Stoplogs, Electrical Gates, Gantry Crane, Trash rack Cleaning Machine
b. Flushing Intake: Service Gate, Guard Gate, Stoplogs (Optional)
c. Draft Tube: Bulkhead Gates, Gantry Crane

### 1.16.2.3 Electrical Equipment (Powerhouse)

#### 1.16.2.3.1 Generators

Key Technical Parameters of Generators

| Description | Unit | Data |
|---|---|---|
| No. of Units | No. | Three (03) |
| Guaranteed rated capacity, each | MVA | 23.20 |
| Real Power at 0.8 pf lagging | MW | 18.56 |
| Rated Voltage | kV | 11 |
| Rated Frequency | Hz | 50 |
| Rated Speed | rpm | 375 |
| Stator/Rotor Winding Insulation | Class | F/F |
| Minimum Efficiency | % | 98 |



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The generator shall be designed, constructed and tested in accordance with IEC Publications No. 60034 and other relevant parts dealing with rotating electrical machines.

The generator and all accessories shall be capable of withstanding all temperature changes and sudden three phase short circuit, at its terminal without damage to the equipment.

#### 1.16.2.3.2 Excitation and Voltage Regulation System

The excitation control equipment shall be a solid-state microprocessor based digital system suitable for operation over the full range of ambient conditions. The excitation control system shall be of fully static type and shall include following.

a. Excitation Control Equipment, incorporating:
    i. Automatic Voltage Regulator
    ii. Manual Field Current Regulation
    iii. Power System Stabilizer
    iv. Thyristor firing circuit output
    v. Monitoring of Excitation Control System
    vi. Interface with DCS
    vii. Limiters and Protection System
b. Excitation Power Transformers
c. Full wave (Force Air cooled) Thyristor Convertor with Controller
d. Field Suppression Circuit and rotor overvoltage protection
e. Field Circuit Breaker

#### 1.16.2.3.3 Generator Step-Up Transformers

The plant shall be provided with four (04) Nos. three-phase, ONAN/ONAF, On-Load tap changers step-up transformers (20/26 MVA) including one spare transformer. The secondary side of all three transformers shall be connected with the switchyard bays (one and a half breaker scheme).

The transformer voltage ratio has been chosen to match the generator voltage finally adopted as 11kV. The generator side of the transformers will be connected in delta formation and the HV side in star (YNd11 vector group). To cater wide range of daily voltage variation in the transmission system, step-up transformers with On-Load tap changers shall be provided.

#### 1.16.2.3.4 11/0.4 kV Auxiliary Transformers

The powerhouse station auxiliary system shall be equipped with four (04) no. 11kV/0.4kV, 630 kVA, dry type station auxiliary transformers including one spare, connecting HV side to 11 kV busbar and LV side to 400V switchgear and associated enclosure complete with accessories.

The power distribution system at intake shall be equipped with two (02) no. 11kV/0.4 kV, oil type 400 kVA auxiliary transformers including one spare transformer.

#### 1.16.2.3.5 Medium and Low Voltage Switchgear

The 11kV busbar shall be fed from the generators and connected with the generator step-up transformers through generator circuit breakers. Three (03) 630 kVA transformers shall be fed though 11kV busbars and supplying power to main low voltage busbars.

The low voltage board shall be connected with two nos. incoming through 630kVA station auxiliary transformers and other from switchyard. This arrangement guarantees enough reliability to secure all essential power needs for security, protection and black start-up.



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The intake area shall be fed from 11kV overhead line (single circuit). Distribution transformers shall be installed at respective areas.

The low voltage AC distribution system shall be designed as a 400 V, 3-phase four wire plus protective (Earth) conductor system. The distribution system shall supply power to the all-plant services systems, lighting and battery chargers, including power cables and local control cabinets with necessary starter motors and sub-distribution panels.

The battery system shall provide a safe and reliable supply of power and control voltage to all primary functions. The system shall be independent of all power systems and ensures reliable execution of the control functions, both for normal operation and during possible fault conditions. Some instrument protection devices or computer interfaces shall need 24V or 48V DC supply. AC/DC converters shall be used.

#### 1.16.2.3.6 Plant Control System

The Plant Control Systems shall be so designed that in the event of subsequent modifications to the controls and associated signal processing, expansion of the system is convenient and straightforward. The actual implementation of the plant control system shall be proposed by the Contractor in the Basic Design. Control and operation of the power station shall include following:

a. Automated Plant Control System (PCS) at powerhouse Central Control Room
b. Backup control at bay/unit level
c. Auxiliary control at device level
d. Interface to the Substation Automation System (SAS), transmitting and receiving data to meet the requirements of the remote load dispatch center
e. Remote control / communication between Plant Control System (PCS) and superior remote-control system (Regional Control Centre)

Supplier shall include provisions for:

a. Powerhouse Control and Protection
b. Generator Control and Protection
c. Transformer Control and Protection
d. Turbine Protection
e. Regulators
f. Metering

#### 1.16.2.3.7 Protection and Relay Equipment

The general principle for the protection of Generators, Generator Step-up Transformers and Auxiliary Transformers shall be that these are covered by two high speed protection schemes which shall be independent to avoid common-mode failures.

The protection equipment shall be complete with all relay panels, instruments, meters, interposing and auxiliary relays, control switches, interposing current and voltage transformers, transducers and all auxiliary equipment. The protection scheme shall be provided with Cyber security support for compliance to IEC 62351 with Centralized Account Management. Separate cores of current transformer (CT) and voltage transformer (VT) shall be used for each protection and metering. Minimum of one (01) core shall be provided as spare for each CT and VT. Whereas, separate CTs and VTs shall be used for primary and backup protection.



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Protection equipment shall be designed and supplied to provide maximum discrimination between faulty and healthy circuits. All equipment is to remain inoperative during transient phenomena which may arise during switching or other disturbances to the system.

#### 1.16.2.3.8 EPABX, PAS And CCTV

#### 1.16.2.3.8.1 EPABX

The EPABX shall be state-of-the-art, digital, non-blocking type utilizing Pulse Code Modulation (PCM) and Time Division Multiplexing (TDM) and Stored program Control (SPC). It must be field proven and conform to ITU-T A-Law Companding standard. It shall at least be equipped with 64 subscriber lines and 08 trunk lines. The system shall allow simultaneous voice and data communication over one twisted pair telephone cable.

#### 1.16.2.3.8.2 Public Address System (PAS)

The system shall be modular in design, flexible and field programmable. The system shall feature an “attention alarm” signal to precede the spoken messages.

#### 1.16.2.3.8.3 Video Surveillance System (CCTV)

The Video surveillance system shall comprise CCTV cameras, power supplies and video recording equipment enabling selected locations of the power house premises to be monitored remotely from the power house control building. The objective of video surveillance system shall be to monitor the entry/exit gates, boundaries, power house premises for security purposes.

#### 1.16.2.3.8.4 Radio/Microwave Communication

Microwave/ Radio Links shall be used to the OFC as a backup digital radio communication link and will be provided from powerhouse to intake for communication and protection purposes.

#### 1.16.2.3.9 Emergency Diesel Generator Set

The emergency diesel generator of powerhouse is required to provide “black start” capability of the generating unit when power from normal or alternate source is not available. The generator shall also be required to meet emergency load requirements in the power plant when the power supply fails. The governor shall be of the droop type to enable paralleling the generator to the distribution system for load testing. The Contractor shall determine the capacity of the diesel generator based on the loads and submit to Employer for approval. The Contractor shall use the following criteria for specifying the main parameters of the emergency generator set and its control system:

- Voltage level of the system to be supplied from the generator is 400V.
- Load requirements and duration.
- Control and automation.

The emergency diesel generators shall be furnished with speed governor, lubricating oil facility, air inhalation, cooling facility, fuel supply facility, exhaust facility, battery starting system, exciter, voltage adjuster and control panel.

#### 1.16.2.3.10 132kV Switchyard

The 132 kV Switchyard shall be constructed nearby the Power Plant which consist of three (03) Transformer Bays (Generator Step Up Transformers), one (01) Power Transformer Bay and three (03) 132 kV Transmission Line Bays. The 132 kV Transmission Line Bays shall be arranged in one and a half breaker scheme. The Attabad Lake HPP shall be interconnected to the proposed 132/66 kV Regional Grid Station at Aliabad and 132/11 kV Grid Station at

Sost. The scope of Remote end bays including 132kV transmission lines shall be covered in separate package.

The interconnection with 132 kV Switchyard and Power Plant shall be through 11kV Segregated Phase Bus (SPB). AC Auxiliary supply shall be fed from Power Plant through One (01) feeder and another feeder from 132 kV Switchyard Power Transformer (10/13 MVA). A complete DC system shall be installed in 132 kV Switchyard Control House Building.

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

# SECTION 2 GENERAL HYDROMECHANICAL AND HYDRAULIC STEEL STRUCTURES REQUIREMENTS

## 2.1 GENERAL HYDROMECHANICAL REUIREMENTS

### 2.1.1 General Design Requirements

All mechanical works under this Contract shall comply with these General Mechanical Requirement and with the Particular Sections of these Specifications. The equipment shall be of an approved, reliable design providing the highest possible degree of uniformity and interchangeability.

The design and arrangement of equipment and installations shall facilitate erection, testing, operation and maintenance.

All equipment shall be pre-assembled in the manufacturers workshop to an utmost extent. Revolving parts shall be truly balanced both statically and dynamically. If running at normal speed and at any load up to the maximum, no vibration may occur due to lack of balance.

Contact between dissimilar metal parts shall be avoided as far as practicable, especially in any fully or partially submerged application. Suitable insulating material such as plastic, neoprene or paint shall be provided where possible to prevent metal to metal contact between dissimilar metals. If it is necessary to use dissimilar metals in contact with each other, the two metals shall be as close as possible to each other in the galvanic series and practical experience shall be submitted to demonstrate their compatibility. Overlapping paint shall be applied where dissimilar metals are welded together.

#### 2.1.1.1 Standards

All equipment, parts and materials, main dimensions and function shall conform to the appropriate standards recommended in the Employer Requirements. For this purpose, the Proposer’s will be requested to specify in their Proposal’s the relevant standards for the main items of their supply and clearly identify the parts, phases, operations, etc. to which each particular standard shall be applied. For example, the Contractor shall indicate the standards to be applied for design, calculations, materials, and fabrication of the supply.

The Contractor shall supply copies of specified standards at the Employer's request, clearly identifying or marking the particular chapters or sections that are being applied. The following standards are recommended.

- EN European Standards
- FEM Federation Europeenne de la Manutention
- IEC International Electrotechnical Commission
- DIN German standards issued by Deutsches Institut fuer Normung e.V.
- ANSI American National Standards
- ASTM American Society for Testing of Materials
- ASME American Society of Mechanical Engineers
- AISC American Institute of Steel Construction
- AWS American Welding Society
- BS British Standards Institute
- IEEE Institute of Electrical and Electronic Engineers



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- JIS Japanese Industrial Standard
- NFPA National Fire Protection Association, USA
- ASCE American Society of Civil Engineers
- FEM Federation Europeans de la Manutention
- SSPC Society for Protective Coatings
- NTDC National Transmission & Dispatch Company

The standard chosen shall be made available to the Employer and the Employer in the English language. The latest revision or edition in effect at the time of the Invitation of Proposal's shall apply.

All equipment and materials related to the supply contract shall conform to the requirements of the Specifications and to the designated standards. In case of discrepancy between the designated standards and the Specifications, the latter shall prevail.

### 2.1.1.2 Materials

### A. General

The material shall be of highest grade free from defects and imperfections, of recent manufacture and unused.

All materials incorporated in the equipment supplied shall be of quality, grades and conditions as set forth in the approved Standards.

Materials not specifically designated herein shall be subject to the approval of the Employer, shall be suitable for their purpose and shall as far as practicable to comply with the latest issue or revision of the designated standards or their approved equivalent.

Materials for general purposes shall be delivered according to the following standards given in Table 2-1, or their equivalent. The grade used will depend on stress levels, environmental conditions, resulting material thickness and manufacturing and inspection procedures.

The material grade shall unless otherwise specified be proposed by the Contractor but are subject to the Employer approval.

**Table 2-1: Standards**

| Material | Specification |
|---|---|
| Structural Aluminum | ASTM B308/B308M, "Specification for Aluminum - Alloy 6061-T6 Standard Structural Profiles". |
| Carbon Steel Castings | ASTM-A27, "Specification for Mild to Medium-Strength Carbon-Steel Castings for General Application," Grade 65- 35, Grade 70-36, and Grade 70-40. |
| Low-Alloy Steel Castings | ASTM-A148, "Specification for High-Strength Steel Castings for Structural Purposes," Grade 80-50. |
| Corrosion-Resistant Steel Castings | ASTM-A743/A 743M, "Specification for Casting, Iron- Chromium, Iron-Chromium-Nickel, and Nickel Base (Corrosion-Resistant) Alloy Castings for General Application," Grade CA-15, Grade CF-8 and Grade CA- 6NM. |



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| Material | Specification |
|---|---|
| Corrosion-Resistant Steel Plate | ASTM-A167, "Specification for Stainless and Heat- Resisting Chromium-Nickel Steel Plate, Sheet, and Strip." |
| | ASTM-A176, "Specification for Stainless and Heat- Resisting Chromium Steel Plate, Sheet, and Strip." |
| | ASTM-A240, "Specification for Stainless and Heat- Resisting Chromium and Chromium-Nickel Steel Plate, Sheet, and Strip for Fusion-Welded Unfired Pressure Vessels," Type 405 and Type 410. |
| Corrosion-Resistant Steel Bars | ASTM-A582, "Specification for Free-Machining Stainless and Heat-Resisting Steel Bars, Hot-Rolled or Cold- Finished," Type 303 and Type 416. |
| Nickel-Copper Alloy Plate (Monel) | ASTM-B127, "Specification for Nickel-Copper Alloy Plate, Sheet, and Strip (UNS No. 4400)." |
| Iron Forgings | ASTM A48/A48M, “Specification for Gray Iron Castings”, Class 30 |
| Carbon and Alloy Steel Forgings | ASTM-A668, "Specification for Steel Forgings, Carbon and Alloy for General Industrial Use," Class D. |
| Carbon Steel Forgings (for pipe flanges, fittings, etc.) | ASTM-A181, "Specification for Forged or Rolled Steel Pipe Flanges, Forged Fittings, and Valves and Parts for General Service," Grade I and Grade II. |
| Carbon Steel Plates (for low- stressed parts) | ASTM-A283, "Specification for Low and Intermediate Tensile Strength Carbon Steel Plates of Structural Quality (Plates 50 mm and Under in Thickness)," Grade A and Grade B. |
| | ASTM-A36, "Specification for Structural Steel." |
| Carbon Steel Plates | ASTM-A285, "Specification for Low and Intermediate Tensile Strength Carbon Steel Plates for Pressure Vessels (Plates 2 in and Under in thickness)," Grade B and Grade C. |
| Intermediate Strength Steel Plates (for important stress- carrying parts) | ASTM-A516, "Specification for Carbon Steel Plates for Pressure Vessels for Moderate and Lower Temperature Service," Grade 60 or better, except that all plates thicker than one inch shall be normalized to produce grain refinement. |
| High Strength Steel Plates (for highly stressed parts) | ASTM-A517, "Specification for High Strength Alloy Steel Plates, Quenched and Tempered, for Pressure Vessels." |
| Bronze Castings | ASTM B584, “Specification for Copper Alloy Sand Castings for General Applications”, UNS Alloy Nos. C90300 and C92300. |
| Bronze Castings, Bronze (for bearings, wearing plates, etc.) | ASTM-B584, "Specification for Copper Alloy Sand Castings for General Applications, UNS Alloy Nos. C93200 and C93700." |
| Bronze (for bolting) | ASTM-B21, "Specification for Naval Brass Rod, Bar, and Shapes, " Alloy No. 464. |



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| Material | Specification |
|---|---|
| Copper Tubing | ASTM-B88, "Specification for Seamless Copper Water Tube," Type K. |
| Copper Pipe | ASTM-B42, "Specification for Seamless Copper Pipe, Standard Sizes." |
| | ASTM B88/B88M, “Specification for Seamless Copper Water Tube”, Type K. |
| Bronze Pipe | ASTM B43, “Specification for Seamless Red Brass Pipe, Standard Sizes”, UNS Copper Alloy No. C23000. |
| Steel Pipe | ASTM-A53, "Specification for Welded and Seamless Steel Pipe." |
| | ASTM A106, “Specification for Seamless Carbon Steel Pipe for High - Temperature Service”. |
| | ASTM A120, “Specification for Pipe, Steel, Black and Hot – Dipped Zinc - Coated (Galvanized) Welded and Seamless, for Ordinary Uses”. |
| Stainless Steel Pipe | ASTM A312, Type 304 "Specification for Seamless and Welded Austenitic Stainless-Steel Pipe." |
| | ANSI B36.19M “Stainless Steel Pipe”, seamless, Grade TP316N. |
| Stainless Steel Pipe Fittings | ASTM A282, Type 304 "Forged Stainless-Steel Fittings, Socket-Welding and Threaded." |
| | ASTM A403, Type 304 "Specification for Wrought Austenitic Stainless-Steel Pipe Fittings." |
| Stainless Steel Tubing | ASTM A269 or ASTM A213, Grade TP304 "Specification for Soft Annealed Stainless-Steel Tubing." |
| Titanium Tubing | ASTM B338, “Specification for Seamless and Welded Titanium and Titanium - Alloy Tubes for Condensers and Heat Exchangers”. |
| Stainless Steel Tube Fittings | Compression type stainless steel flareless tube fittings, suitable for 1200 psi working pressure. |
| Steel Pipe Flanges and Flanged Fittings | ANSI-B16.5, "Steel Pipe Flanges and Flanged Fittings." |
| Wire Rope and Strand | U.S. Fed. Spec. RR-W-410 C, “Wire Rope and Strand”, IWRC, Regular stranded, Type 1, Class 2 and Class 3. |
| Brazing Filler Metal | ANSI/AWS A 5.8, “Specification for Brazing Filler Metals”. |
| Welding Electrodes | AWS A 5.1, “Specification for Carbon Steel Covered Arc- Welding Electrodes”. |



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| Material | Specification |
|---|---|
| Zinc Lining | ASTM A123/A123M, “Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products”. |
| | ASTM A153/A153M, “Specification for Zinc Coating (Hot - Dip) on Iron and Steel Hardware”. |
| Motors | NEMA MG 1, “Standards for Motors and Generators”. |
| Tanks and Metal Pressure Tanks | ASME “Boiler and Pressure Vessel Code”, Section VIII, Division 1. |

**B. Test of Materials**

**2.1.1.3 General**

Unless otherwise agreed by the Employer, all materials or parts shall be new and shall be tested by the material supplier, in conformity with applicable methods prescribed by the ASTM, or such other equivalent international standards organizations approved by the Employer. For mass produced equipment, the supplier shall indicate that material testing is part of its quality program.

**2.1.1.4 Test Certificates (Mill Certificates)**

Certified material test reports shall be submitted by Contractor to the Employer as soon as possible after the tests are made. The test certificates shall identify the component for which the material is to be used and shall contain all information necessary to verify compliance with the Contract.

**2.1.1.5 Workmanship**

Except where the manner of design, manufacture or execution is otherwise specifically set forth in this Contract, the Works shall be designed and executed in a proper and workmanlike manner, all in accordance with prudent industry practice for such Works. All work shall be done by personnel skilled in the related professions and trades.

All parts shall be made accurately to a standard gage, so as to facilitate replacement and repairs. All bolts, nuts, screws, rivets, threads, pipe, gauges, gears, and measurements or dimensions shown on the Contractor’s Drawings shall conform to customary standards.

The Contractor shall provide and maintain in storage for at least ten (10) years, free of cost to the Employer, sufficient templates, gauges, patterns, and other records to enable the Employer to make repair and replacement parts. All special gages and templates necessary for field erection shall be furnished and shall become the property of the Employer. Patterns shall remain the property of the Contractor.

**2.1.1.6 Working Stresses**

**A. Loading**

Ample factors of safety shall be used throughout the design of the equipment, especially in the design of parts and components subject to alternating stresses, vibration, impact or shock.



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In general, the loading shall be divided into 3 different classes according to the following typical examples.

**2. Normal Loading**

a. Loading due to dead loads
b. Hydrostatic loads, from vacuum to design water pressure
c. External pressure
d. Hydrodynamic loads, design values for surges and pressure rise
e. Friction loads
f. Forces due to temperature variations
g. Environmental loads with a return period of 50 years
h. Dynamic loads due to normal operation
i. Vibration loads caused by flowing water or by ordinary operation

**3. Unusual loading**

a. Sediment loading. Construction shall be appropriate for an increased load due to sedimentation
b. Un-symmetric loading due to uneven frictional forces

**4. Extreme loading**

a. Earthquake loading (Maximum horizontal acceleration of 0.3 g; Maximum vertical acceleration of 0.15 g)
b. Loading due to transportation and erection
c. Pressure testing at 50 % above design pressure
d. Loading due to maximum (PMF) floods
e. Loading due to transportation and erection
f. Emergency situations, complete short circuit forces in generator
g. Emergency hoisting
h. Continuous run away of the generating unit

The various loads shall for normal loading be combined if physically possible, and the most severe shall determine the design conditions. At unusual and extreme loading, each unusual or extreme load cases shall be combined with the most severe normal loading. Unusual or extreme load cases do not need to be combined.

**B. Design Conditions**

**5. Normal Design Conditions**

The following stress levels at the different load cases are the maximum allowable values. Lower stress levels may be prescribed in the particular specifications for the individual sections of work, or under Construction Elements in these General Specifications, or in the various design standards used for particular components.

Under design conditions, the combined stress levels calculated according to von Mises theory shall not exceed what is allowed according to the approved standards but shall in no case exceed the values in Table 2-2 unless otherwise stated by the Contractor and approved by the Employer.



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**Table 2-2: Normal Design Condition Stress Limits**

| Material | Stress Condition | Stress Limit |
|---|---|---|
| Structural steel materials | Maximum general stress level | 60% of the yield strength |
| Structural steel materials | Average stress at points with local stress concentrations, calculated according to methods approved be the Employer | 75% of the yield strength, provided the quality of material can be confirmed by approved methods at the point with stress concentration. |
| Other materials | Maximum stress in tension or compression | 33% of the yield strength or 20% of the ultimate strength of the material |
| Cast steel | Maximum general stress level | 50% of the yield strength |
| Cast steel | Average stress at point with local stress concentrations, calculated according to methods approved by the Employer | 67% of the yield strength provided the quality of material can be confirmed by approved methods at the point with stress concentration. |
| Cast iron | Maximum general stress level | 20 N/mm² |
| Ductile materials in general | Shear stresses | 57% of allowable stresses in tension |
| Ductile materials in general | Hydrostatic pressure testing | 90% of the yield strength |
| Vertical pump, turbine and generator shafts | Maximum torsion shear stress | 40 N/mm² |
| Horizontal pump and turbine shafts exposed to water | Maximum torsion shear stress | 35 N/mm² |

- Ratio between ultimate strength and yield strength minimum 1.2
- Elongation, A, test length 5.65. minimum 17%
- Impact Strength, KV, at design temperature minimum 27 J

The minimum properties shall be tested in the direction of highest principal stress of any component, including weld zones.

The yield strength shall mean the guaranteed, minimum yield strength. For materials not having a defined yield point, the 0.2% proof stress shall be used.

All components shall be designed for a lifetime of 40 years under normal running conditions, and components subject to fatigue shall have a theoretical safety factor of 1.5 against failure unless otherwise stated. Due consideration shall be made to dynamic stresses, which shall



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be kept within the stress limits stated above. The effects of corrosion, stress concentrations, notches, etc., shall be duly considered.

The maximum general stress levels shall be calculated in accordance with the elastic theory, considering all main stress components.

The resulting effect of peak stresses, due to secondary bending moments, may be calculated using a non-linear theory, provided that the material is not subject to fatigue, the ductility allows limited yielding without danger of cracking and that the quality control procedures during production with a satisfactory degree of probability shall detect cracks well below the critical crack size.

Materials for pressure vessels, spiral casings, larger valve housings and similar which are heat treated after manufacture, shall have a critical crack length which will cause the crack depth to penetrate the vessel, thus causing the vessel to leak without bursting at its lowest operation temperature and at the general maximum stress level. For vessels not heat treated, the same shall apply for stresses equal to the yield stress.

**6. Unusual Design Conditions**

For structural steel materials the general maximum stress level may be increased to 75 % of the yield strength, and up to 80% of yield strength for the maximum stress at points with local stress concentrations.

For other materials, the stresses may be increased accordingly.

**7. Extreme Design Conditions**

For structural steel materials the general maximum stress level may be increased to 80 % of the yield strength, and up to 90 % of yield strength for the maximum stress at points with local stress concentrations.

For other materials, the allowable stresses may be increased accordingly subject to the Employer approval.

**a) Pressure Testing**

Before pressure testing of larger components, the critical crack size shall be calculated and compared with the crack detection level. The general membrane stress in any part shall not exceed 80% of the yield stress.

**b) Runaway Conditions**

Under maximum runaway conditions, the increasing forces due to deformations under loading shall be considered.

Earthquake loading shall be calculated using the specified horizontal and vertical acceleration. The method of calculation shall be subject to approval of the Employer.

**2.1.1.7 Special Design Criteria**

**a. Shaft Bending Frequency**

The following criteria shall be observed for main shaft systems (turbine/generator, pump/motor, diesel-engine/generator etc.):

- The first order shaft natural bending frequency shall exceed the maximum transient runaway speed by 25% or more. The shaft natural bending frequencies shall have a



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separation of 25% or more to the operating speed, to the line frequency (50 Hz) and to other predominant system frequencies.

- The first order shaft natural torsion frequency shall exceed the maximum transient runaway speed by 25% or more. The shaft natural torsion frequencies shall have a separation of 25% or more to the operating speed, to the line frequency (50 Hz) and to other predominant system frequencies.

For auxiliary motors, pumps and other rotating equipment, the shaft speed shall not exceed 90% of the first order shaft natural frequencies at a temporary line frequency or75 Hz.

Standardized electrically driven equipment rated less than 6 kW shall, after approval by the Employer, be exempted from these criteria.

The deformations shall at all loads be within acceptable limits according to the best engineering practice.

The Contractor shall assume full responsibility for an adequate design and shall use lower stresses wherever necessary.

### 2.1.2 Welding

#### 2.1.2.1 General

All welding shall be performed by the electric-arc method, by a process that excludes the atmosphere from the molten metal, and, by automatic machines, however, manual welding shall be performed on the welds where automatic welding cannot be performed due to access issues. After being deposited, all welds shall be cleaned of slag by shot blasting, unless otherwise approved by Employer, and shall be uniform, smooth, showing good fusion with the base metal, and free of voids, crack, and clinkers. Machined surfaces of parts affected by welding shall be machined to final dimensions after welding. Machined surfaces of parts requiring stress relief shall be machined to final dimensions after the parts have been stress relieved. Localized stress relieving shall not be permitted for shop-welded parts. All principal load-carrying welds shall be full penetration type welds. Strength of welded joints shall be based upon the allowable stress of the parent materials. Welding methods shall be such that residual stresses shall be reduced to a minimum. The weld seams shall, as far as possible, be positioned outside zones of stress concentration.

All joining of plates in the principal stress direction shall be carried out using double welded butt joints. Adjacent plates, carrying high stresses, shall in general not differ more than 3 mm in thickness. If the difference is greater, the thicker plate shall be chamfered maximum 1: 4.

Principal welds shall be ground as specified in the approved welding procedure. Besides, all welds exposed to water having a velocity of 10 m/s or more, shall be ground flush with the plates unless otherwise approved by the Employer.

Cracked or defective tacks shall be removed before welding.

For double welded butt joints, the root shall be completely removed by grinding or back gauging before proceeding with the welding on the other side in order to prevent the presence of residues.

Where auxiliary structural members are welded to components for the purpose of assembly and installation, the connecting welds shall be given particular care. Once an installation has been completed, these auxiliary structural members shall be removed by burning them off,



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followed by grinding the affected areas flush with the plate, without introducing additional local thermal stresses. Knocking off of such members shall not be permitted.

The electrodes for arc welding shall be classified on the basis of mechanical properties of the as welded deposited weld materiel, type of covering, hydrogen absorption, welding position of the electrodes and type of current.

Electrodes shall be used only in the positions and under the conditions of intended use in accordance with instructions with each container. Electrodes for manual welding shall be suitable for welding in any position.

During the welding operations the electrodes shall be stored and dried in electric heaters prior to welding, according to the instructions from the manufacturer and approval of the Employer.

The ignition of welding-electrodes shall not be initiated at the steel surface adjacent to the weld, but at the groove flanks to prevent detrimental increments of local hardness. Where ignition points of electrodes are discovered, they shall be ground appropriately.

Designs shall be such as to minimize Site welding.

Unless otherwise stated the qualification of welding procedures, welders, and welding operations, including weld repairs of castings shall conform to Section IX of the ASME "Boiler and Pressure Vessel code".

Unless otherwise stated all welded parts shall be designed, fabricated, inspected and tested in accordance with Section VIII of the ASME "Boiler and Pressure Vessel code" and shall be stress relieved prior to machining in accordance with the requirements of the same code. No Site welds shall require stress relieving.

For certain structural items welding, welders and weld procedure shall be in accordance with AWS Standards. These items shall be identified in these Specifications. All pressure vessels and items subject to penstock pressure shall be welded to ASME "Boiler and Pressure Vessel code".

Welds shall in general be treated so that they shall display good appearance and a surface suitable for painting. Structural welds shall be ground and blended to avoid stress raisers. All welds which require non-destructive examinations shall be dressed by chipping and grinding as required for good interpretation by the selected weld examination methods.

All welds shall be continuous, watertight and free from voids.

Welded-on fabrication aids shall be kept to a minimum. They shall be attached only by approved welders and shall be removed by flame cutting not less than 1.5 mm above the parent plate surface and then by subsequent grinding and crack detection of the weld area.

All plate butt welds shall be full penetration back gouged and welded from both sides.

The minimum size of fillet welds shall be 6.5 mm measured on the leg. Undercutting not exceeding 1 mm shall be removed by grinding. Undercutting exceeding 1 mm shall be filled by welding.

The edges of surfaces (up to the thickness of the metal) to be welded shall be of sound metal free from visible defects such as laminations or defects caused by cutting operations and free from rust, oil grease and other foreign matter.

### 2.1.2.2 Edge Preparation

Members to be joined by welding may be cut to shape and size by mechanical means such as shearing, machining, grinding, or by gas or arc cutting, to suit the conditions. Design of welded joints and selection of weld filler metal shall allow thorough penetration and good fusion of the weld with the base metal. The edges of surfaces to be welded shall be sound metal free of visible defects, such as laminations or defects caused by cutting operations, and free from rust, oil, grease and other foreign matter.

### 2.1.2.3 Welding Qualifications

The qualification welding procedures, of welders, and of welding operators shall conform to standards at least equal to ISO 9606 or Sections VIII and IX of the ASME Boiler and Pressure Vessel Code. The Contractor shall furnish the facilities and all equipment, materials, and other articles required to perform qualification tests of its welders and welding operators. The Contractor shall prepare the procedure for qualification testing of the field welders, and the qualification tests shall be witnessed and accepted by the Contractor. All welders' and welding operators' test certificates shall be submitted to the Employer. Welders for on-site work shall be tested no earlier than 3 months prior to commencing site work. Contractor shall replace any welder or welding operator deemed unacceptable by Employer.

WPS and Welder Qualification Tests shall be in accordance with the relevant welding standard and shall be performed by the Contractor and witnessed by the Employer.

### 2.1.2.4 Welding of Stainless Steel

All welding of stainless steel shall be carried out using the inert gas method (TIG/MIG). Pipes shall be locally filled with inert gas during welding.

Butt welds on thin-walled pipes shall have a smooth, fully penetrated weld seam inside and outside. Partly penetrating, drops or metal sputter shall not be accepted.

All welds and heat affected zones shall be carefully descaled and cleaned with a suitable cleaning paste and fresh water if inert gas has not been applied or if the inert gas method has failed. Carbon steel tools shall not be used.

### 2.1.2.5 Field-Weld-Filler Metal

The calculated quantity of weld-filler electrodes or wire required for field-welded joints plus twenty percent (20%) additional shall be furnished. The Contractor shall select the proper filler material for all field-welded connections and shall specify it on the applicable Contractor's Drawings submitted for the Employer approval, together with the detailed design of the field-weld joint.

### 2.1.2.6 Heat Treatment

The need for heat treatment shall be determined in accordance with the approved Design Standard and/or Boiler and Pressure Vessel Code, taking into account the stress levels and design temperature, material properties including notch toughness, material thickness and forming, welding and inspection procedures. The shop heat treatment of welded components shall be performed on the completed component prior to final machining.

Procedures for heat treatment shall be submitted to the Employer for approval.

Heat treatment of site welding shall be performed according to the specifications for the welding procedure for the corresponding parts, which shall be submitted to the Employer for approval.

#### 2.1.2.7 Quality and Procedure Control

Quality testing and inspection methods, e.g. inspections by non-destructive testing (NDT) means, shall be carried out in accordance with the appropriate manufacturing code. However, the Contractor shall indicate clearly on the drawings the extent to which these methods shall be used.

#### 2.1.2.8 Documentation

The Contractor shall maintain a strict quality control program for the welding work performed in the shop. Weld procedure specifications (WPSs) shall be submitted for review and approval by the Employer prior to starting the fabrication work. All welds shall be identified on the Contractor's Drawings by numbers. All welding work shall be performed by qualified welders and welding operators and shall be properly documented.

#### 2.1.2.9 Nondestructive Testing

**a) General**

Unless otherwise indicated, all nondestructive tests shall be in accordance with the applicable section of ASTM Standards, Part III, Metallography Nondestructive Tests or approved equivalent. The Contractor's Drawings submitted to the Employer for review and approval shall define the areas, extent, and type of nondestructive examination employed.

**b) Examination of Welds**

All welds on weld-fabricated parts, except minor parts or low stressed parts, shall be given complete nondestructive examination by Contractor. Weld examination shall be by TOFD, dye penetrant and magnetic particle methods, supplemented by radiographic examination. Supplemental radiographic examination shall include examination of critical high-stressed areas where interpretations of other methods are unclear, or where the integrity of the weld is doubtful. All butt-welded joints exposed to headwater pressure, or to significant stress levels shall be given a one hundred percent (100%) radiographic or TOFD inspection by Contractor, accompanied by a one hundred percent (100%) magnetic particle or liquid penetrant inspection. At least, 25% of Butt Welds at Site shall be radiographic tested. The Employer shall have the right to request random spot-check examination of welds, including radiographic examination, as part of its inspection of the equipment. The Employer shall have the right to review films of previously performed radiographic examinations. The nondestructive examination scope, procedures and acceptance standards of welds shall be clearly indicated on the Contractor’s Drawings. The detailed program for nondestructive examination of welds shall be submitted by Contractor for review and approval by the Employer.

#### 2.1.2.10 Machine Work

**a) General**

Sufficient machining stock shall be allowed on all parts to be machined to ensure true finished surfaces of solid material. Finished contact or bearing surfaces shall be true and exact to secure full contact. Journal and sliding surfaces shall be polished, and all surfaces shall be

finished with sufficient smoothness and accuracy to ensure proper operation when assembled. No machining shall be done on working surfaces of self-lubricating bushings or washers.

**b) Finished Surfaces**

In addition to the machined surfaces indicated on the Contractor's Drawings, all surfaces that require machining for their intended function and those surfaces that are normally machined in good shop practice shall be machined.

**c) Unfinished Surfaces**

All work shall be laid out to secure proper matching of adjoining unfinished surfaces. Where there is a large discrepancy between adjoining unfinished surfaces, they shall be chipped and ground smooth, or machined, to secure proper alignment. Unfinished surfaces shall be true to the lines and dimensions shown on the Contractor's Drawings and shall be chipped or ground free of all projections and rough spots. Depressions or holes not affecting the strength or usefulness of the parts may be filled in an approved manner. Corrosion-resistant-steel, seal plate surfaces in contact with seals shall be thoroughly cleaned to have a smooth and even surface.

**d) Pins and Pin Holes**

Pin holes shall be drilled smooth and straight and at right angles to the axis of the member. The drilling shall be done after the member is securely fastened in position.

**e) Assembly**

Before assembly, all bearing surfaces, journals, and grease and oil grooves shall be carefully cleaned and lubricated with an approved oil or grease. Solvents shall not be used on self-lubricating bearings. After assembly, each lubricating system shall be filled with an approved lubricant. Self-lubricating bearings shall not be greased and shall be assembled dry according to the manufacturer's instructions.

**f) Surface Finish**

The quality of all surface finishes shall be selected with due regard for the nature and function of the surface and in accordance with conservative design practice. Surface finish shall be subject to approval.

### 2.1.2.11 Steel Forgings

The Contractor shall supply a list of all important forgings and draw up material specifications for each forging. Copies of this list and specifications shall be supplied to the Employer for his use.

Steel forgings shall be in accordance with the requirements of BS Standards, the equivalent ISO Standards, or agreed national Standards.

Test blocks from which mechanical test pieces will be machined shall be cut from forgings at positions to be agreed by the Employer. On large and important forgings several test pieces shall be taken from radial and longitudinal directions.

Forgings shall be free from cracks externally or internally, extensive non-metallic inclusions and surface defects. The Contractor shall carry out non-destructive testing of forgings during machining to verify that no unacceptable defects are present.



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Repairs by welding or other means shall not be undertaken on forgings at any stage of the production cycle.

Each forging shall be suitably branded with an identification number which shall be transferred throughout all final machining stages. The identification number shall be marked on all documents and test certificates related to the forging.

### 2.1.2.12 Casting

#### a) General

Test bars shall be provided from medium and large castings for all necessary material and chemical tests which are to be witnessed by the Employer. If required by the Employer any castings for rotating or highly stressed parts are to be subjected to non-destructive testing by approved methods including radiographic and ultrasonic means, the cost of which shall be borne by the Contractor.

All castings shall be homogeneous and free of shrinkage, pipes, under sizing, porosity or voids. "Burn in" repairs are not acceptable and no welding, filling, interlocking or plugging of defective parts shall be done without the Employer approval in writing. All repairs shall be subjected to non-destructive examination (ultrasonic, X-rays, gamma rays) after heat treatment.

#### b) Steel Castings

The Contractor shall prepare material purchasing specifications for all important castings. Each document shall indicate fully the quality and inspection requirements for the component casting covered. Copies of the Specification shall be issued to the Employer for his approval.

Castings shall be repaired by welding providing the approval of the Employer is first obtained. The Contractor shall submit drawings, sketches or photographs and metallurgical test reports showing the location and principal dimensions of the defect together with the proposed weld repair procedure. The maximum size of defect for which weld repair shall be permitted is:

- Maximum length of defect 20 mm
- Maximum width of defect 10 mm
- Maximum depth of defect no greater than 10% of the wall thickness but in no case greater than 20 mm

Only welders who have passed an appropriate qualification test shall be employed on the repair of castings. All repairs shall be carried out by the metal arc process.

Ultrasonic inspection shall be applied to all important castings to locate the extent of sub surface defects and to check the wall thickness.

All castings shall be identified by stamped or cast on reference marks which shall be entered on all relevant documents and test certificates.

The Employer may require that certain castings shall be examined using radiographic techniques. The Contractor shall include for this eventuality and shall comply with the Employer instructions when issued.

#### c) Cast Iron Castings

Cast iron shall not be used for any part of equipment which is in tension or which is subjected to impact, or to a working temperature exceeding 200 °C unless specifically approved by the Employer.



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Weldable grades of Ni resist austenitic cast iron castings shall be repaired by welding provided the approval of the Employer is first obtained. The Contractor shall submit full details of the proposed weld repair procedure and weld procedure qualification test prior to making any weld repairs. The maximum size of defect for which weld repair shall be permitted is:

- Maximum length of defect 20 mm
- Maximum width of defect 10 mm
- Maximum depth of defect No greater than 10% of the wall thickness.

Test blocks shall be integrally cast on all medium and large castings.

The Employer may require that certain castings shall be checked using radiographic techniques. The Contractor shall include for this eventuality and shall comply with the Employer instructions when issued.

**d) Aluminum Bronze Castings**

The Contractor shall prepare material purchasing specifications for all important castings. Each document shall indicate fully the quality and inspection requirements for the component casting covered. Copies of the Specification shall be issued to the Employer for his use.

The inspection and quality requirements shall include an analysis of each cast, mechanical testing of test bars from each cast, pressure testing, penetrant flaw detection and radiographic examination of selected critical areas.

Weldable grades of aluminum bronze shall be repaired by welding provided the written approval of the Employer is first obtained. The Contractor shall submit full details of the proposed weld repair procedure and weld procedure qualification test prior to making any weld repairs. The maximum size of defect for which weld repair shall be permitted is:

- Maximum length of defect 20 mm
- Maximum width of defect 10 mm
- Maximum depth of defect No greater than 10% of the wall thickness but not more than 20 mm

On completion of repairs, welded areas shall be ground smooth and carefully blended into the parent material. The repaired areas shall be examined for defects using penetrant flaw detection and radiography. Crack like linear defects shall not be permitted.

### 2.1.3 Corrosion Resistant Elements

All new bolts, nuts, studs, dowels, pins and other elements provided as part of the Works that are exposed to water or high humidity or subjected to frequent adjustment or frequent removal shall be of corrosion resistant steel or bronze. Bolts and nuts shall be of different grades of stainless steel to avoid problems of spalling.

### 2.1.4 Nameplates

Each major and auxiliary item of upgraded equipment shall have a nameplate permanently affixed thereto showing in a legible and durable manner the serial number, name and address of the manufacturer, ratings, characteristics, weight, manufacturing date and other significant information, as applicable. Nameplates of distributing agents only shall not be acceptable.

Additional nameplates shall be provided to indicate main operating instructions, caution or warning for personnel and operational safety. In addition, each panel-mounted instrument, position indicator, pushbutton, switch, light, or other similar device shall be identified by a



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permanently affixed nameplate that describes the control functions. Electrical wiring and instruments including relays shall also be labeled to correspond to the numbers assigned on the electrical control schematics.

The above general nameplate requirements shall be used in preparing nameplate lists and drawings shall be submitted to the Employer for review and approval. Contractor's Drawings for nameplates, as they will appear on the finished equipment, shall be submitted to Employer for review and approval.

All nameplates shall be in English and shall be suitably engraved and shall be weather-resistant. All nameplates shall be permanently attached to the respective parts, components, or equipment items in clearly visible locations. Nameplates for control equipment shall be screw- mounted laminated plastic, white with black cores, with engraved capital letters 6.4 mm minimum height.

### 2.1.5 Foundation Materials

#### 2.1.5.1 General

All permanent foundation materials including all anchor bolts, jacks, tie rods, turnbuckles, anchor loops, leveling screws, supporting columns made of pipe or structural steel, soleplates, embedded anchor plates, bracing, and all other foundation materials required for anchoring and/or supporting the parts during concreting, shall be provided with all equipment.

#### 2.1.5.2 Anchor Bolts

All anchor bolts and anchoring materials, for anchoring the equipment and accessories, shall be provided. Calculations showing the stresses in the anchor bolts for the, shall be submitted for review and approval by the Employer.

### 2.1.6 Fasteners and Anchor Bolts

#### 2.1.6.1 General

All bolts, studs, nuts, etc., shall have a standard metric threading and conform to the relevant standards as regards shape and tolerance. They shall be marked by the manufacturer's symbol and class of strength.

Nuts and bolt-heads shall be hexagonal in shape and truly faced. Bolts and screws with sunk heads such as Hexagon Socket Head Cap Screws or Hexagon Socket Countersunk Head Cap Screws shall be made from stainless steel only unless approved by the Employer.

All bolts, studs, nuts, washers, screws, etc., above size M10, shall, if not in stainless steel or other corrosion resistant material, be hot dip galvanized, except for bolts above Strength Class 8.8, for which corrosion resistant materials or electrolytic zinc-coating shall be preferred.

All bolts and nuts used in bolted and screwed joints in hydraulic steel structures shall have a minimum dimension of M16.

Expansion bolts shall have a minimum dimension of M16 and shall be stainless steel.

Bolts, nuts, studs and screws which require frequent tightening and unbolting during inspection or maintenance procedures shall be of stainless steel.



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For equipment within closed cabinets, in oil sumps and similar locations the Employer shall approve other types of corrosion protection.

All bolts, nuts and screws shall be secured in an approved manner against their becoming loose during operation.

The Contractor shall supply the net quantities plus 5% spare of all permanent bolts, screws and other similar items and materials required for installation of the works at the site. Any such bolts, screws, etc., which are surplus after the installation of the equipment has been completed shall become spare parts and shall be wrapped, marked and handed over to the Employer.

Washers, locking devices and anti-vibration arrangements shall be provided and shall be subject to the approval of the Employer. Taper washers shall be fitted where necessary.

Nuts, bolts and screws that might become loose during operation shall be locked in fastened position by means approved by the Employer.

Bolts shall be designed so that with the nuts fully tightened, the stress intensity at the bottom of the thread shall not exceed half the yield stress of the material under all conditions.

All torque values shall be stated on the Contractor's Drawings or torque value listing.

All existing fasteners in contact with water shall be replaced. All existing fasteners, which exhibit corrosion, or are not reusable, shall be replaced.

Bolts, nuts and studs, except for fitting-up bolts and shaft coupling bolts, shall be as specified in Table 1-3.

**2.1.6.2 References**

Table 1 3: Bolt and Nut References

American Society for Mechanical Engineers

| | |
|---|---|
| B1.1 | Unified Inch Screw Threads (UN and UNR Thread Form) |
| B1.15 | Unified Inch Screw Threads (UNJ Thread Form) |
| B1.13M | Metric Screw Threads (M Profile) |
| B1.21M | Metric Screw Threads (MJ Profile) |
| B18.2.1 | Square and Hex Bolts and Screws (Inch Series) |
| B18.2.3.1M | Metric Hex Cap Screws |
| B18.2.3.2M | Metric Formed Hex Screws |
| B18.2.3.3M | Metric Heavy Hex Screws |
| B18.2.3.4M | Metric Hex Flange Screws |
| B18.2.3.5M | Metric Hex Bolts |
| B18.2.3.6M | Metric Heavy Hex Bolts |
| B18.2.3.7M | Metric Heavy Hex Structural Bolts |
| B18.2.3.8M | Metric Hex Lag Screws |



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| | |
|---|---|
| B18.2.3.9M | Metric Heavy Hex Flange Screws |
| B18.2.2 | Square and Hex Nuts |
| B18.2.4.1M | Metric Hex Nuts, Style 1 |
| B18.2.4.2M | Metric Hex Nuts, Style 2 |
| B18.2.4.3M | Metric Slotted Hex Nuts |
| B18.2.4.4M | Metric Hex Flange Nuts |
| B18.2.4.5M | Metric Hex Jam Nuts |
| B18.2.4.6M | Metric Heavy Hex Nuts |
| B18.3 | Socket Cap, Shoulder, and Set Screws, Hex and Spline Keys (Inch Series) |
| B18.6.2 | Slotted Head Cap Screws, Square Head Set Screws, and Slotted Headless Set Screws |
| B18.3.1M | Socket Head Cap Screws |
| B18.6.3 | Machine Screws and Machine Screw Nuts |
| B18.6.7M | Metric Machine Screws |
| B18.21.1 | Lock Washers (Inch Series) |
| B18.22M | Metric Plain Washers |
| B18.22.1 | Plain Washers |

Society of Automotive Engineers

| | |
|---|---|
| SAE J429 | Mechanical and Material Requirements for Externally Threaded Fasteners |
| SAE J1199 | Mechanical and Material Requirements for Metric Externally Threaded Steel Fasteners |

**2.1.6.3 Fasteners**

A. Threads

I. All bolts, studs, machine screws, nuts and tapped holes shall be threaded in accordance with ASME B1.13M, B1.21M for metric forms.

II. Fine pitched threads shall be made to Class 3 tolerances for U.S. Customary forms and to Class 4H and 5H for metric bolts and nuts respectively.

III. Fasteners subjected to fatigue loads shall have rolled UNJ or MJ thread forms.

B. Bolts

I. Bolts shall be finished hex bolts conforming to either ASME 18.2.1 for U.S. Customary or ASME B18.2.3.xM for metric.

II. Carbon steel bolts shall be SAE J429 Grade 2 or higher and/or SAE J1199 Grade 5.8 or higher.



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C. Nuts

I. Nuts shall be finished hex nuts conforming to either ASME B18.2.2 or ASME B18.2.4.xM for metric.

II. Nuts and tapped holes shall be selected/designed to support more load than the bolt, and to minimize galling.

D. Cap and Set Screws

I. Cap and set screws shall conform to the applicable requirements of ASME B18.3 and/or to ASME B18.3.1M for metric screws.

II. The hardness of socket head cap screws utilized in load carrying members shall not exceed Rockwell C40.

E. Machine Screws and Nuts

I. Machine screws and nuts shall conform to the requirements to ASME B18.6.7M for metric screws.

F. Washers

II. Plain washers shall be hardened and conform to the requirements of ASME B18.22M for metric.

III. Lock washers shall conform to the requirements of ASME B18.21.1 for helical spring type.

### 2.1.6.4 Anchor Bolts

A. General Requirements

I. Anchor bolts shall be supplied in accordance with the anchor manufacturer's recommendations for the equipment design, details shown on the approved Contractor's Drawings and with the requirements of the Specification unless otherwise directed.

II. The anchor bolts specified herein are intended for anchorage of equipment to new concrete foundations or existing concrete structures. Such items include but are not limited to: anchorage of the connection ring liner prior to welding, anchorage of sump tanks, accumulator tanks, equipment skids, pipe hangers and supports.

III. Anchor bolts shall be of the dimension, size and grade as indicated in the Contract documents. Nuts and washers shall be as specified for grade, type and style.

IV. Chemical anchors with past due expiration dates shall not be used and shall be properly discarded.

V. Anchors for lighter static loads shall be of the drilled, wedge type of 303 or 304 stainless steel.

VI. After anchor bolts have been embedded, Contractor shall protect threads by applying grease and by having the nuts screwed on until the time of installation of the equipment or metalwork.

B. Embedment Depth

Minimum depth of embedment of drilled mechanical anchors shall be as recommended by the manufacturer, but no less than six and one-half bolt diameters.



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### 2.1.7 Coupling Guards

All rotating shafts and couplings shall be fitted with rigid guards of wire mesh or plate so designed that accidental contact with the rotating parts is not possible.

### 2.1.8 Locks

Locks shall be supplied for all normally closed valves and for electrical cabinets and cubicles. Three keys shall be supplied for each lock and all keys shall be non-interchangeable. All padlocks shall be of brass.

A key cabinet shall be supplied to accommodate the keys. The keys shall have an engraved identification tag and the key hooks in the cabin shall also have engraved labels.

### 2.1.9 Lubrication

Grease, oil and hydraulic fluid for all Plant and systems shall be provided by the Contractor for initial filling of all the equipment, plus an additional fifty percent. The types of lubricants and hydraulic fluids to be used shall be coordinated with the Employer so that the same types shall be used throughout the Project. Upon completion of the design, the Contractor shall provide a schedule showing the types, the quantities of oil, hydraulic fluid and grease required for the initial filling of each item of Plant.

Lubricants and greases shall be of types readily available in Pakistan.

During erection, use shall be made of an approved anti-scuffing lubricant, such as molybdenum-di-sulphide, on threads of bolts and nuts for items requiring subsequent routine dismantling.

### 2.1.10 Handling Devices

The Contractor shall furnish any required special handling and lifting devices for handling all newly furnished components.

Lifting lugs, brackets, and eyes as required for attaching lifting devices shall be provided on all of the major components of new equipment.

All equipment over 50 kg weight shall be equipped with lifting lugs or screwed sockets for eye bolts conveniently located for ease of handling. Sufficient eye bolts shall be supplied for the equipment to be handled and these shall be handed over to the Employer at the end of the erection period in good working condition. The lugs and eye bolts shall meet the requirements of FEM or other approved recognized international Standards. Lugs and eye bolts shall have a factor of safety of 5 in relation to the load being handled and shall be ultrasonically examined before use.

### 2.1.11 Pumps

#### 2.1.11.1 General

All pumps to be supplied for the Works shall be of a reputable make and of a type best suited for their purpose. They shall be furnished complete with electrically driven motors of ample capacity to provide safe and continuous service under all operating conditions of the respective system. Each pump shall be supplied with a common base plate or support, as the case shall be for its drive motor.



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The main dimensions shall as far as possible be standardized, as an example according to ISO 2858 or similar relevant standards.

Pumps rated less than 100 kW, shall in general be delivered with guarantees according to ISO 2548 Class C, unless otherwise specified.

Pumps rated above 100 kW shall in general be delivered with guarantees according to ISO 3555 Class B, unless otherwise specified.

Pump bodies of larger pumps (above 30 kW rating) or maximum pressure above 6 bar, shall be of nodular cast iron quality not less than 400-12 ISO 1083 (GGG 40 DIN 1693), or cast steel 45.3 DIN 1681.

Pump bodies of smaller pumps (less than 6 kW) may be of cast iron of a quality not less than GG 25 DIN 1691 or approved equivalent.

All wearing parts, sealing faces and shafts, etc., shall be of a corrosion proof material and easy to replace. The shafts shall have wear collars where required. Mechanical shaft seals shall be preferred. Shafts sealed by stuffing boxes shall be fitted with sleeves. Seals shall be exchangeable without extensive disassembly of the pump. Leakage water shall be led to suitable canals/gutters. Each pump shall have air and drain valves.

Pump impellers and labyrinth rings shall be of Ni Al - bronze or stainless steel. For standard pumps being supplied with more than one impeller diameter, the proposed impeller shall not be of the maximum nor the minimum size for the selected pump.

Pumps intended for continuous operation with water with suspended sediments shall have materials and surface coating for impeller, labyrinths and shaft seal specially designed for such service.

Pumps shall not require frequent lubrication of the shaft bearings.

All pumps shall be fitted with a suitable manometer, as specified hereafter. The pressure tapping for this item as well as other instruments required in the Specifications shall be arranged so as to ensure a correct indication of the value to be measured, as indicated in ISO 3555 or DIN 1944. All instruments shall be easily visible. Should transfer pipes be required, they shall be of a corrosion proof material with an isolating valve at the connecting point.

The size of the pump motor forming part of the supply of pumps shall be:

Pm = 1.10 x Pp

Pm = rated motor power

Pp = maximum required power at the rated pump capacity

The pumps shall withstand corrosion and wear by abrasive matters within reasonable limits.

For submersible pumps, pump and motor shall be contained in the same casing and designed as a package unit with incorporated suction strainer. The impeller shall be of bronze or with rubber lining or of stainless steel. For dirt water pumps, the flow channels shall be rubber or epoxy lined.

Dirt water submersible pumps with the motors mounted on top of the pump shall be suitable for running dry continuously, without damage to seals, bearings, or motors.

For any pump, the overall pump/motor efficiency for the specified rated head and discharge shall not be less than 60%.

If requested by the Employer, one out of three pumps with Pp larger than 30 kW shall pass a performance test to ISO 2548 Class C (DIN 1944, Class II), with measurements taken at discharges of 0%, 50%, 80%, 100% and 110% of nominal capacity at rated speed. The results have to be certified in a Workshop certificate. For pumps with Pp larger than 100 kW, these tests shall be compulsory.

Prior to the test, the Contractor shall provide certified motor performance curves.

All pumps shall have a pressure rating, guaranteed by the manufacturer, of minimum 50% above the normal system working pressure.

Acceptance test of oil pumps shall be performed according to relevant standards approved by the Employer at the manufacturer's shop or at the Site.

### 2.1.11.2 General Requirements of Centrifugal Pumps

Preventive and routine maintenance time shall be minimized by the selection of appropriate design of pumps, preferably those that leave casing to piping joints intact, i.e. horizontal split-casing types for large centrifugal pumps and horizontal, back pull-out types for smaller units.

Where a significant saving in floor space or improvement of layout can be demonstrated, a vertical pump may be acceptable.

All pumps above 150 kW shall be provided with temperature sensors on the bearing of the pump and the motor. Vibration sensors shall also be fitted on pumps above 150 kW.

Pumps shall be capable of continuous operation with minimum maintenance over the operating range from minimum flow to maximum flow. The Contractor shall define this range.

The rating of the driver and the pumps net positive suction head (NPSH) requirements shall be such that the pump is capable of a flow rate 10% in excess of the maximum flow rate required.

In addition, pumps shall be designed to have a reasonable margin on head (normally 5% on head for clean fluids, 10% for solids bearing fluids) to compensate for normal wear of pump components. There shall be an adequate margin on NPSH, normally greater than 1 m for values of NPSH required and between 2 m and 12 m with flow rates up to the stated maximum.

When pumps are installed to operate in parallel, they shall be capable of equal load sharing throughout the operating range. This implies a pump head flow characteristic that falls continuously from shut valve to duty point by at least 10%. The pump unit shall, when operating over its normal range of flow rates, comply with the noise emission requirements stated in this section.

All pump motor units shall be installed on a substantial base plate, with isolating valves, a discharge non-return valve, air release valves (for both pump casing and seal chamber), drain valves, suction and discharge pressure gauges unless otherwise stated. The supplier should review the minimum flow rates stated and advice if a leak off system is necessary, in which case all minimum flow detection devices, diversion valves and pipe work shall be supplied.

### 2.1.11.3 Technical Requirements for Centrifugal Pumps

In selecting bearing type, account should be taken of possible vibration damage to the bearing surfaces while the machine is stationary. Where sleeve bearings are used, bearing shells shall be replaceable without removing pump or motor shaft. Bearing housings shall be effectively

sealed against loss of lubricant and ingress of fluid or dirt. Oil seals shall be replaceable without major dismantling of the pump.

All oil lubricated bearings shall have housings fitted with means of drainage, visual oil level indicator and capped filler or a constant level oiler which is accessible whilst the unit is operating. Grease lubricated bearings shall be connected to readily accessible greasing points either singly or at a battery plate. Lubrication should be by means of a pressure gun.

Where rolling contact bearings are used, they shall be sized to provide a minimum L10 life of 16,000 hours (as per ISO Standard 281/1) under conditions of maximum load on the bearings.

In the case of a close coupled pump, this requirement applies to the motor bearings. Replaceable case wear rings shall be fitted where diameters exceed 150 mm and replaceable impeller neck rings where diameters exceed 250 mm. All wear rings shall be a press fit on or in their respective component and positively locked against rotation.

Casing design pressure shall be at least 1.1 times the pump shut valve pressure with the pump operating at maximum possible inlet pressure. The pump casing and base plate shall be capable of withstanding all hydraulic forces, together with externally applied pipe moments and loads as stated in the technical particulars. The supplier shall state the pump's pipe load limitations.

The pump unit and all removable components greater than 10 kg in weight shall be fitted with suitable lifting lugs and eyes to facilitate all erection and maintenance tasks. Any special lifting tackle shall be supplied.

Suitable means, such as jacking screws, shall be provided to aid the separation of pump components; these shall be arranged so that no damage can be done to mating or sealing faces by their use.

The method of fitting the impeller to the shaft shall adequately center the component but allow its removal without risk of damage to either component. Torque shall be transmitted to the impeller by keying, other than in the case of a multistage vertical pump for which a collect drive may be acceptable. The main impeller nut or screw shall not have its thread exposed to the pumped fluid and shall either be locked or maintained tight by virtue of the normal direction of rotation.

The pump shafts shall be designed such that the first critical speed of the pump is at least 20% higher than the maximum speed encountered in service.

All rotating components shall be dynamically balanced and the complete pump shall comply with the requirements of the vibration section of this section.

Where two pumps are connected in parallel, the units shall be capable of reverse rotation under full pump head without sustaining any damage.

**2.1.11.4 Shafts, Seals and Couplings**

The pump shall be fitted, depending on its duty with a packed gland or mechanical seals of a reputable manufacturer, preferably of a pressure balanced type. The design of the unit shall allow the mechanical seal to be replaced or the gland to be repacked without disturbing the pump or driver.

Any leakage at the gland shall be intercepted by a flinger.



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All pump glands shall be provided with trays and guards to catch leakage. Piping shall be fitted for drainage to an approved location. Other than on small pumps (i.e. with driver less than 50 kW) auxiliary pipe work for seal harnesses, drains, etc., shall be not less than 20 mm bore.

Couplings shall be dynamically balanced and the couplings shall be match marked. Where a spacer coupling is used, the spacer shall similarly comply.

#### 2.1.11.5 Pump Materials

Materials of construction shall be selected with due regard to the corrosive nature of the pumped fluid and risk of corrosion, cavitation, and metal to metal galling that can occur within a pump in all its modes of operation. It is the Contractor's responsibility to select materials that shall provide an adequate service life.

### 2.1.12 Hydraulic Systems

Hydraulic systems shall fulfill the general safety requirements set forth in ISO 4413 or other relevant standards.

#### 2.1.12.1 Oil Pumps

Pumps for hydraulic systems shall be of the displacement type. Parallel to each pump or group of pumps operating in parallel, a relief valve of sufficient capacity to by-pass the full delivery of the pumps at a pressure only 10% above the maximum allowable working pressure shall be provided as a safety measure.

The pumps shall be provided with check valves and pressure switches for actuating the starting equipment. Hand operated valves shall be provided to isolate any pump from the hydraulic system and permit its removal without losing oil pressure.

#### 2.1.12.2 Oil Pressure Tanks

Oil pressure tanks shall be of welded construction, designed, constructed and tested in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII, part 1, for 1.5 times the maximum system operating pressure.

The welded joints of the tank shall be finished smooth. The welds shall not be ground to the extent that the tank is weakened structurally, but it shall be free of irregularities that would throw highlights when painted.

#### 2.1.12.3 Sump Tanks

The capacity of the sump tank shall, unless otherwise specified, not be less than that required to contain all of the oil that can be discharged back into the sump by completely discharging the oil in the system. The oil volume in the sump tank shall be sufficient to maintain the oil level within an adequate working level during operation.

- Oil sump tanks shall be provided with:
- Suitable access openings
- Fine mesh strainer(s) combined with a magnetic filter/plug which all oil returning shall pass. The strainer(s) shall be readily removable for cleaning.
- Humidity separating air filter.
- Flush mounted oil level indicator(s), covering most of the tank height.
- Capped filler hole with a suitable strainer



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- Drain connection with hand operated shut off valve.

Sump tanks shall be installed so that the bottom of the tank and the drain connection are at least 400 mm above the floor.

The interior of the tank shall be free of crevices, open joints, or dead-end holes, and all welds inside the tank shall be continuous. Oil sumps shall be made from stainless steel. The interior and exterior surfaces of any sump tanks not made from stainless steel shall be cleaned and painted as specified in these specifications.

### 2.1.12.4 Hydraulic Oil Piping

All main piping shall be seamless tubing with welded joints, approved couplings or steel flanges for bolted connections. All piping shall be thoroughly cleaned (removing all mill scale, weld deposits, etc.), oiled inside, painted on the outside as specified in these specifications, and protected for shipment by protectors on all flanges and plugs on pipe ends. If stainless steel piping is used, no painting is required, such piping requires couplings and fittings of identical material. All gate valves in the pressure lines shall be of the cast steel, solid wedge, rising stem, type with close guide clearances to minimize vibration of the gates when operating at partial opening. Piping shall be shop fabricated to the maximum extent possible, consistent with erection, handling and shipping requirements, so as to reduce field work.

Oil piping shall be completed with taps for oil sampling and pressure testing.

Adequate pipe supports shall be provided to prevent vibration and movement of the oil piping during sudden pressure changes. All necessary studs, bolts, nuts, washers, oil resisting seals, pipe supports, and hangers for field assembly of the oil pressure system shall be furnished.

## 2.1.13 Piping

### 2.1.13.1 General

Pipe work drawings shall be in accordance with ISO 6412.

Piping shall be arranged to facilitate access for maintenance and such that removal or replacement of Plant can be achieved with the minimum dismantling of piping. The design of piping shall be such as to minimize Site welding.

All pipes work 25 mm and below shall be stainless steel. All piping for cooling water system shall be Stainless steel unless otherwise specified or approved by the Employer. The piping shall have material combinations which avoids galvanic corrosion.

Provision shall be made for the draining and release of air in systems. Plugged drain and air release bosses shall be welded to pipes at appropriate points to facilitate hydraulic testing.

All interior water pipes shall be lagged with fiberglass lagging not less than 1” or equivalent as approved by the Employer.

Embedded pipe should be kept to a minimum. In preference to running pipe in covered floor trenches it shall be supported from walls and ceilings.

Floor collars or wall box shall be provided at all points where pipes pass through floors and walls. The floor collars shall have raised kerbs not be less than 75 mm in height. All wall boxes shall be sealed and flush fitting.



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The Contractor shall provide all necessary fittings for the passage of pipes through external walls and roofs, together with all necessary components for the protection against weather.

In the case of flanged pipe work, boxes shall be large enough to permit the passage of the flange.

### 2.1.13.2 Identification of Piping

The Contractor shall furnish and apply pipe identification markers on all piping systems. The markers shall be applied after all insulation and painting work has been completed. Each pipe shall be identified at each valve, at every point of pipe entry or exit where two or more lines go through a wall, at each tee joint, and on continuous lines, at least once in every unit block. A direction of flow marker shall be affixed downstream of each pipe identification marker. Markers shall be applied on the two lower quarters of the pipe where the view is unobstructed. The markers shall be of adhesive-coated vinyl cloth which shall be applied in accordance with the manufacturer's instructions and shall be white with black letters. Letters shall vary between 10 mm and 40 mm in height to suit the piping size. Pipe marker legends shall be designated by the Employer.

### 2.1.13.3 Welding

Pipe work welding, testing and inspection shall conform to the appropriate ASME and ASTM Standards and where applicable AWS.

### 2.1.13.4 Hydrostatic Testing

Except as precluded by shipment in parts for Site welding due to size, hydrostatic works tests shall be carried out by the Contractor on all casings, vessels, valves, pipes and other pressure fittings. Such tests shall be at 50% above the maximum operating pressure. The test pressure and date shall be stamped on all parts tested and certificates or written particulars of each test shall be supplied to the Employer.

In each case the pressure shall be maintained for a period of thirty minutes, the item under test remaining tight under the specified pressure.

All valves shall be tested for both "open end" and "closed end" conditions. All piping systems shall be hydrostatically tested at Site.

### 2.1.13.5 Pipe Supports and Anchors

Pipe work and accessories shall be supported and mounted in accordance with ANSI B31.1 Power Piping. All necessary slings, saddles, structural steelwork, foundation bolts, foundation inserts and plates, fixing bolts, locks and all other attachments shall be supplied.

No point of passage of pipes through floors or walls shall be used as a point of support.

### 2.1.13.6 Flanges

All pipe flanges, shall be in accordance with ISO 7005 Standard as applicable for the appropriate condition. Threaded pipe shall be in accordance with ISO 7 and ISO 228 as applicable.



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### 2.1.13.7 Jointing Material

Complete jointing material, bolts, nuts and washers shall be provided for flanged pipes, valves and fittings supplied under this Contract. Threads and other details of fasteners shall comply with ISO Standards. The quantities supplied shall include twenty percent excess to allow for wastage.

### 2.1.13.8 Internal Cleaning of Pipes

The Contractor shall ensure that the internal surfaces of all pipelines are thoroughly clean.

All internal surfaces prior to erection shall be cleaned to remove accumulations of dirt, rust, scale, and welding slag due to Site welding before erection.

Prior to and during erection, all parts shall be inspected to make sure that they are clean, and adequate steps shall be taken to prevent entry of foreign matter both during and after erection. Each section erected shall be cleaned out before the next section is connected to it. All headers shall be cleaned before closing up.

All ferrous oil pipe work shall be acid pickled and flushed with oil prior to erection. All pipe work after erection shall be flushed using the same fluid as for the system.

The Contractor shall provide all necessary facilities in the pipe system for cleaning including any temporary pipe work.

### 2.1.13.9 Pipe Terminations and Connections

The Contractor shall co-operate fully with other Contractors and the Employer to establish agreement on the jointing technique at terminal points.

All pipe connections shall be fusion welded except where flange connections are required or specified to facilitate erection or maintenance, or where pipe materials used preclude welding.

Screwed pipe work shall only be permitted for pipes of less than 50 mm bore in non-critical air or water services.

Below 25 mm bore connections shall be of flared connectors or welded cone nipple in positions where leakage shall not introduce any hazard and the type of coupling and particular application has been approved by the Employer.

Pipe work flanges shall comply with the requirements of the code to which the pipe work is designed. Flanges having ratings less than 10 bar g shall not be permitted except where agreed with the Employer.

All metallic pipe flanges either for high or low pressure or for high or low temperature shall be in accordance with ANSI/ASME B16.5, and other approved standards, as applicable for the appropriate condition.

All plastic pipe flanges shall be in accordance with ISO 2536 and 3663 and the other standards issued by Technical Committee 138 (TC138) of the International Organization for Standardization.

Jointing material, bolts, nuts and washers shall be provided where necessary for flanged pipes, valves and fittings supplied under this Contract.

In the case of cast iron flanges full face gaskets shall be used so that bending stresses shall not be induced in the flange by bolt tightening.

Jointing of thermoplastic piping shall be carried out in strict accordance with the Manufacturer's recommendation.

#### 2.1.13.10 Fluid Velocities in Pipes

The maximum allowable velocity of flow in pipes shall be as listed in the following table:

**Table 2-3: Maximum Allowable Flow Velocity in Pipes**

| Service | Maximum Allowable Velocity (m/s) |
|---|---|
| Compressed air | 15 |
| Cooling water | 3 |
| Lubricating Oil | 2 |
| All other pipe work | 0.6 m/s per 25 mm bore up to a maximum of 4.2 |

#### 2.1.13.11 Embedded Pipe Work

All service pipe work embedded in concrete shall be of stainless steel.

### 2.1.14 Valves

#### 2.1.14.1 General

All valves shall comply with the relevant ISO Standards.

All valves shall be arranged so that the hand wheel moves in a clockwise direction to close the valve. The face of each hand wheel shall be clearly marked with the words "open" and "closed" and shall be provided with an arrow to indicate direction for opening and closing. As far as possible, valves shall not be fitted in an inverted position.

All valves shall be readily accessible for both operating and maintenance and, where necessary for ease of manual operation, the spindles shall be extended and an approved form of pedestal hand wheel provided at convenient operating floor or intermediate floor level. Pedestals shall not be mounted on checkered plate cover or floor gratings.

All hand operated valves shall be capable of being opened or closed against their maximum working pressure with a force at the hand wheel not exceeding 200 N.

Valves of 100 mm nominal bore and above shall be provided with valve position indicators. All valves shall be fitted with labels showing duty and identification number.

All hand wheels shall be of metal. Bonnets and valve covers shall be bolted in position, not screwed.

Valves used for isolation purposes shall not be smaller than the pipeline size.

Where appropriate all valves of 250 mm bore and above other than drain valves shall be provided with by-passes connected to the valve body.

A complete valve schedule for each pipe work system shall be provided for approval.

Parallel slide or gate valves shall be used for isolation purposes for water, oil and gas services. In general valves shall not be used for throttling service. Flow control shall be achieved by stainless steel orifice plate mounted between flanges for ease of adjustment. To the approval



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of the Employer needle valves shall be used for throttling services in special cases. Butterfly valves shall be used for application of 200 mm diameter and above.

Parallel slide or gate valves shall be such that the bore of the fully open valve is unobstructed by any part of the gate.

Non-return valves shall be of the non-slam type. Safety relief valves shall be of the pop action type.

### 2.1.14.2 Parallel Slide, Gate and Sluice Valves

Parallel slide and gate valves shall be used generally for isolating purposes. The valves shall be of the full way open type unless approved to the contrary and when in the fully open position, the bore of the valve shall not be obstructed.

Where applicable bypasses and equalizing pipes shall be fitted to parallel slide and gate valves in accordance with the following table:

**Table 2-4: Use of Parallel Slide and Gate Valves**

| Valve type | Pressure Range | Valve Size |
|---|---|---|
| Parallel slide only | 0 to 19 bar g | 250 mm and above |
| Parallel slide and gate valves | 19 to 65 bar g | 200 mm and above |

For potable water supplies, sluice valves shall be cast iron wedge gate valves with bronze trim in accordance with BS 5163 or equivalent approved standard. The valves shall be of solid wedge gate type. The valve bodies shall be of the best quality cast iron complying with BS 1452 (Grade 14). Valve seals and facing rings shall be zinc free bronze or gunmetal and spindles of manganese bronze. The valve gates shall be provided with bronze guide shoes and locating channels where necessary to oppose unbalanced forces during opening and closing. The spindles of valves subject to unbalanced pressures during operation shall also be provided with ball thrust collars to reduce the turning effort required. The ball bearings shall be contained within totally enclosed grease packed housings with seals to prevent the ingress of dust and moisture.

Large bore wedge gate valves are to be provided with easing screws and a suitable flushing connection, complete with valve, which shall be fitted at the valve sealing to facilitate removal of any dirt preventing complete closure.

Gate valves to be used for seawater shall have the body and internals manufactured from materials as specified in this Specification.

### 2.1.14.3 Globe Valves

Globe valves shall generally be used for regulating purposes. The valve shall have radiused or spherical sealings and the disc shall be free to revolve on the spindle. An arrow indicating the direction of flow through the valve shall be clearly cast or embossed on the body of each valve.

Globe valves shall comply with BS 5154 or BS 5160 or equivalent as might be applicable to the particular installation requirement.



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### 2.1.14.4 Safety Relief Valves

Pressure relief valves shall be of the spring-loaded type unless otherwise specified, or unless the Employer has given written permission for the use of a different type of valve actuation.

Safety valves shall comply with BS 6759 or equivalent.

Spring loaded valves shall be fitted with easing gear which shall not be extended.

Where necessary relief valves shall be supplied with vent pipes, silencers and drains, and with gagging equipment for hydraulic testing following erection and in the long-term maintenance of the plant.

### 2.1.14.5 Butterfly Valves

Butterfly valves shall have bodies of either the flanged or lugged wafer type. The actuator/manual gearbox shall be mounted direct to the valve body, other than where both actuator and body are fitted with feet for pedestal mounting; no actuator loads shall be transmitted via the pipe work. The valve should be mounted with spindle set horizontal. If the valve is designed for unidirectional flow, an arrow shall be cast or embossed in a prominent position on the valve body to indicate that direction.

The valve shall be capable of positive shut off in both directions against full system pressure. Unless an alternative type is proposed by the Contractor and approved by the Employer as being fully suitable for the particular duty, the seating of the disc shall be positive (that is, the disc shall not be capable of passing through the shut position); a stop fitted on the actuator/operating level is not adequate for this purpose.

Unless the Contractor can demonstrate that some alternative design is capable of adequate long-term sealing, the design shall be such that the shaft is offset from the seal ring. That is, there shall be an unbroken peripheral seal when the valve is shut.

Internal shaft bearings shall be capable of operating dry, that is, not dependent on the presence of the pumped fluid.

In the case of butterfly valves for potable water supply mains, they shall be of cast iron resilient seal construction and in accordance with BS 5155 or an equivalent approved standard.

Each valve body shall be of best quality cast iron conforming to BS 1452 (Grade 14 or 17) with a closure sealing of bronze or stainless steel, or the resilient seal material. The valve disc shall be of high-quality cast iron with the seat facing of bronze, stainless steel or the resilient seal material.

The disc shaft is to be of stainless steel to ASTM 316L. Shaft bearings shall preferably be of the self-lubricating type, with "O" ring seals.

The actual position of the valve disc shall be clearly shown by an external indicator.

Besides mechanical operation tests, each valve shall be subjected to a body pressure/leakage test and strength/leakage test.

### 2.1.14.6 Float Valves

Float valves should be of the equilibrium ball float type. Floats for cold water duty shall be plastic, of a grade that does not deteriorate in sunlight. All operating rods, guides, brackets and covers shall be of non-ferrous material.

Float valves operating in liquids other than fresh water shall be of materials to the Employer approval. Float valve shall comply with BS 1212 or equivalent and be complete with float rods, guides, covers and brackets where required.

### 2.1.14.7 Non-Return Valves

For severe service conditions, cushioned check valves shall be used. Cushioning piston and valve disc area shall be as nearly equal as possible to produce balance and obviate valve clatter.

Swing check valves shall have facilities for quickly examining the clack. The body seat shall be inclined at such an angle from the vertical as shall facilitate closing and prevent clatter, and the clack shall be arranged to possess a movement in favor of closure increasing in the final stages of the swing. The clack shall be secured to the hinge in a manner which allows for the self-seating of the clack. Counterpoise devices and dashpots shall not be used except when specifically approved by the Employer. Where solids are liable to hazard operation of the valve, due precautions shall be taken.

All non-return valves shall be provided with means of draining the space between the valve and its adjacent isolating valve. The design shall preclude the possibility of the valve jamming in the open position; the effect of solid particles settling out in dead spaces within the valve should be recognized in this respect. Where screw down non-return valves are supplied, they shall provide a demonstrable leak tight joint.

Unless stated to the contrary, non-return valves should be rapid closing. Power assisted closing is acceptable where necessary for rapid shut off. For large non-return valves on air and water services, consideration shall be given to the consequences of valve slam and the possible requirements for a hydraulic snubber to minimize slam effects.

### 2.1.14.8 Pressure Reducing Valves and Relief Valves

Pressure reducing valves shall be of the external pilot valve operated type capable of passing the required total flow while operating over the same head range as the turbine. The minimum discharge head shall include a generous margin to overcome the total losses of the raw water system and discharge to the tailrace. It shall be complete with all necessary fittings. The pressure reducing valve shall be designed to close reliably on cessation of flow. A relief valve shall be provided, designed to open at 10% overpressure and pass full flow at 25% overpressure.

### 2.1.14.9 Power Operated Valve General Requirements

Valves, dampers and similar devices requiring abnormal physical effort to operate or high-speed operation, shall be provided with powered actuation. Hand operating equipment shall also be fitted for closing and opening, which is effectively decoupled during power operation.

The following criteria are preferred in the selection of the power source for the servo mechanism:

Isolation and other duties not subject to operation of more than once in 10 minutes - electrical, compressed air.

Continuous or intermittent modulation - compressed air, electro hydraulic.

Continuous or intermittent modulation involving heavy control forces likely to produce fluttering or hunting - electro hydraulic, electrical.

Emergency control or isolating duties - compressed air, spring loaded, or electro hydraulic with sufficient reservoir capacity to complete the operation without an external source.

Electric actuators for on/off duties shall be fitted with travel limiting devices capable of accurate and positive adjustment. Torque limiting or other devices shall be provided to prevent damage to the mechanism in the event of jamming of the driven device.

All powered valve or damper mechanisms shall be provided with accurate indication of the position of the driven device.

Electrically operated devices shall be provided with integral or separate switch/control equipment in accordance with the requirements of the Control and Instrumentation Specification. Provision shall be made for the inclusion of interposing relays and volt free contacts to suit modern control systems, including digital control systems.

Power supplies shall be in accordance with those specified in Electrical General Design Specifications.

Direct solenoid operation of valves shall comply with the requirements of the Control and Instrumentation Specification.

Reversing contactors and limit switches, used to control electric power-driven mechanisms, shall be robust and of proven reliability by both type test and commercial operation. Solid state switching shall be accepted when temperature conditions permit.

**2.1.14.10 Compressed Air Systems**

Compressed air systems shall fulfill the safety requirements set forth in EN-983 or other relevant standards.

Vessels shall be of the cylindrical, vertical type. The vessel shall be mounted on a structural steel base. Each vessel shall be equipped with the following provisions:

- Inlet sockets with valves
- Outlet sockets with valves
- Pressure safety valve
- Dial pressure gauges, one with four electric contacts or separate pressure switches
- Manhole or inspection hole
- Drain valve

In case the pressure vessel is used for pressurized oil or water systems, the vessel shall further be equipped with:

- One (magnetic) level gauge with shut off valves
- Level indicators with electric contacts in a number as required or specified

Each vessel has to pass a pressure test at 1.5 x nominal pressure lasting for 8 hours in the manufacturer's Workshop before coating is applied.

Each vessel shall be furnished with a test certificate of an independent, internationally reputable underwriters' society.

Compressors shall be provided with:

- Automatic lubrication
- Air intake filter and silencer
- Pressure Gauges



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- Thermometer for measuring temperature of the compressed air
- Automatic shut down if the discharge air temperature exceeds a predetermined adjustable value
- Unloading valves
- Water drains valves
- Water and oil separator
- Pressure safety valve
- Cooler for compressed air
- Non-return valve
- Inlet pressure valve
- Outlet pressure valve

The water and oil separator shall be equipped with an automatic solenoid operated drain valve to achieve automatic draining during standstill. Both compressor stages shall be equipped with unloader valves, which shall close time delayed after start to avoid compressor start against full pressure.

The compressors shall be delivered as package units on common frame with the appropriately sized AC squirrel cage motor and the respective motor control center ready for operation.

If requested by the Employer, each compressor shall pass a performance test in the manufacturer's Workshop according to ISO 1217 (DIN 1945), without extra cost. The ready assembled compressors, controls and switchgear have to pass a functional test.

### 2.1.15 Noise

The Plant shall be designed and constructed to operate within the following noise limits:

- Within the building or structure containing the Works not exceeding ISO 1996 level NR 90 between 62.5 and 8000 Hz.
- Within control rooms not exceeding ISO 1996 NR 50 between 250 & 2000 Hz. Noise levels shall be measured by the Contractor during commissioning of the Plant.

If the noise level of the Plant is found to be more than the specified limits, the Contractor shall take necessary measures and carry out any modification/additions to the Plant to meet the requirements of these Specifications.

### 2.1.16 Vibration and Balance

The amplitude of vibration of rotating Plant when measured on the bearing housings under steady state conditions at the designed operating speeds shall not exceed the values given by the 2.8 mm/s criterion of ISO 3945.

Provision shall be made for the reduction of vibration transmitted to covers, cladding, platforms and structures that are liable to vibrate. The vibration of any such radiating surface shall not exceed the values shown in Table 1-6**.**

**Table 2-5: Radiating Surface Vibration Limits**

| Frequency (Hz) | Peak-to-Peak Amplitude (mm) |
|---|---|
| 5 | 0.40 |
| 10 | 0.20 |
| 25 | 0.08 |



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| Frequency (Hz) | Peak-to-Peak Amplitude (mm) |
|---|---|
| 50 | 0.04 |
| 100 | 0.02 |
| 120 | 0.017 |

### 2.1.17 Painting and Protection

#### 2.1.17.1 General Design for Protective Coatings

Unless otherwise specified all Plant shall be painted using lead-free paints. The design and layout of the Plant shall be such that all surfaces can be recoated after erection.

Where corrosion resistant materials (e.g., concrete, galvanizing, copper, aluminum) are used no decorative finish shall be applied unless otherwise specified.

Surface preparation and protective coatings shall conform to SSPC.

#### 2.1.17.2 Painting

**a) Surface Preparation**

After fabrication, the Contractor shall clean and paint the Plant in accordance with this Clause and the paint schedule given in these Specifications. Painted surfaces shall be protected from abrasion or other damage at all times.

Surfaces to be painted shall be cleaned of all mill scale, dirt and other foreign substances by scraping, chipping, blasting, wire brushing or other effective means in accordance with the applicable sections of SSPC Specification. All oil and grease shall be removed from the surfaces. In the event that rust forms or the surfaces otherwise become contaminated in the interval between cleaning and painting, the surfaces shall be recleaned. Surfaces of stainless steel, bronze and machined surfaces shall be protected by effective masking during the cleaning and painting of adjacent metal work.

**b) Application Procedures**

Paint and coating materials shall be in a thoroughly mixed condition at the time of application. If necessary, to improve application properties, the paint shall be heated by means of a hot water bath to a temperature not exceeding 40°C. Paint other than primer shall not be thinned. Priming paint shall be thinned if necessary to improve application qualities but shall be thinned only with mineral spirits not exceeding 1 part of thinner per 8 parts of paint. Paint shall not be applied when the temperature of the metal or of the surrounding air is below 10°C or is above 40°C. Surfaces shall be free from moisture at the time of painting. The first coat shall be applied immediately after cleaning. All paint shall be applied strictly in accordance with the manufacturer's instructions. When paint is applied by spraying, suitable means shall be provided to prevent segregation during the painting operations. Means shall be provided for removing all free oil and moisture from the air supply lines of all spraying and blasting equipment. Different colors or shades shall be used for each coat. Each coat of paint shall be free from runs, sags and missed areas and shall be allowed to dry and harden thoroughly before the succeeding coat is applied.



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**c) Painting Schedules**

Painting schedules are given in these Specifications. The make of paints to be used shall be selected by the Contractor. The Contractor shall submit his proposed paint schedules together with applicable paint specifications for approval. Surface preparation shall be done in accordance with the methods specified in the paint schedules given in these Specifications.

### 2.1.17.3 Metallic Coating Galvanizing

All punching, cutting, drilling, screw tapping and removal of burrs shall be completed before galvanizing.

All galvanizing shall be done by the hot dip process with spelter, not less than 98% of which shall be pure zinc. Subject to the approval of the Employer, where an item is of a size or shape to render hot-dip galvanizing impracticable, zinc spraying or other approved method of coating shall be adopted. Common bolts shall be completely galvanized including the threads, but the threads shall be left uncoated in the case of nuts. High tensile steel bolts shall not be galvanized.

The zinc coating shall be uniform, clean and smooth. The zinc coating shall weigh not less than 400 g/m² of area covered and be not less than 0.060 mm in thickness.

Galvanized wire shall comply with the requirements of ASTM A641 a. Nuts and bolts and small components shall be coated in accordance with ISO 1461.

All galvanized parts shall be protected from injury to the zinc coating during the periods of transit, storage and erection. Damaged areas of the coating less than 50 mm² shall be cleaned back to bright metal, feathering the edge of the surrounding galvanized coating, and touched up with zinc-rich paint. Parts which have suffered greater damage shall be re-galvanized.

**a) Metal Spraying**

Surface preparation prior to metal spraying shall be dry grit blasting SA 2½.

Immediately after grit blasting the surface shall be cleaned of any traces of blast product on the surface and in pockets, pits, and corners by brushing with clean brushes, blowing with dry compressed air or vacuum cleaning.

The surface shall be coated with the metal spray before discoloration occurs.

**b) Chromium Plating**

The chromium plating shall comply with the requirements of ISO 2081.

### 2.1.17.4 Color

The Contractor shall submit, for the approval of the Employer, within 266 days after the date of the Letter of Acceptance of the finish colors for the individual items of Plant.

Pipework shall be identified by a color banding code. The Contractor shall submit, for the approval of the Employer, of the code as it is applicable to this Contract within 266 days of the Letter of Acceptance.

### 2.1.18 Witnessing of Shop Assemblies and Tests

The shop assemblies and tests specified for the various items of equipment shall be witnessed by a representative(s) of the Employer and the Contractor and the completed shop inspection

and test forms showing the results shall be signed by both parties. Copies of all shop inspection and test records shall be furnished to the Employer. No equipment shall be shipped from the shop until it has been inspected and tested, or the Employer has waived the inspection in writing. However, the waiver of any test or the witnessing of shop assemblies and tests by the Employer shall not constitute a release of the Contractor's responsibility to meet fully the requirements of this Contract. A minimum of sixty (60) days prior to major shop assemblies and tests, the Contractor shall submit an outline of the procedures and tests it plans, to demonstrate fulfillment of the requirements specified in subsequent Sections of the Specification for the equipment. Target dates for shop assembly and tests shall be included in the Program, projecting dates for shop tests far into the future.

### 2.1.19 Tools and Spare Parts

#### 2.1.19.1 Tools, Wrenches and Lifting Devices

Prior to shipment Contractor shall furnish and deliver to the Employer a complete set of any specialized tools, fixtures, devices, slings, lifting devices, appurtenances, or other equipment that shall be required or convenient for the most expeditious assembling, dismantling and maintenance of the equipment supplied under this Contract.

The Contractor shall permanently label all specialized tools and devices to indicate their purpose and the equipment on which they are to be used. All custom tools and devices shall be accurately machined to fit the parts to be handled. The tools shall be supplied in a neat metal toolbox or cabinet or on a neat tool board with each item marked clearly for identification.

Special installation tools, fixtures, lifting devices, jacks, spiders and appurtenances for parts which cannot be removed after installation shall be furnished as part of the Contract.

#### 2.1.19.2 Spare Parts

All spare parts shall be interchangeable with and be of the same materials and workmanship as the corresponding parts of the original equipment furnished.

All mandatory spare parts for the equipment shall be provided as mentioned in the relevant sections of these specifications. However, the Proposer shall submit list of any other spare parts (which in the opinion of the Proposer) are necessary for plant as per recommendation of the equipment supplier(s).

All spares furnished shall be new and interchangeable with the corresponding original parts. They shall also be of the same material and workmanship, and shall have all the features and provisions of the corresponding original parts. Second-hand spare parts shall be rejected.

All spares are to be suitably treated and packed for long storage under conditions prevailing at the Site. Each spare shall be clearly marked or labelled on the outside of its packing with description and purpose, and, when more than one spare is packed in a single case, box or container, an inventory is to be shown on the outside of same, and a detailed list enclosed inside. All cases, containers, boxes and other packages shall be suitably marked and numbered for purposes of identification.

The Contractor shall manufacture the spare parts and deliver them to Site at the same time as the rest of the Plant. Spares shall be handed over to the Employer not later than at the date 30 days prior to the start of the final performance tests.

Spare parts catalogues and/or necessary drawings with item lists shall be supplied giving all necessary data for ordering spare parts directly from the manufacturers. The spare parts



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catalogues shall include data on complete modules and assemblies as well as sub-modules, sub-assemblies and individual components. The drawings shall show the location, main dimensions and the ways of disassembly or assembly of the various spare parts.

The Proposer shall recommend additional spare parts required for five years of plant operation. Moreover, the Proposer shall also confirm the manufacturing/availability of spares till next 20-25 years and shall provide them on demand.

## 2.2 GENERAL HYDRAULIC STEEL STRUCTURE

The Hydraulic steel structures included in scope of work shall conform to the following basic requirements and specifications.

### 2.2.1 Design & Stress Levels

#### 2.2.1.1 Gates

a) Various components of the gates and embedded parts shall be designed in accordance with the provisions ASTM, DIN, BS or US Corps manual or equivalent International Standards. The horizontal girders and wheels/guide shoe shall be so spaced that they carry equal load (approximately).

b) Loads to be considered for design:

i. The gate shall be designed for the hydrostatic head corresponding to upstream maximum surge levels

ii. The design of gates shall be checked for the combination of design head and earthquake effect in accordance with ASTM, DIN, BS or US Corps manual or other equivalent International Standards Criteria for Earthquake Resistant and the Building Code of Pakistan for Design of Structures. Allowable stresses in this case shall be increased by 33.3% subject to an upper limit of 85% of Y.P.

#### 2.2.1.2 Stoplogs

a) The stoplogs for flushing and power intake shall be designed for head corresponding to Max. Water Level.

b) Various components of stoplog and embedded parts shall be designed in accordance with the provisions of ASTM, DIN, BS or US Corps manual or other equivalent International Standards.

c) The design of stoplog shall be checked for the combination of hydrostatic head and earthquake effect in accordance with DIN, BS or US Corps manual or other equivalent International Standards Criteria for Earthquake Resistant and the Building Code of Pakistan for Design of Structures. Allowable stresses in this case shall be increased by 33.3% subject to an upper limit of 85% of Y.P.

#### 2.2.1.3 Trash rack

a) The trash racks for power intake shall be designed for head corresponding to Max. Water Level and as per turbine manufacturer.

b) Various components of trash rack and embedded parts shall be designed in accordance with the provisions of ASTM, DIN, BS or US Corps manual or other equivalent International Standards.



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c) The design of trash rack shall be checked for the combination of hydrostatic head, vibration analysis and earthquake effect in accordance with DIN, BS or US Corps manual or other equivalent International Standards Criteria for Earthquake Resistant and the Building Code of Pakistan for Design of Structures. Allowable stresses in this case shall be increased by 33.3% subject to an upper limit of 85% of Y.P.

**2.2.1.4 Hydraulic Servomotor Hoists**

Various components of hydraulic hoist such as cylinder, piston, rod, shafts, keys, bearings and coupling etc. and their design shall meet the requirements of ASTM, DIN, BS or US Corps manual or other equivalent International Standards.

Bolts, nuts and screws used shall conform to relevant ASTM standards. Bolts and screws in rotating parts shall be locked. Bolts in tension shall be avoided as far as possible. Wherever necessary, net section of such bolts at the root shall be increased by 15%. These shall be of the size rated for the shafts to which these are connected and shall have torque rating suitable for the loads transmitted. These shall be of flanged type fully enclosed and dust proof.

**2.2.1.5 Gantry Cranes (For Stoplog and Gates)**

Various components of this equipment shall be designed in accordance with provisions of ASTM, DIN, BS or US Corps manual, FEM, CMAA or other equivalent International Standards. Capacities of these shall be 125 percent of all the forces opposing the hoisting with loads intended to be handled.

**2.2.1.6 Lifting Beams**

The lifting beam for stoplogs, trash rack and draft tube gate shall be designed in accordance with provisions ASTM, DIN or US Corps manual or other equivalent International Standards.

**2.2.2 Permissible Stresses**

**2.2.2.1.1 Gates (Power Intake, Flushing Intake and Draft tube)**
The permissible stresses shall be taken those corresponding to wet inaccessible conditions as per ASTM, DIN, BS or US Corps manual or other equivalent International Standards and are given as under:

Structural Steel - Wet & Accessible condition

| Type of Stress | Permissible Stress |
|---|---|
| i) Direct Compression/tension | 0.45 Y.P. |
| ii) Compression/tension in bending | 0.45 Y.P. |
| iii) Shear | 0.35 Y.P. |
| iv) Combined | 0.55 Y.P. |
| v) Bearing | 0.45 Y.P. |

**2.2.2.2 Stoplogs (Power Intake, Flushing Intake)**

As these shall be stored above water level and shall be occasionally used, permissible stresses shall be taken corresponding to Dry-accessible conditions as per ASTM, DIN, BS or US Corps manual or other equivalent International Standards and are given as under:

Structural Steel - Dry & Accessible conditions



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| Type of Stress | Permissible Stress |
|---|---|
| i) Direct Compression/tension | 0.55 Y.P. |
| ii) Compression/tension in bending | 0.55 Y.P. |
| iii) Shear | 0.40 Y.P. |
| iv) Combined | 0.75 Y.P. |
| v) Bearing | 0.75 Y.P. |
| vi) Bearing Stress - Bronze on Steel | 0.04 U.T.S. |

### 2.2.3 Materials

All materials incorporated in the equipment shall be new, unused and of first-class quality, free from defects. Materials and Proprietary items shall be selected taking into consideration customary use for type and class of equipment having regard to strength, the durability and best engineering practice.

As a general guidance, materials used for various items of gates and hoists are given as under:

#### 2.2.3.1 Gates (Power Intake, Flushing Intake and Draft Tube)

**Table 2-6: Gates Material Standards**

| Sr. No. | Component Part | Material | Material Standard (Latest) |
|---|---|---|---|
| (i) | Structural parts of gates i.e. skin plate, horizontal girders, end vertical girders, Vertical stiffeners, seal bases, seal clamps, guide shoes, etc. | Structural Steel | ASTM or DIN or BS |
| (ii) | Wheel track bases, seal seat, bases, Sill beam base, guides, anchor bolts etc. | Structural Steel | ASTM or DIN or BS |
| (iii) | Guide Shoe | Structural Steel | ASTM or DIN or BS |
| (iv) | Seals - 44 mm dia. (Hollow) | EPDM rubber | DIN, BS or ASTM |
| | (a) Side | Music Note type | |
| | (b) Bottom | Wedge Type | |
| (v) | Wheel track and Seal Seats | Corrosion Resistant Steel | 30 Cr 13 for Track 04 Cr 18 Ni 10 for seal seat |

#### 2.2.3.2 Stoplogs (Power Intake, Flushing Intake)

**Table 2-7: Stoplog Material Standards**

| Sr. No. | Component Part | Material | Material Standard (Latest) |
|---|---|---|---|
| (i) | Structural parts of stoplogs i.e. skin plate, horizontal girders, end vertical girders, | Structural Steel | ASTM or DIN or BS |



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| Sr. No. | Component Part | Material | Material Standard (Latest) |
|---|---|---|---|
| | vertical stiffeners, seal bases, seal clamps, guide shoes, etc. | | |
| (ii) | Track bases, seal seat bases, Sill base, guides, anchor bolts, etc. | Structural Steel | ASTM, AISI or DIN or BS |
| (iii) | Tracks, seal seats | Corrosion Resistant Steel | 04 Cr 18 Ni 10 AISI |
| (iv) | Seals - 44 mm dia. (Hollow) | EPDM Rubber | ASTM |
| | (a) Side | Music Note Type | |
| | (b) Bottom | Wedge Type | |
| (v) | Thrust Pad | Structural Steel Cladded with Bronze (Min.10 mm thick) | ASTM |

**2.2.3.3 Hydraulic Hoists and Gantry Cranes**

Materials for various components of the equipment shall conform to provisions of ASTM, AISI, DIN, BS or US Corps manual, FEM, CMAA or other equivalent International Standards.

**2.2.4 Embedded Frames for Guides**

Wheel paths, seal path and guide tracks shall be provided up to following heights:

Guide Tracks : Full range of gate/stoplog travel
Seal Paths : Sill level to one gate height or up to lintel seal.

For installations of embedded parts in 1st stage block-out, suitable and adequate number of anchor bolds welded to first stage anchor plate shall be provided to align and level embedded parts and retains them during concreting. Necessary stainless-steel sealing faces and corrosion resistant roller/wheel paths machined accordingly shall be provided. The spacing of first stage embedded parts (anchor plate) shall be not more than 500 mm.

**2.2.5 2.1.24 Shop Assembly & Testing**

All equipment fabrications and structures covered by the specifications shall be fully assembled in Manufacturer's shop for inspection by Purchaser to the extent necessary to demonstrate matching of structural components. All necessary adjustments shall be made in the shop to achieve the specified tolerances. Checks on dimensions and tolerances shall be recorded by Manufacturer and three (03) copies furnished to Purchaser within a week of shipment of the material.

Without limiting the foregoing, the following shop assemblies shall be carried out.

The gate components such as

- Wheel assemblies (in case of fixed wheel type gates);
- Hydraulic Servomotor Hoist
- The electrical control panels, starter, contactors, position indicators etc.



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Prior to dismantling, each assembly shall be permanently and clearly match marked in the shop to facilitate site erection. Dismantling shall be done only to the point required for shipping. In particular there shall be minimum disconnection of electrical wiring.

Employer will inspect all equipment during fabrication and before shipment and witness the shop tests after final assembly.

#### 2.2.5.1 Gate Frames

The metal work shall be shop assembled to the extent necessary to ensure that all parts are properly fitted and that the dimensional and tolerance requirements shown on the drawings have been obtained. All holes for field connections of parts furnished under these specifications shall be drilled or reamed as noted on the drawings, with the embodiments so assembled. Members to be shop-riveted shall have all parts well pinned up and drawn together with bolts before riveting is commenced.

#### 2.2.5.2 Gates

Each component of gate and stoplog shall be assembled in the shop to the extent necessary for inspection and to ensure that all parts fit properly and that dimensions. Clearances and tolerances required in the specifications and drawing has been achieved. Holes for field connections shall be carefully drilled or reamed. Connections which have to be disassembled for shipment shall be made by the use of erection pins, one size less in diameter than the designed size or temporary machine bolts.

Proper functioning / operation of filling in valve and lifting beam, automatic engaging / disengaging shall be checked during shop assembly.

#### 2.2.5.3 Hoists

All electrical and mechanical components shall be tested in accordance with the appropriate applicable standards at either the Maker's or equipment manufacturer's works or tests certificate provided.

The hoist shall be assembled in the shop to the extent necessary to ensure that all parts are properly fitted. Surfaces of metal which will be in contact shall be cleaned before the parts are assembled. The parts shall be adjusted to line and fit and shall be well pinned and bolted so that the surfaces are in close contact before reaming, drilling, riveting or welding is commenced. Drifting done during assembly shall be only that is necessary to bring the parts into position and not so much as to enlarge the holes or distort the member, if any, hole shall be enlarged to admit fastening, it shall be reamed. The field connections shall be fitted and checked in the shop to assure proper fit during field erection.

After shop assembly the hoist shall be tested at manufacturer's works in accordance with relevant Standards. The manufacturer shall supply all material equipment and labour required for shop assembly and tests and cost thereof shall be included in the Proposal price.

All shop tests shall be made in the presence of the Purchaser or his representative. The hoist shall be prepared for shipment in as large units as practicable. One print of a diagram of match marks shall be enclosed with the shipment and four prints shall be forwarded to the Employer.

#### 2.2.5.4 Place of Manufacture and Inspection

The contractor shall intimate the place of manufacturer, testing and inspection of the various portions of the work. Authorized representative of the Purchaser may be present at the time



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of any or all tests and the Manufacturer shall provide all necessary facilities for the same. Representatives of the Purchaser shall also be entitled to access to Manufacturer's sub-contractors work at any time during the working hours for the purpose of inspecting the manufacture of equipment and materials.

To satisfy himself that the materials and equipment comply with the Conditions of Contract, the Purchaser reserves to himself the right of having at his expense, any inspection or tests of a reasonable nature carried out in addition to the routine tests specified in the relevant Standards.

#### 2.2.5.5 Inspection

All materials furnished shall be of tested quality and all work performed shall be subject to rigid inspection and no articles or materials or supplies shall be dispatched until all tests, analysis and shop inspection have been completed or certified copies of reports or results of tests and analysis shall have been accepted. Duplicate copies of manufacturers test certificate shall be submitted to the Purchaser as soon as the tests are completed. In case tests certificate are not available for any of the materials, the same may be got tested and only those materials which fulfill the requirements of the specifications shall be used.

From any part/item, it should be possible to locate its manufacturer Batch/Lot mark, which shall be achieved by transferring the batch mark before parting the materials.

All supplies (which include without limitation raw materials. components. intermediate assemblies and assemblies and end products) shall be subject to inspection and test by the Purchaser to the extent practicable at all times and places. If any inspection or test is made by the Purchaser in the premises of the Manufacturer or subcontractor, the Manufacturer without additional charge shall provide all reasonable facilities and assistance and the safety and convenience of inspectors in the performance of their duties.

### 2.2.6 Site Testing & Commissioning

#### 2.2.6.1 Operational Tests

a) The Manufacturer shall carry out in the presence of Purchaser such tests on the equipment to determine that the same will fulfill the functions for which they have been designed. The tests shall be carried out in accordance with applicable standards. Tests shall be repeated, if necessary, until successfully carried out to the satisfaction of the Purchaser. Leakage tests and operational tests shall be carried out after completion of other portions of the work at upstream maximum water level.
b) For hoists a proper testing procedure/ document shall be submitted for Employer approval before tests shall be carried at site after erection.

#### 2.2.6.2 Dry Test

Operational tests in dry shall be carried out as soon as possible after completion of erection and all controls and permanent power supply have been connected. The tests shall include at-least two complete traverses from the maximum raised position to the full sealing position. All adjustments, clearances, brakes etc. shall be checked for proper and smooth operation.



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#### 2.2.6.3 Wet Test

These tests should simulate the actual operating conditions as closely as possible. At-least two complete traverses will be made from the fully closed position to the fully raised position as follows:

a) When gate is closed, raise gate to its fully open position in steps and observe the performance including vibration.
b) Lower the gate to the full closed position in steps and observe the performance of the gate vibration.
c) Checkup operation of limit switches.

#### 2.2.6.4 Leakage Tests

Leakage tests shall be carried out with the gate resting on to the sill. Before measuring the leakage, the gate shall be raised and lowered several times by about 20 to 40 cm or so in order to dislodge any debris that may have lodged in the side seal seat. The leakage shall then be measured and recorded. The maximum leakage past the seals shall not be more than 15 liters per min. per meter length of seal under maximum head conditions.

#### 2.2.6.5 Final Acceptance

Final acceptance of the equipment shall be based on the following:

a) Quality and workmanship of the equipment including dimensional accuracy.
b) Satisfactory operation of the equipment after erection as required under these specifications.
c) Acceptance of various tests or test certificates by the Purchase.

All tests may be witnessed by the Manufacturer or his authorized representative. On successful completion of all tests the equipment shall be accepted but all the responsibilities shall remain with the Manufacturer within the guarantee period.

The labour and material for the field tests shall be provided by the Contractor. The test load and necessary lifting tackles shall be provided by the Purchaser and Contractor respectively.

#### 2.2.6.6 Guarantee

Within one year after issue of Certificate of Completion if any part of the gates, embedded parts, hoists etc. are found defective because of workmanship or material or otherwise the Manufacturer shall, at his own expense furnish and install new parts and materials approved by the Purchaser.

### 2.2.7 Welding Procedure

#### 2.2.7.1 Preparation

The edges of plates and shapes to be joined by welding shall be properly formed to suit the type of welding selected. Where plates and shapes have been sheared edges to be joined by welding shall be machined or chipped to sound metal. Plates and shapes to be field welded shall have their edges prepared in the shop for the type of weld selected.

Where bending or forming of plates or shapes is required, the plates or shapes shall be bent by cold forming. Heating and hammering to correct bends will not be permitted.



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### 2.2.7.2 Welding

**a)** Members to be joined by welding shall be cut accurately to size, and where required, shall be rolled or pressed to proper curvature in accordance with the approved drawings. The dimensions and shape of edges to be joined shall be such as to allow thorough fusion and complete penetration and plates shall be planned, if necessary, to accomplish this result. Members to be welded together shall be in sufficiently intimate contact at the time of welding so that members will not be forced more closely together with the cooling of the weld, thus setting up additional strains and distortions in the weld and parent metal.

**b)** The surfaces of plates to be welded shall be free from rust, grease and scale for a distance of 12 mm back from the welding edge at the time of welding. Flame cutting may be used in the preparation of the various members provided the operation is performed carefully, and the edges so cut are cleaned thoroughly after being cut so as to expose clean metal.

Any contour irregularities at points of critical stress shall be removed by grinding.

**c)** Welding Technique Care shall be taken in designs that the welds when being made are well accessible. Overhead welding is to be avoided, if possible and flat position welding is to be strived for. Drawings should clearly indicate the joint position, or field welding, kind of welding, method of welding, welding sizes and other required information/data. Symbols to be shown on the drawing would conform to relevant Standards. All welding shall be done by the electric arc method by a process which will exclude the atmosphere from the molten metal, except where otherwise specifically permitted. All welding electrodes required shall be furnished by the Contractor. Correct selection of electrodes shall be done taking due care of welding method and base metals of components to be welded. The welding electrodes shall be of heavily coated type designed for all position welding. The make, type and size of all welding electrodes shall be subjected to the approval of the Purchaser. In assembling and during welding the component parts of built-up members shall be held in place by sufficient clamps or other adequate means to keep all parts in proper alignment and position.

Radiographic tests shall be carried out for all critical full-strength butt welds.

**i. Butt joints**

In principle, butt joints shall be made with back-run. Backing strap should be placed and welding should be so made that the molten metal fully penetrates and a full penetration is achieved. Dye-penetration test shall be carried out after each pass of the weld. Radiographic testing of butt welds shall be carried out to the extent required by the Purchaser.

**ii. Fillet Joints**

All fillet welds shall be continuous. For the main member, no fillet welding should be made on members whose thickness differs substantially. Fillet weld at T Joints should be made, as a rule, on each side of the joint unless it is otherwise agreed due to some practical reasons. Radiographic test is not normally required for fillet welds. All the fillet welds shall be checked by Dye Penetrant Test by the Manufacturer in the shop. However, 20% to 30% of fillet welds shall be checked by dye-penetrant test in presence of Purchaser to check soundness of weld.



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At Welded butt joints, where the weld material is required to be deposited on both sides of the joints, the weld shall be chipped or melted to obtain a clean surface prior the application of the first head of the welding on the opposite side of the joint. Where fillet welds are used, the lapsed sections shall fit closely and shall be held together during the welding operation. When weld metal is deposited in two or more layers, each layer shall be brushed with a wire brush or otherwise cleaned before subsequent layer is deposited. In welding, precautions shall be taken to minimize stresses due to expansion or contraction either by preening the welds while hot, or by other satisfactory methods and also by using the proper sequence in welding. Correction of distortion by blows after welding is completed and the place is cold will not be permitted. Upon completion, the welds shall be brushed with wire brushes and shall show uniform section, smoothness of weld metal, feather edges without excessive overlaps and freedom from porosity and clinkers. Visual inspection at edges and ends of fillets and butt joints welds shall indicate good fusion and penetration into base metals.

**d) Welding Process**

All specification of the welding process that is proposed to be used shall be established and recorded and if required, a copy of such specification together with a certified copy of report for results of tests made in accordance with the process and specifications shall be furnished. The qualification of the welding process shall be at least equal to that required by 'Standard Qualification Procedure' of the ASME Standards and the minimum requirement of the tests shall be at least as stated in the said 'Standard Qualification Procedure':

**e) Qualification of Welders**

The Manufacturer shall be responsible for the quality of the work performed by his welding staff. All welders assigned to the work shall have passed qualification tests for welders. If at any time the work of any welder appears questionable, welder shall be required to pass additional qualification tests to determine his ability to perform the type of work on which he is engaged.

### 2.2.8 Surface Preparation & Painting

#### 2.2.8.1 General

a) The Manufacturer shall provide as part of his supply the surface treatment, priming, corrosion protection and painting of the equipment furnished. Such work shall include the coating and painting work at the workshop and at the site up to and including the finish painting. Unless otherwise specified the coating and painting shall be carried out in accordance with provisions of DIN, BS and ASME Standards. All paints, painting material and accessories for painting shall be included in the price Proposal. All finished and unfinished surfaces of metal work (other than of aluminum brass, bronze or stainless steel) except screw threads, mating surfaces, sliding surfaces, rolling surfaces shall be cleaned and protective coatings applied as specified in the above-mentioned Standard.

b) All paints and painting material shall satisfactorily fulfill the requirements imposed by the site conditions, as well as the stresses to which the respective equipment is subjected during operation of the works. Shades of the finishing coatings shall be as approved by the Purchaser or his representative.

c) The paints and shades of the finished coatings proposed by the Manufacturer shall be got approved by the Purchaser before application of the same. The analysis in respect of paint properties, paint composition and performance requirements of the paints shall be submitted by the Manufacturer for check and approval. All painting material shall conform to relevant Indian Standards.

   Each coat of printer and paint shall be compatible with the previous and subsequent coats. All pigmented primers and paints which will be used for priming and painting at the site shall be delivered in original and sealed containers packed by the manufacturer.

d) The Manufacturer shall supply full details regarding the extent to which sand-blasting, priming and painting will be carried out in his workshops (or his sub-contractors, as the case may be) at the site and after erection. A properly equipped paint shop shall be set up at the site using a specialist organization, experienced and skilled in the preparation and application of protective coatings at the conditions prevailing at the site.

### 2.2.8.2 Surface Preparation

After the equipment has been fabricated, it is essential that before any primer and coat of paint is applied, the surface is properly prepared. Such preparation shall include through cleaning, smoothing, drying and similar operation that may be required to ensure that the primer and/or paint is applied on suitable surfaces. Clean cloths and clean fluids shall be used to avoid greasy film or greasy residue on the surfaces being cleaned. The procedure for surface preparation shall be as follows:

a) Weld spatters or any other surface irregularities shall be removed by any suitable means before cleaning. b) All oil grease and dirt shall be removed from the surface by the use of clean mineral spirits, white gasoline (lead free) and clean wiping materials.

b) Following the solvent cleaning, the surfaces, to be painted shall be cleaned of all rust, mill scale, and other tightly adhering objectionable substances by sand blasting or grit blasting to uniform bright base metal. Average surface roughness for sand blasted area shall not exceed 40 microns. Any grit or dust remaining after the cleaning operation shall be completely removed from the surface by wire brushing; air blowing, suction or other effective means before the surface is painted.

c) Surfaces of stainless steel, nickel, bronze and machined surface adjacent to metal work being cleaned or painted shall be protected by masking tape or by other suitable means during the cleaning and painting operations.

d) Primers shall be applied as soon as the surface preparation is complete and prior to be development of surface rusting. In case there is considerable time gap, the surface shall be re-cleaned prior to priming.

### 2.2.8.3 Measures during Painting

a) Any bare spots or holidays shall be recoated with additional application of primer.

b) All runs, sags, floods, or dips shall be removed by scrapping and cleaning, the cleaned area shall be retouched or all such defects shall be remedied by re-blasting or re-priming.



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c) Special attention shall be given to obtaining good coverage on rivets, welds and sharp edges and corners.

d) Suitable measures shall be taken to protect applied primer from contact with rain, fog, mist, dust or other foreign matter until completely hardened and next coat applied.

e) The air temperature at the time of application shall not be below 10°C and relative humidity shall not be above 60%.

### 2.2.9 Installation, Operation & Maintenance Manuals

For guidance during the installation of the work and subsequently for guidance of the plant operating and maintenance staff, Manufacturer shall prepare requisite manuals.

The manuals shall include a separate and complete section describing the normal and emergency operating procedures for the gates and control equipment and shall include easily read diagrammatic drawings of the equipment to facilitate understanding of the descriptive information.

The manuals shall describe and illustrate the Procedure for assembling, adjusting, operating and dismantling of each component and control system. The maintenance of each component shall be described, including the recommended frequency of inspection and lubrication.

Manuals shall also describe and illustrate procedures for installation, storage, handling, unloading, reloading, unpacking and upkeep of each component and of the system.

Three (03) copies of the manuals shall be submitted in English in draft form for approval of Purchaser three months prior to the time the information is at site. Six (06) suitably bound copies shall be provided to Purchaser not later than days after receipt of approval.

If revision of the manuals becomes necessary, as a result of information gained during installation and initial operation, Manufacturer shall make the necessary revisions and furnish six (06) copies of the revised sections.

The manuals shall include a complete list of all drawings prepared by Manufacturer, a list of spare parts and a list of parts for each component or item of equipment. The parts list shall include manufacturer's name and serial numbers and source of their procurement.

Manufacturer shall ensure that his Erection, Installation Supervisor has a copy of all approved drawings and the manuals in his site office.

## 2.3 GENERAL ELECTRICAL REQUIREMENTS

### 2.3.1 GENERAL

The Works shall be designed to ensure continuity of operation under all working conditions pertaining at the site as the first consideration and to facilitate inspection, maintenance and repairs. All reasonable precautions shall be taken in the design of equipment and of the works, to ensure the safety of personnel concerned with the operation and maintenance of the works.

Outdoor equipment shall be designed so that water cannot collect at any point. The undersides of all tanks shall be ventilated in an approved manner to prevent corrosion.

Cast iron shall not be used for the chambers of oil filled apparatus or for any parts subject to mechanical stress.

Mechanisms shall be constructed to prevent sticking due to rust and corrosion, and the bearings of exposed operating shafts shall be designed to prevent moisture seeping along shafts into the interior of equipment.

No welding, plugging or filling of defective parts shall be carried out without prior sanction of the Employer in writing.

Corresponding parts of similar equipment, and equipment liable to renewal, shall be fully interchangeable and the Contractor will be required to demonstrate this.

All equipment shall operate without undue vibration and with the least practical amount of noise.

All equipment shall be designed to minimize corona or other electrical discharges, to comply with local electromagnetic compatibility (EMC) standards and IEC 60801 and IEC 61000.

All electrical components shall be adequately rated for their most onerous duty and the specified ambient temperature. When equipment is mounted in panels, cubicles etc., due account shall be taken of any heat generated by the equipment therein and the components shall be appropriately selected, rated or de-rated as necessary to suit the most onerous operating temperatures within the enclosure.

### 2.3.2 SERVICE CONDITIONS

- Altitude — A height above sea level not exceeding 2500m.
- Temperature range — Not below -7 degrees centigrade
  Not above +40 degrees centigrade
- Seismic Conditions — As per value provided in other relevant Section of Tender Documents

### 2.3.3 EQUIPMENT ENCLOSURE CLASSIFICATION

Unless otherwise specified, the minimum equipment enclosure classifications for non-rotating electrical equipment shall be as follows:

Indoors only in totally enclosed rooms with provision for limiting ingress of dust: IP31

Indoors, except as noted otherwise: IP54

Outdoors, and indoors in areas subject to water spray, or heavy condensation: IP65

### 2.3.4 CURRENT RATINGS

Current ratings in accordance with IEC 60059 shall be adopted, unless otherwise approved. Every current carrying part of the equipment shall can carry its site rated current continuously under the site ambient conditions as specified and shall not be rated based on air-conditioned rooms even when these are specified. Air conditioning shall only be installed for comfort of operational personnel.

The maximum temperature attained by components under the most onerous service conditions shall not cause damage or deterioration to the equipment or to any associated or adjacent components.

Electrical equipment shall be adequately supported and braced to withstand the forces associated with the maximum short-circuit currents specified or pertaining, whichever is the



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greater, and if the inception of the short-circuit is at such a time that gives maximum peak currents.

Equipment shall be so constructed as to withstand the specified maximum short-circuit currents for a duration of 3 seconds, unless otherwise specified, without the temperature exceeding the specified maximum short-time temperature or value stated in the relevant standard, under these conditions.

### 2.3.5 VOLTAGE RATING

Standard voltage levels in accordance with IEC 60038 shall be adopted, unless otherwise approved.

All electrical equipment shall, except where otherwise specified, be capable of continuous operation at a voltage in the range of 90% to 110% of the nominal a.c voltage and at a frequency in the range of 50±6% (94% to 106%) of the nominal frequency coincidentally without deterioration. DC voltage in the range of 80% to 115% in accordance with IEEE 421.4, section 8.8.

The temperature rises of electrical equipment continuously operating at the specified extreme voltage and frequency shall not exceed the temperature rise when operating at nominal voltage and frequency by more than 5 K.

All electrical equipment shall be so designed such as to withstand abnormal system voltages as required by the applicable IEC Standard.

### 2.3.6 BUSBAR AND CONNECTIONS

Bus bars and connections shall comply with BS 159 and shall be electrolytic copper, unless otherwise approved.

The bus bars, assemblies and connections of metal-enclosed or metal-clad switchgear shall be of a type, which does not rely solely on air for insulation purposes. The conductor temperature during short circuit shall not exceed the temperature limit of the insulation material and the insulation shall have such thickness as is required to withstand rated line to line voltage between a bus bar and a conducting object on the exterior of the insulation material for a period of not less than 1 minute.

The bus bars shall carry the full rated current continuously without exceeding the maximum temperature specified in IEC 61439 or IEC 62271, as applicable, under site ambient conditions.

Bus bars shall be of uniform cross-sectional area throughout the length of a switchboard and shall not be of a varying (tapered) section.

### 2.3.7 INSULATORS AND BUSHINGS

Porcelain or glass insulators and bushings shall comply with the requirements of IEC 60137, IEC 60168, IEC 60273, IEC 60305, IEC 60433 and IEC 60591, as applicable. Porcelain for insulating purposes shall comply with the requirements of IEC 60672.

Insulators and bushings shall satisfy the test requirements of IEC 60168, IEC 60233 or IEC 60383, as applicable. The design of insulators shall be such as to minimize radio Frequency Interference (RFI) and tests shall be made in accordance with IEC 60437, or equivalent, to limit RFI to CISPR (International Special Committee on Radio Interference) or ITU-T



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(Telecommunication Standardization Sector of the International Telecommunications Union) recommended limits, or equivalent National Standards or Regulations.

Insulators and bushings of organic moulded or resin-bonded material shall comply with the requirements of IEC 60660 as appropriate.

Insulators and bushings of moulded, or resin bonded material shall be identified with the manufacturers mark and batch identification. Such marking shall not impair the electrical properties of the surface finish.

### 2.3.8 ELECTRICAL INSULATION

The insulation of all machine windings, solenoids, etc. other than those immersed in oil or compound, shall be of Class F materials, unless otherwise specified elsewhere.

Linseed oil and untreated materials of fiber, leatheroid, presspahn, asbestos or other similar hygroscopic types of materials shall not be used for insulation purposes. Untreated leatheroid and presspahn may be used for mechanical protection of winding insulation.

Polychlorinated Biphenyl (PCB) type materials shall not be used anywhere in the equipment or in any component.

Insulating oil shall comply with the requirements of IEC 60296.

### 2.3.9 FUSES AND LINKS

Fuses shall be of the non-deteriorating HRC (High Rupturing Capacity) cartridge type complying with IEC 60269, IEC 60282 or IEC 60644 as applicable. Fuse holders shall be so designed as to permit detection of fuse-rupturing without removing the bridge. "Zed" and screw-in type fuses shall not be permitted.

Test links in current transformer circuits shall be of the bolted or plug-in type.

### 2.3.10 FUSE SWITCHES

Fuse switches shall comply with IEC 60947-3 and the operating mechanism shall be of the spring-loaded type, such that the speed of operation cannot be controlled by the operator. Full closing or opening of the switch shall not depend upon the operator pushing the operating handle fully home. In the event of a spring failure, it shall be possible to open the switch without endangering the operator.

### 2.3.11 MOLDED CASE CIRCUIT BREAKER AND MINIATURE CIRCUIT BREAKER

All miniature circuit breakers (MCB's) shall be of the high-speed fault limiting thermal/magnetic type to IEC 60898.

All moulded case circuit breakers (MCCB's) shall be of the high speed, fault limiting thermal/magnetic type to IEC 60947-2. Circuit breakers used in combination type motor starters and contactors shall be interlocked with the panel enclosure. The panel enclosure/cover cannot be opened unless circuit breaker is open.

### 2.3.12 DISTRIBUTION BOARDS AND ISOLATORS

Distribution boards shall be provided throughout the plant for local distribution of lighting, small power and welding supplies.

LV distribution boards shall conform to IEC 61439. All distribution boards shall be of the weatherproof enclosure type to IP54 and shall be arranged so that the door or cover can be locked in the closed position.

Distribution boards shall be capable of withstanding without injury the mechanical and electrical stresses set up by the maximum prospective fault current for twice the period required to disconnect such fault on any circuit.

Indoor distribution boards shall be of galvanized or enameled sheet steel with a paint finish. The finished colour of all indoor distribution boards shall be chosen to match the adjacent switchboards.

The current rating of the bus bars in each distribution board shall not be less than the sum of the maximum current rating of all outgoing circuits. The neutral connection for each circuit is to be direct to the neutral bus bar.

Cabling to distribution boards shall generally be bottom entry. However, for indoor boards top entry maybe permitted subject to the approval of the Employer.

### 2.3.13 CURRENT TRANSFORMERS

Current transformers shall comply with IEC 61869-2 as amended and supplemented by the following requirements.

Separate cores of current transformer (CT) shall be used for each protection, metering and instrumentation. Minimum of one (01) core shall be provided as spare for each CT.

For measuring current transformers, the following accuracy classes shall apply:

- 0.1 for generator output for the purposes of acceptance testing, and for tariff metering of large supplies, unless otherwise specified
- 0.2 for plant record metering, and for other acceptance testing purposes
- 0.5 for automatic voltage regulators (AVRs)
- 1.0 for indicating instruments.

Current transformers for protective and protective/indication purposes shall be designed to suit the requirements of the associated protection which, in general, shall be in accordance with the recommendation given in IEC 61869-2.

Class 5P current transformers shall be used for combined over current and earth fault protection of the inverse time over current type. The rated accuracy limit with actual burden connected shall be equivalent to the ultimate maximum symmetrical three phase fault current or earth fault current of the protected circuit. The current transformers shall meet the 5P error classification at rated accuracy limit current over the full range of relay settings.

Current transformers for combined purposes e.g. inverse time relays and indicating meters, shall have a dual Class 5P/Class 1 performance and where necessary the secondary circuits shall have an approved means of protecting the meters and reducing their burden under system fault conditions.

Current transformers for protection using high impedance relays shall be of the low reactance type and their performance shall be stated in terms of the Class TPS, TPX, TPY and TPZ parameters of IEC 61869-2 (low reactance current transformers are preferred for all forms of protection), or equivalent approved standard.

The rated volt-amp output of each current transformer shall not be less than the connected burden, as installed in service, the burden of cable connections being considered.

Current transformers shall be capable of withstanding without damage the peak and rated short-time currents of their associated equipment.

The secondary windings of each set of current transformers shall be earthed at one point only, via a bolted disconnecting link. The current transformer core, where accessible, shall be separately earthed.

When multiple ratio secondary windings are specified, a label shall be provided at the secondary terminals of the current transformer, indicating clearly the connections required for each tap. The connections and the ratio in use shall be indicated on all connection diagrams.

Design magnetization curves and DC resistance values shall be submitted before manufacture for each current transformer used for protective purposes and shall be subsequently verified by works routine tests.

For metal-clad switchgear, all current transformers shall be located on the outgoing circuit side of the circuit breaker. Current transformers may also be provided on the bus bar side of the circuit breaker to permit protection zone overlap. The primary conductors of all current transformers shall be readily accessible for primary injection testing on site.

Where current transformers shall be mounted on apparatus provided under other contracts, the Contractor shall be responsible for ensuring compatibility with the other contractors' apparatus.

Current transformers incorporated in equipment which are spare or for future use, shall (if not connected to associated relays, instruments etc.) be provided with a suitably rated shorting link mounted at a convenient terminal block to avoid the current transformer being energized with its secondary connections open circuited.

Bushing type current transformers shall be provided with taps to measure capacitance and loss factor (tan delta).

### 2.3.14 VOLTAGE TRANSFORMERS

All voltage transformers shall comply with the requirements of IEC 61869-3 as amended and supplemented by this specification. They shall have outputs 50% more than the present requirements unless otherwise specified.

Separate cores of voltage transformer (VT) shall be used for each protection, metering and instrumentation. Minimum of one (01) core shall be provided as spare for each VT.

Voltage transformers shall have the following accuracy classes unless otherwise specified:

- 0.2 For plant record metering, AVRs and indicating instruments
- 3P for protection

The voltage transformer secondary circuits shall be complete in themselves and shall be earthed at one point only. Metal cases shall be separately earthed. The transformer core, where accessible, shall be separately earthed. All voltage transformers at the same voltage level shall be earthed in the same manner.

Where it is required to earth the primary neutral of a metal clad voltage transformer, the neutral earthing connection shall be insulated from the tank and brought out separately from the secondary earthing connection.



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Primary windings shall be connected through fuses with current limiting resistances or having current limiting features. However, such fuses may be omitted when the voltage transformer is located within the overall protection zone of the main circuit.

Secondary main protection fuses or miniature circuit breakers shall be provided as close as possible to, and preferably mounted on, each voltage transformer, within a lockable or bolted enclosure. Secondary main protection fuses or miniature circuit breakers shall be labelled to show their function and phase colour. It shall not be necessary to de-energize the primary circuit or remove the voltage transformer of metal clad switchgear to gain access to the fuses or miniature circuit breaker. Auxiliary contacts shall be provided for alarm purposes in the event of loss of supply.

Voltage transformers shall be so designed that saturation of their cores does not occur when 1.732 times normal voltage is applied to each winding.

Magnetization curves shall be submitted for approval for each type of voltage transformer prior to Works Tests.

The standard secondary voltage between phases shall be 110 V unless special circumstances dictate otherwise.

Secondary circuits of different voltage transformers shall not be connected in parallel.

Voltage transformers shall preferably be mounted on the outgoing circuit side of circuit breakers.

Three phase voltage transformers having an earthed - star primary winding shall have cores with five limbs, the outer two of which shall be unwound.

### 2.3.15 PROTECTION EQUIPMENT AND AUXILIARY RELAYS

Protective relays shall comply generally with the requirements of IEC 60255. They shall be contained in dustproof flush mounted cases with glass fronts and semi-gloss black bezels and shall be provided with breathers. They shall be of the withdrawable type unless otherwise approved. All relays shall have a provision for testing without withdrawing the relay from its case; this shall take the form of an adjacent test block, unless a test plug can be inserted between the contact fingers of the relay and the relay case. This requirement shall be in addition to any permanently connected injection test scheme.

Two test plugs to suit each different type of relay case or test socket shall be provided for each switchboard or suite of relay panels. The test plugs shall have terminals for both the relay and wiring side connections, which will accept both wires and plug connections and be complete with lengths of flexible cable for connection to a portable relay test set.

Schemes of protection shall be relatively straightforward to commission and shall not require unique test equipment. Each relay or scheme which initiates tripping shall be provided with trip isolation links or other means of isolating outgoing trip signals to permit testing of the scheme, preferably mounted on the front of the associated relay panel or switchboard.

All relays shall be so arranged that, providing reasonable care is taken, any dust, which may have collected in or upon the case, shall not fall on the relay mechanism when opening the case.

Auxiliary relays shall also be mounted in dustproof cases.

All protective relays shall be provided with a name and data plate.

Any relay mounted on a panel associated with a circuit breaker and which initiates tripping of any other circuit breaker shall, in addition to the required trip isolation link, bear a distinctively colored warning label.

All metal bases and frames of relays shall be earthed, except where the latter shall be insulated for special requirements.

Relay equipment incorporating electronic devices shall be arranged to jack-in and have positive means of retaining them correctly in the service position. Equipment incorporating telephone type relays shall preferably have similar facilities.

Rectifiers used in, or in association with, protective relays shall be suitable for the climatic conditions pertaining to the site of installation.

Relay contacts shall be suitable for making and breaking the maximum currents which, they may be required to control in normal service but where contacts of the protective relays are unable to deal directly with the tripping currents, approved auxiliary contactors, relays or auxiliary switches shall be provided. Separate contacts shall be provided for alarm and tripping functions. Relay contacts shall make firmly without bounce and the whole of the relay mechanisms shall be as far as possible unaffected by vibration or external magnetic fields. Switching of contacts in AC/DC control circuits shall not produce harmful over voltages.

Where relays rely for their operation on an external dc supply, (e.g. from a supply provided by others or a supply different to all other relays), this supply shall be monitored and an alarm provided in the event of failure.

All relays shall be provided with clearly inscribed labels describing their application and rating in addition to the general-purpose labels.

The maximum AC voltage across any two points of a current circuit shall not exceed 3 kV peak and non-linear resistors shall be provided if necessary to achieve this limitation.

AC operated control relays and timers shall operate correctly between 85 % and 110 % of the rated voltage and shall remain energized without chatter at 75% supply voltage, measured at the bus bars.

All relays which are connected to complete either the tripping circuit of a circuit breaker, or to the current coil of an auxiliary tripping relay, shall be provided with approved operation indicators which, whenever possible, shall be of the mechanically operated type, or non-volatile LED type. Indicators shall also be provided on such additional relay elements as will enable the phase of the fault condition to be identified. Each indicator, whether of the electrically operated or mechanically operated kind, shall be capable of being reset by hand without opening the relay case and it shall not be possible to operate the relay when resetting the operation indicator. Each indicator shall be so designed that it cannot move before the relay has completed its operation. Indicators shall not reset during a failure of auxiliary power to the relay.

All relays which are of the hand reset type shall be capable of being reset without opening the case.

It shall not be possible to operate any relay by hand without opening the case.

Where relays are required to operate with a fixed time delay, the time delay shall not be of the dashpot type.



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DC operated control relays and timers shall operate correctly between 80 % and 110 % of the rated voltage and the drop out voltage shall not be less than 40% of the rated voltage. They shall be impervious to the effects of induced AC voltages and shall not be caused to operate by such effects. DC operated relays and timers shall be fitted with a free-wheel (quenching) diode across the coil of sufficient voltage and current rating.

All possible precautions shall be taken to ensure that direct current operated relays which perform a tripping function are not liable to mal-operation. For this reason, the total capacitance to earth of all connections to the either pole of the tripping battery shall not exceed 10 microfarads.

To minimize the effects of electrolysis, operation indicator coils and DC relay operating coils shall be so placed in the circuit that they are not connected to the positive pole of the battery, except through contacts which are normally open.

If bolts or nuts are so placed as to be inaccessible with an ordinary spanner, not less than two special tools shall be provided.

The Contractor shall provide relay setting details for all relays within his supply. Where information is required to determine settings on equipment not supplied by the supplier, the Contractor shall request the information.

Settings for protective relays which require discriminative time and/or current grading with protection schemes shall be determined by the Contractor. The Contractor shall request any relay settings required and demonstrate by submitting for approval grading curves, etc. that correct grading has been achieved.

All calculations to determine relay settings and CT and VT requirements shall be submitted for approval.

The Contractor shall arrange for the supplier of the relaying equipment to do site tests required for the determination of correct relay settings irrespective of supply of primary circuit plant, pilot cables or signaling channels and the Contractor shall co-ordinate all such site testing.

### 2.3.16 PANELS, DESK AND CUBICLES

Unless otherwise specified, panels, desks and cubicles, shall be of floor-mounted and free-standing construction and be in accordance with the enclosure classification specified elsewhere. All control and instrumentation panels in any one location shall be identical in appearance and construction.

Panels shall be rigidly constructed from folded sheet steel of adequate thickness to support the equipment mounted thereon, above a channel base frame to provide a toe recess. Alternatively, a separate kicking plate shall be provided.

Overall height, excluding cable boxes, shall not exceed 2.5 m. Operating handles and locking devices shall be located within the operating limits of 0.95 m and 1.8 m above floor level. The minimum height for indicating instruments and meters shall be 1.5 m unless otherwise specified.

Panels shall be mounted on an approved form of anti-vibration mounting, whenever necessary.

All panels, desks and cubicles shall be vermin-proof. All cable entries to equipment shall be sealed against vermin as soon as possible after installation and connecting-up of the cables.



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All panels, desks and cubicles shall be provided with a natural air circulation, ventilation system. All control equipment shall be designed to operate without forced ventilation. Where required and typical for outdoor installation, panels shall be equipped with attachable and detachable internal filters to prevent dust from entering through ventholes/ventilating openings used for ventilation purposes.

For outdoor equipment, metal to metal joints shall not be permitted and all external bolts or screws shall be provided with blind tapped holes where a through hole would permit the ingress of moisture. For harsh environments, all nuts, bolts and washers shall be plated.

Door sealing materials shall be provided suitable for the specified site conditions. Doors shall be fitted with handles and locks. Where walk-in type panels are supplied the door shall be capable of being opened from inside the panel without the aid of a key after they have been locked from the outside. Hinges shall be of the lift-off type.

The bottom and/or top of all panels shall be sealed by means of removable gasketed steel gland plates. Gland plates for bottom entry shall be at least 250 mm above the floor of the cubicle.

Panels shall be suitably designed to permit future extension wherever appropriate or specified.

Each panel shall include rear access doors, internal power socket and door-operated internal lighting, and be clearly labelled with the circuit title at front and rear, with an additional label inside the panel. Panel sections accommodating equipment at voltages higher than 125 V (nominal) shall be partitioned off and the voltage clearly labelled. Each relay and electronic card within panels shall be identified by labels permanently attached to the panel and adjacent to the equipment concerned. Where instruments are terminated in a plug and socket type connection both the plug and the socket shall have permanently attached identifying labels.

Instrument and control devices shall be easily accessible and capable of being removed from the panels for maintenance purposes.

Terminations, wiring and cabling shall be in accordance with the requirements of applicable IEC standard.

For suites of panels, inter-panel bus wiring shall be routed through apertures in the sides of panels and not via external multi core cabling looped between the panels.

All panels, whether individually mounted or forming part of a suite, shall incorporate a common internal copper earthing bar onto which all panel earth connections shall be made. Approved studs or holes shall be left at each end of the bar for connection to the main station earthing system and possible future extension.

Earth connection between adjacent panels shall be achieved by extending the bar through the panel sides and not by interconnecting external cabling.

Where intrinsically safe circuitry is routed from a hazardous area to a safe area instrument panel, it shall be connected through Zener Barriers located in the safe area (instrument panel). The Zener Barriers shall be of suitable rating and mounted on an insulated, earthing bus bar, having facilities for connection of a separate, dedicated outgoing cable to a "clean earth" system.

Control supplies in desks, panels and cubicles shall be derived from a duplicate standby/UPS system, except if specified otherwise in this specification. The following alarms shall be provided to monitor the systems: voltage high, voltage low, no volts and earth fault. These alarms shall be signaled to the plant control system.

Cubicles and cubicle doors shall be rigidly constructed such that, for example, door mounted emergency trip contacts can be set so that mal-operation will not be possible due to any vibrations or impacts as may reasonably be expected under normal working conditions.

Indoor cubicles, desks and panels shall be of galvanized or enameled sheet steel with a paint finish. The external finished colour of all indoor cubicles, desks and panels shall be agreed. A wear strip of polished stainless steel shall be applied to the leading edge of control desks. The internal surface of all cubicles, desks and panels shall be painted matt white.

Outdoor cubicles and panels shall be of galvanized sheet steel with a paint finish. The external finished colour of all outdoor cubicles, desks and panels shall be subject to approval of the Employer.

All outdoor kiosks, cubicles and panels shall be provided with sun/rain shades.

All cubicles, or panels mounted external to control and apparatus rooms shall be filled with anti-condensation heaters.

### 2.3.17 INDICATING LAMPS AND FITTINGS

All indicating lamps shall be adequately ventilated and as far as practicable, lamps of a common type and manufacture shall be used throughout the contract.

Lamps shall be easily removed and replaced where possible from the front of the panel by manual means preferably not requiring the use of extractors.

Where specified every circuit breaker panel shall be equipped with one red and one green indicating lamp, indicating respectively circuit closed and circuit open and an amber lamp for indicating 'auto-trip'. Where specified for in the lines of mimic diagrams, indicating lamps may be of the three-lamp single-aspect type.

The variety of indicating lamps provided shall be rationalized to reduce maintenance and spares requirements.

The lamps shall be clear and shall fit into a lamp holder. The rated lamp voltage shall be at least 20% more than nominal supply voltage, whether AC or DC. The lamps shall have an operating life of at least 10,000 hours, under site conditions. If other indicating devices, such as light emitting diodes, are used in place of lamps, then these shall have the same life expectancy and performance capability as the lamps they replace.

The lamp glasses shall comply with International Commission on Illumination (CIE) 2.2 and IEC 60073 and be in the standard colours, red, green, blue, white and amber. The colour shall be in the glass and not an applied coating.

Where illuminated pushbuttons are used for control purposes, the illuminated pushbuttons shall be engraved with a clear instruction such as 'push to open' or 'push to close', and the lamp shall illuminate in accordance with the following colour code after the instruction has been carried out and the device has operated.

Unless otherwise approved, all lamp colors shall conform to the following practice:

- Red — Energized or operative position
- Green — De-energized or inoperative position
- Amber — Fault or abnormal condition
- White — Healthy or normal condition
- Blue — Other purposes, to be used with descriptive label



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Lamp test facilities shall be provided for all switchboards, control panels etc. to enable all lamps to be tested whilst the equipment is in service. Operation of the lamp test facility shall not cause any other device to operate.

Indication circuits shall be fused.

### 2.3.18 ANTI-CONDENSATION HEATERS

All switchboards, panels, cubicles and the like shall incorporate electric heaters capable of providing movement of sufficient heated air to avoid condensation.

A thermostat shall be provided which shall switch the anti-condensation heater off automatically when the panel upper air temperature limit has been reached and will switch the heater on automatically when the panel air temperature falls below the set point.

The switchboard anti-condensation heaters shall be fed from an LV single phase and neutral supply, manually switched by a two-pole switch with red lamp, mounted on the back of the board, panel or cubicle and bus wired through the board. Labels shall be provided on the switch stating, "Heater Supply". Heater terminals shall be shrouded and labelled "Heater".

Motor anti-condensation heaters where fitted shall be fed from an LV single phase and neutral supply bus wired through the associated switchboard. The heater supplies shall be individually fused and shall be switched by auxiliary contacts on the contactor and isolated by auxiliary contacts on the contactor disconnector.

### 2.3.19 PANEL WIRING

The wiring shall generally comply with BS 7671 or applicable IEC standard. All wiring shall be of adequate cross-sectional area to carry prospective short-circuit currents without risk of damage to conductors, insulation or joints.

The following classes of copper conductor, as defined in IEC 60228, shall be used for panel wiring:

- Class 1 conductors up to a maximum of 0.9 mm diameter where necessary for wire-wrapped terminations and similar techniques,
- Class 2 conductors except where specified otherwise,
- Class 5 and Class 6 conductors between points subject to relative movement.

The following minimum conductor sizes shall be used:

- 2.5 mm² for current transformer secondary circuits with a rated secondary current of 0.5 A or greater,
- 1.5 mm² except where specified otherwise,
- 0.5 mm² for alarm and indication circuits with a continuous or intermittent load current not exceeding 1 A.

### 2.3.20 IDENTIFICATION OF WIRES

All wiring and cores in control and instrument cables shall be identified in accordance with the associated schematic and/or wiring diagrams either by means of discrete wire numbers or wire colors, except when an automatic or proprietary system of wiring is used, e.g. point-to-point wiring on a mother board.

When a wire numbering system is used, it should be in accordance with one of the main marking systems described in IEC 60391 or with a functional marking system.

Both ends of every wire and core in control and instrument cables shall be fitted with interlocking ring ferrules of white insulating material indelibly marked with black characters complying with BS 3858.

### 2.3.21 TERMINAL AND TERMINAL BOARDS

Terminal boards shall have separate terminals for internal and external connections, and not more than one wire shall be connected to each terminal.

Adjacent terminals to which wires of different voltage, polarity or phase are connected, shall be separated by a protruding insulating barrier. This requirement also applies to terminals carrying wires of the same voltage but originating from different sources.

Trip circuit wiring and instrument transformer secondary wiring shall be connected using hook type crimped terminations in screw clamp, spring loaded insertion type terminals.

Where clamp type terminals are used, Class 1 and Class 2 conductors may be terminated without lugs. Crimp lugs shall be used for Class 5 and Class 6 conductors. Means shall be provided for retaining the identifying ferrules of the wire end when it is disconnected. Pinch screw type terminals shall not be permitted.

Subject to approval of the Employer, "wire-wrap", "termi-point" or equivalent methods of terminations of single strand conductors may be used.

Wires shall be grouped on the terminal boards according to their functions.

All terminal blocks shall provide a degree of protection of not less than IP2X when correctly installed, either inherently or by provision of insulating covers.

Cage clamp type terminal block shall be used for applications that are sensitive to vibration.

Terminal boards shall be mounted vertically, not less than 150 mm above the gland plates, and spaced not less than 100 mm apart, on the side of the enclosure and set obliquely towards the rear doors.

Sufficient terminals shall be provided to permit all cores on multi core cables to be terminated. Terminals for spare cores shall be numbered and be located at such position as will provide the maximum length of spare core. At least 10 % spare terminals shall be provided in all cases.

The tails of multi core cables shall be bound and routed so that each tail may be traced without difficulty to its associated cable. All spare cores shall be made off to terminals.

When two lengths of screened cable are to be connected at a terminal block (i.e. junction box) a separate terminal shall be provided to maintain screen continuity.

In the main and local control and equipment rooms, means shall be provided on the terminal blocks of panels, desks, cubicles, etc., for testing all the instrument circuits without the need to remove the internal or external wiring from the block.

The Contractor shall submit full details and specification for approval of the proposed means of termination where wire wrapping, soldering and similar methods are used. The Contractor shall identify all special tools, such as wire wrapping tools required for termination, and shall make provision for their supply in sufficient numbers.

The use of pre-formed factory tested cable connections to field mounted marshalling boxes shall be subject to approval of the Employer.



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### 2.3.22 CABLE BOXES AND GLANDS

Electrical equipment shall be provided with all necessary cable boxes, which shall be complete with all required fittings. All cable boxes shall be of adequate size to allow for the correct termination of the cable sizes required or specified, considering the crossing of cores to achieve the correct phasing, and to accommodate all cable fittings, including stress cones or other means of cable insulation grading, if required. All cable boxes shall be designed in such a manner that they can be opened for inspection without disturbing the gland plate or incoming cable.

Cable lugs and terminations for the receipt of all power, control and instrumentation cable cores shall be provided.

Cable glands for extruded solid dielectric insulated cables (PE, XLPE) shall be of the compression type and as specified in BS 6121 Part 1.

All glands shall be provided with an earthing tag or equal facility. For cables having conductors not larger than 4 mm² serrated washers may be used in place of earthing tags to provide earth continuity.

### 2.3.23 CONDUITS AND ACCESSORIES

Conduit installations shall comply with IEC 60364, IEC 60621, IEC 60981 and IEC 61035, unless otherwise approved.

All conduit and conduit fittings shall comply with IEC 60423 and IEC 60614. Unless otherwise approved, all conduit and conduit fittings, shall be thread able steel conduit with enclosure classification IP55, at least heavy mechanical protection and high resistance to corrosion inside and outside.

No conduit smaller than 20 mm diameter shall be used.

Standard circular boxes or machined face heavy-duty steel adaptable boxes with machined heavy type lids shall be used throughout. For outdoor mounting all boxes shall be galvanized, weatherproof and fitted with external fixing lugs.

Where conduit is terminated so that the bare end of the conduit is exposed the conduit end shall be fitted with a brass bush.

The use of running threads, solid elbows and solid tees will not be permitted.

Conduit ends shall be carefully reamed to remove burrs. Draw-in boxes shall be provided at intervals not exceeding 10 m in straight-through runs.

Conduit runs shall be in either the vertical or horizontal direction unless otherwise approved and shall be arranged to minimize accumulation of moisture. Provision for drainage shall be made at the lowest points of each run.

Conduits shall be supported on heavy galvanized spacer saddles to stand off at least 6mm from the fixing surface.

All conduits run in any circuit are to be completed before any cables are pulled in.

Flexible metallic conduit shall be used where relative movement is required between the conduit and connected apparatus, and a separate earth continuity conductor shall be provided. For outdoor installation, liquid tight flexible metallic conduit shall be used.

The maximum number of cables in any conduit shall be in accordance with IEC 60364.

### 2.3.24 CABLE LADDERS AND TRAYS SYSTEM

Cable ladder and tray system shall meet the requirement of IEC 61537. Independent cable ladder and tray systems shall be provided for Cables of different voltages, and for power and control cables with adequate separation.

Where available space is restricted such that requirement of use of independent cable ladder and tray cannot be met, use of cable separators with adequate separation between different voltages and power & control cables are permitted following applicable International Standard.

The width of the cable ladder/tray shall be chosen to accommodate all the cables in one tier, plus 30 to 50% additional width for future expansion. This additional width shall be minimum 100mm. The overall width of one cable ladder/tray shall be limited to 800mm.

#### 2.3.24.1 Galvanized Cable Trays

All hot-dip galvanized Cable Trays shall be manufactured from pre-galvanized mild steel, to BS EN 10142 and BS EN 10143 with a minimum coating weight of 275g/m². Cable tray and cable fittings shall be fully perforated.

Cable trays shall be installed using factory formed bends and tees. Where cut sections are used for sets they shall be free from sharp edges and joined by means of fish plates or couplers bolted to each section in accordance with the manufacturer's recommendations. Cable trays shall be painted with zinc rich paint to BS.4652 where cuts have been made.

Earth continuity connectors shall be fitted between each length of cable tray to ensure compliance with BS.7671. The earth continuity connectors shall be manufactured from copper braid to BS EN. 13602 complete with copper lugs to BS EN. 1976, BS EN 1978 and BS EN. 13600 or copper earth links with a minimum conductor area of 4mm² and with an electro-tinned finish. The connectors shall be fastened by M6 x 12mm roofing nuts and bolts. The connectors shall be fixed in accordance with the cable tray manufacturer's recommendations.

Ventilated cable tray covers shall be provided to all external trays. The covers shall provide an adequate gap along either side through which air can circulate. Ventilated cable tray covers shall be secured using proprietary clips and fixings in accordance with manufacturer's recommendations. All straight covers shall be supplied in lengths of 1.5m or 3m.

Cables shall be fixed to the tray by means of proprietary forms of LSZH or copper cable clips, hot dip galvanized cleats, saddles or straps with zinc plated or serrated bolts or nuts and washers at intervals of not more than 1200mm. Plastic tie wraps shall not be permitted. Cables on inverted or vertical cable trays shall be fixed using fire resistant cleats etc.

#### 2.3.24.2 Galvanized Cable Ladders

All hot-dip galvanized Cable Ladder shall be manufactured from either mild steel to BS EN ISO 1461 Part 1, hot dip galvanized after manufacture to BS EN ISO 1461 or, for certain internal application, from pre-galvanized mild steel to BS EN 10142 and BS EN 10143 with a minimum coating weight of 275g/m². Rungs shall be of shallow channel profile and shall be located at the bottom of the cable ladder side to maximize the loading depth.

Galvanized cable ladders shall be extra heavy-duty, general-purpose cable ladder with minimum flange height 150mm, material gauge 2.0mm and rungs at 300mm centers. Rungs shall be of shallow channel profile with slot pattern to suit cable ties and straps.

Cable ladders shall carry without undue deflection, the total weight of cable likely to be carried on the ladder regardless of the location of the joints.

Cable ladders shall be installed using factory formed bends and tees. Where cut sections are used for vertical or horizontal offsets they shall be free from sharp edges, and joined by means of couplers bolted to each section in accordance with the manufacturer's recommendations.

Cable ladders shall be supported on purpose-made suitably treated mild steel supports which shall permit easy adjustment and modification or by suitable channel, brackets, and accessories to BS.6946 at intervals necessary to provide a rigid fixing in accordance with the manufacturers recommended fixing centers. Channels to BS.6946 shall be manufactured from 2.5mm material conforming to BS.1449 Part 1, hot dip galvanized after manufacture to BS EN ISO 1461. Brackets to BS.6946 shall be manufactured from 6mm mild steel, 40mm wide, hot dip galvanized after manufacture to BSEN ISO 1461 and shall have a minimum hole size of 14mm diameter holes to accept M12 setscrews.

Cable ladders shall be painted with zinc rich paint to BS.4652 where cuts have been made.

Earth continuity connectors shall be fitted between each length of cable ladder to ensure compliance with BS.7671. The earth continuity connectors shall be manufactured from copper braid to BS.4109 complete with copper lugs to BSEN 1976, BSEN 1978 and BS EN 13600 or from copper strip. The conductor area shall be a minimum of 10mm² and shall have an electro-tinned finish. The connectors shall be fixed in accordance with the cable ladder manufacturer's recommendations.

Ventilated cable ladder covers shall be provided for all external cable ladders. The covers shall provide an adequate gap along either side through which air can circulate. Ventilated cable ladder covers shall be secured using proprietary fixings in accordance with the cable ladder manufacturer's recommendations. All straight covers shall be supplied in lengths of 1.5m or 3m.

Cables shall be fixed to the ladders by means of proprietary hot dipped galvanized cleats with zinc plated or serrated bolts or nuts and washers. Plastic tie wraps shall not be permitted.

#### 2.3.24.3 Fire Barriers

When electrical services pass through fire compartment walls or floors great care shall be taken to ensure that the gaps between the services and structure are properly sealed for acoustic and fire rating properties. The gaps shall be filled to the full thickness of the structure with mineral fiber having a minimum density of 150 Kg/m². Both faces of the mineral fiber shall be coated with a fire-resistant ablative mastic to dry film thickness of at least 1mm. Fire barriers shall only be installed where services pass through pre-determined fire compartments which shall be highlighted by the Contractor. It shall be the responsibility of the Contractor to ensure that all holes surrounding are filled for both acoustic and fire rating properties. It is the Contractor's responsibility to fill all trucking internal spaces/voids with mineral fiber as detailed above.

### 2.3.25 ELECTRIC VARIABLE SPEED DRIVE SYSTEMS

#### 2.3.25.1 General

Electric Variable Speed Drive Systems (VSDS) shall comply with all the international standards applicable for the VSDS components.

VSDS shall be of well-proven, high reliability design backed by long site operational experience in environmental conditions compatible with the plant. It shall comprise the complete drive system including motor and typically, static converters, dc link reactor, and associated control equipment.

If necessary, converter supply transformers may be included. Motor supply transformers shall not be used.

**2.3.25.2 Converters**

The Converters shall be of the variable voltage/variable frequency type utilizing power semiconductor technology to supply power to the VSDS motors. Each converter shall include a rectifier stage, dc. link with smoothing reactor and an inverter. The inverter shall be of the voltage source type using PWM ac. waveform generation.

The scope of supply of the converters shall include all necessary controls, auxiliary supplies, protection, alarm and measuring equipment required for operation of complete VSDS.

**2.3.25.3 Motors**

VSDS motors shall be cage induction motors. Where VSDS, using brushless synchronous motors, are economically competitive and/or are advantageous for the application, these may be offered as alternatives.

**2.3.25.4 Harmonic Distortion**

The total harmonic distortion under the most adverse operating conditions shall not exceed the limits laid down in the UK Engineering Association's Engineering Recommendation G5 (current version), or other approved standard; these limits shall apply both at the point of common coupling and at other switchboards within the plant's distribution system.

If the calculated levels of distortion exceed the limits laid down above, the Contractor shall provide one or more harmonic filters to reduce the harmonic distortion to a level to be approved. The harmonic filter(s) may include power factor correction, where required or specified.

Calculated levels of distortion shall be submitted with the Proposal, considering individual VSDS and the effect of the maximum number of VSDS running on a common supply system.

**2.3.25.5 Critical Speeds**

Critical speeds of the VSDS motor and driven equipment shall not lie within the operational speed range.

**2.3.25.6 Miscellaneous Technical Requirements**

Full technical details shall be provided in the Proposal including but not limited to:

- Transient Torque Performance
- Torque Pulsations
- Control Linearity
- Radio Interference
- Protection



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The VSDS shall be designed to withstand the mechanical, electrical and thermal stress which may arise from short circuits or other fault conditions, and to limit the damage caused by faults to the component concerned. Injury to personnel shall be completely prevented.

### 2.3.26 MOTOR STARTERS AND CONTACTORS FOR SEPARATE MOUNTING

In special cases for motors below 30 kW, and non-essential non-plant auxiliaries, such as roller shutter doors, and where approved, separately mounted starters for motors may be provided. Each such motor starter shall be equipped with two or three pole control gear, as appropriate, for direct-on-line starting and shall be complete with a fully shrouded lockable isolating switch mechanically interlocked with the means of access.

All starters shall be supplied by one manufacturer, except where otherwise approved.

Contactors shall be of robust design and shall comply with IEC 60947.

All contactors and their associated apparatus for minor motors shall operate without overheating for all specified motor operating conditions and including for a period of five minutes at normal frequency if the supply voltage falls to 80% of nominal voltage.

For motors, up to 30 kW rating, motor starters shall be provided with direct connected thermal overload and phase failure industrial pattern protection tripping devices integral with the motor contactor. Phase failure protection shall operate with out-of-balance currents not exceeding 85% of motor full load current. Separate contacts for a remote trip alarm shall be provided and connected if required.

For motors above 30 kW, starters shall not be wall mounted but included in a switchboard unless specifically approved. For such circuits motor protection relays with a more accurate and easily adjustable overload setting shall be used, which are sensitive to out-of-balance currents not exceeding 20 % of full load and shall include instantaneous earth fault elements. Alternatively, instantaneous earth fault protection may be incorporated in the motor circuit breaker. The earth fault protection shall not operate for unbalanced current surges during motor starting.

### 2.3.27 MOTORS

Motors shall comply with the requirements of IEC 60034 and IEC 60072 as amended and supplemented by this specification.

To minimize condensation in all motors, above 11 kW, when out of service, heaters of an approved type and rating, suitable for operation from the plant's LV ac single phase supply, shall be fitted inside the lower half of the stator frame.

The control of anti-condensation heaters shall be so arranged that they are normally energized when the motor is not running.

All motors shall be provided with a means of earthing the frame.

All AC motors shall be capable of direct on-line starting and of continuous operation at rated output under abnormal frequency conditions and shall also be capable of operation for a period of not less than 5 minutes, with a voltage 25% below nominal voltage, at nominal frequency, without injurious overheating.

Motors shall be capable of withstanding the electrodynamic stresses and heating imposed if it is started at a voltage of 110% of the rated value.

All hardware associated with the motors shall be made of corrosion resistant materials.

The terminal box shall be weatherproof and firmly fixed to the motor frame.

The arrangement of the terminal box shall be such as to facilitate installation of cables, and allow interchanging of any two-phase leads, without 1 disturbing the sealing compound if this is used at cable terminations.

Where practicable, the motor end cover remote from the driving end shall have a removable plug to allow the speed to be checked by means of a portable tachometer.

Motors, where installed outdoors, shall be weatherproof and protected by a sun canopy.

### 2.3.28 MOTORS TEST

Type tests shall be made on one unit of each type of different equipment at the Contractor's expense in presence of the Employer and the actual type test report shall be submitted to the Employer for approval. Instead of carrying out the type tests, the Contractor may submit duly certified and complete type test reports for tests carried out by an independent, accredited authority on similar equipment of the same type. However, the Employer reserves the right of accepting these certificates or to reject them partially or totally.

One motor of each type and rating shall be type tested and all motors shall be routine tested in accordance with the tests specified in IEC 60034, NEMA MG1, IEEE 112, 114, 115 and 85. These shall include, but not be limited to, the following:

- Winding resistance measurement (cold)
- Winding insulation resistance measurement (1-minute test)
- Winding temperature rise test
- Losses measurement
- No load tests
- Efficiency at 100, 75, 50 percent full load
- Power factor at 100, 75, 50 percent full load
- Locked rotor test
- Speed, torque/current curve
- Slip measurement
- Over-speed test
- Noise level test
- Bearings/lube. oil temperature measurement

Each motor shall be tested after installation as follows:

- Winding resistance measurements
- Insulation resistance test
- Air gap and alignment check (motor assembled on site)
- Direction of rotation check
- Start time running test uncoupled

### 2.3.29 PUSHBUTTONS

Pushbuttons, which may be of the illuminated or non-illuminated type, shall be shrouded or well recessed in their housings in such a way as to minimize the risk of inadvertent operation.



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In instances where "enable" pushbuttons are required they shall be electrically interlocked with the normal control such that deliberate operation of the "enable" push-button is required before the normal control can take place.

The colour of pushbuttons shall be as follows:

- When mounted on pushbutton stations adjacent to running plant the stop button shall be coloured red and the start button coloured green
- When mounted on the front of the contactor panel the stop button shall be coloured red and the start button coloured green.
- When mounted on panels or desks with adjacent indication lights both buttons shall be coloured black, unless required otherwise.

Loose pushbutton stations unless supplied as weatherproof free-standing enclosures shall be of the metal-clad weatherproof type suitable for wall or bracket mounting with a minimum enclosure classification of IP54. All outdoor mounted pushbutton stations shall incorporate a protective cover or guard (e.g. toughened glass door) to prevent inadvertent operation.

Control stations shall be clearly labelled showing the duty or drive to which they are applicable. Location of ammeters shall be subject to approval of the Employer.

Pushbuttons used on desks, panels etc. many of necessity required to be of special types (e.g. miniature, illuminated). The Specifications and requirements for these special pushbuttons shall be subject to approval of the Employer.

Emergency stop pushbuttons shall be provided adjacent to all motors and machinery with exposed moving parts, couplings etc. to prevent danger, and on main and local control panels. These pushbuttons shall have a large "mushroom" head, be coloured red and incorporate a protective cover or guard to avoid accidental operation. These buttons shall automatically lock in the depressed position, requiring twist or key resetting. Contacts shall be provided to cause tripping of the associated circuit, prevent restart of the circuit and bring up an alarm.

Stop pushbuttons mounted local to motors shall trip the associated circuit breaker or contactor regardless of the control position selected.

The contacts of all pushbuttons shall be shrouded to minimize the ingress of dust, and accidental contact, and shall be amply rated for voltage and current for the circuits in which they are used.

### 2.3.30 EARTHING AND BONDING

The main earthing conductors for connection to all electrical equipment, cables, motors, panels, etc., shall be provided for connection to the main earthing system.

All non-current carrying metal parts of electrical equipment shall be bonded to an earth terminal or terminals mounted on the equipment and readily accessible.

All equipment terminals provided for an external earth connection shall be identified by indelible means unless such terminals are directly and visibly mounted on metallic equipment frames or earth bars, when such marking may be omitted.

Identification marks for earth terminals shall comprise the colours green/yellow in combination or a reproduction of the symbol no. 5019 in IEC 60417.

Assemblies containing electrical equipment, including switchboards, control boards and control desks, shall be provided with a separate copper earth bar running the length of the



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assembly. All metal parts and the earth terminal or terminals shall be bonded to this earth bar. Earthing connections shall not depend upon the bolting of steel/steel joints between adjacent panels or cubicles.

Earth bars shall be of adequate size and suitably supported and braced to carry the rated short circuit current for the associated electrical circuits for the rated short-circuit current duration, without damage or excessive heating likely to damage joints, associated or adjacent components.

Switchgear and control gear assemblies shall be provided with two or more earth terminals unless otherwise specified. The copper earth bar shall be sized to withstand the maximum system earth fault current for three seconds without deterioration.

The size of the copper earth bar in control panels, control desks or similar enclosures containing low voltage apparatus shall be such as to comply with the specified requirements for withstanding prospective short-circuit currents. The size of this bar shall be a minimum of 120 mm² cross-sectional area, providing that sufficient mechanical integrity is provided by adequate supports and terminals, and providing this size is not less than the size of the largest incoming power supply conductor.

The metal cases of all instruments, relays and the like shall be connected to the panel earth bars by copper conductors of not less than 1.5 mm² cross-sectional area, or by other approved means.

### 2.3.31 TESTING EQUIPMENT

Contractor shall provide the valid calibrated testing equipment required for all the site tests and commissioning free of charge and shall take back after testing and commissioning is completed.

## 2.4 GENERAL CONTROL AND INSTRUMENTATION REQUIREMENTS

### 2.4.1 INTRODUCTION

This section provides general requirements for controls, instrumentation and associated equipment. This section shall be applied in conjunction with the specific requirements sections, which specify aspects of the plant and equipment particular to the Contract. In the event of conflict between the specific requirements and the general requirements stated in this specification the specific requirements shall take precedence.

The requirements stated in this specification shall be deemed to apply throughout the plant.

### 2.4.2 SCOPE

The Contractor shall supply, install and commission all instrumentation required for the control, alarm and protection of his equipment taking account of the requirements of the specifications.

Equipment covered by the control and instrumentation specifications shall be designed, specified, selected, installed, commissioned or operated in accordance with relevant and recognized international design standards or codes of practice.

The latest issue of any standard including formal amendments at the time of Contract award shall be applicable. The Contractor shall maintain an index of standards and codes used throughout the Contract as part of the control and instrumentation documentation. Where



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multiple parts or sections of a standard or code exist, the Contractor shall determine, and comply with, the relevant part or section.

All electrical equipment supplied shall be in accordance with the relevant clauses in the General Electrical Design Requirements.

### 2.4.3 DESIGN REQUIREMENTS

#### 2.4.3.1 General

The requirements of these Specifications shall be strictly observed. In the event of contradictions, the Contractor is responsible for writing to the Employer to obtain written clarifications and approval.

All requirements are minimum requirements. The rules of good engineering practice and the relevant approved standards and regulations shall be observed.

The Contractor shall, where possible, use the same make and type of Control and Instrumentation equipment for similar applications throughout the entire power plant.

A consistent supply policy shall apply throughout the Plant and shall be implemented in terms of a range of equipment exhibiting a minimum diversity of type and manufacture. The objective shall be to standardize measurement and control equipment throughout the Plant to the maximum feasible extent in order to rationalize operation and maintenance skills required and to reduce the spares holding.

Generally, equipment of each type shall be supplied from one product range of a reputable manufacturer of international standing.

The systems shall be so designed that in the event of subsequent modifications to the controls and associated signal processing, expansion of the system is convenient and straightforward.

A minimum of 20% spare capacity shall be provided in all main signal cabling, junction box terminations, cables, input and output signals (including input/output (I/O) modules, interposing relays, internal wiring and terminations), instrument power supply miniature circuit breakers (MCBs) and fuses. A further 20% spare physical space shall be provided within panels and instrument racks and on cable routes.

The equipment covered by the control and instrumentation specifications shall have high electromagnetic and radio frequency interference immunity to an international standard and shall not be affected by portable communication equipment operated in its vicinity.

All electronic devices shall be protected against transient voltage levels. Surge protection, lightning protection and susceptibility to electrostatic discharge shall be in accordance with international standards.

#### 2.4.3.2 Safety and Reliability

The installed control and instrumentation equipment shall ensure that the Plant is always operated within safe limits of any measured process variable. Equipment supplied shall have proven reliability in similar previous power plant applications.

The Contractor’s design intent shall be to ensure the safety and protection of all personnel and equipment while achieving a high level of Plant availability.

Where a safety system is required, the Contractor shall be responsible for carrying out the safety integrity level assessment for the safety functions and thereafter demonstrate how the required integrity of the safety system design is achieved, in accordance with recognized international standard. This requires that sensors and actuators selected by the Contractor for safety related duties have demonstrable manufacturer's data for failure rates, failure modes, diagnostic facilities, etc., as required to carry out the safety integrity analysis.

#### 2.4.3.3 Plant Identification

A plant identification system shall be applied to all equipment within the Contractor's scope of supply.

Following Contract award and prior to issuing the initial design documentation the Contractor shall submit a detailed, Project specific plant identification system manual for approval to the Employer, this manual shall be maintained and updated as necessary throughout the Project.

The plant identification system manual shall include details of the following aspects of the system:

- Symbols, identifiers and numbering principles used on design documentation such as piping and instrumentation diagrams and electrical single line diagrams;
- Designation of instrument and control devices;
- Method of identifying different types of valves and instruments from the tag number;
- Numbering principles applied to cables, cable cores and junction boxes;
- Method of identifying piping breaks and piping functions;
- Identification of control signals, control functions, controller (within hardware and software);
- Incorporation of system or equipment numbers into the Project document numbering system.

#### 2.4.3.4 Basic Interfacing

##### 2.4.3.4.1 Binary signals

Potential free contacts shall be provided for status signals. Mechanically operated switches shall have snap action, the switch contacts shall be change over type and interrogated at +48 V dc.

Control signals shall be a pulsed square wave type output at either +24 or +48 V dc and maintained for a time period that is variable up to 1 second.

Where interposing relays are required to operate equipment, these shall be supplied by the equipment supplier and installed in his cabinets. These interposing relay coils shall not require more than 100 mA to operate.

Pulsed signals shall be available as either a single pulse or pulse stream.

Contacts used on all circuits which interface with the plant control system (PCS) shall be gold plated and suitable for low voltage and current operation. Wherever possible they should be hermetically sealed.

##### 2.4.3.4.2 Analogue signals

Analogue signals shall be in the 4 to 20 mA range at 24 V dc.

A 0 to 20 mA signal shall be acceptable for electrical transducers only if 4 to 20 mA is not available.



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Where an analogue signal has more than one destination, signal isolators shall be used to provide galvanic isolation between the two circuits.

#### 2.4.3.4.3 Wiring

For standard applications the field cabling requirements are given in General Electrical Requirements section of the specifications. Additionally, the conductor size multi-core control cables and multi-pair control cables shall not be less than 1.5 mm2 (7/0.53).

Cable used for external wiring for analogue signals shall be twisted pair, individually screened, poly vinyl chloride (PVC) with low smoke zero halogen (LSZH) sheath overall screened multi-pair cable with a copper drain wire.

For special applications, e.g. thermocouple, resistance temperature device (RTD), vibration sensing circuits, data etc. other cable types may be used, subject to approval from the Employer.

### 2.4.4 LOCAL CONTROL SYSTEMS

#### 2.4.4.1 General Requirements

Certain specialized, packaged equipment shall be supplied with a local control system provided by the equipment manufacturer.

The control and instrumentation requirements stated in this specification shall be deemed to be applicable to any equipment supplied as part of a package.

Where local control systems are provided these shall be suitably interfaced with or integrated into the PCS, to enable the supervisory control and monitoring of the local control system by the operators via the PCS HMI in the Central Control Room (CCR).

The signal exchange between the local control systems and the PCS shall be finalized during the design phase

The inputs and outputs associated with each local control system shall include: start/stop commands; trip, alarm, permissive and interlock signals; operational status and diagnostic data; condition monitoring data; all sufficient to allow safe and efficient operation of the Plant and for the purposes of performance monitoring and reliability centered maintenance.

Serial data communication may be adopted for bulk data exchange with the PCS, except for safety related signals and critical control commands and measurements, which shall be hardwired.

Where safety and reliability in operation of certain packages is critical the local control systems shall be subject to redundancy of communication, power supplies, processors and critical process measurements. Where redundant communication with the PCS cannot be implemented, the use of remote PCS I/O with redundant communication and/or hard-wired backup of the serial data link shall be considered.

All local control systems shall be synchronized to the master clock system used for the PCS and all events are time stamped at source on the same basis.

It shall be possible to operate all local control systems independent of the PCS in both manual and automatic modes. Local operations shall include start up, continuous operation and shut down of the packaged equipment and its associated auxiliaries. During such operation the equipment shall be interlocked with other areas as necessary to prevent any unsafe condition.



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In general, loss of communication with the PCS should not cause the system to failure of the local control system or the associated plant.

#### 2.4.4.2 Mimic Panels

Process or electrical one-line mimic diagrams shall be installed on panels where specified or alternatively where their presence would assist plant operators in assimilating the operational state of the Plant. Mimic diagrams shall meet the following general requirements:

- Different and distinctive colours shall be used for the different media around the plant or for different voltage levels on electrical mimics. The assignment of colours shall be subject to approval by the Employer.
- The position of valves, switchgear and other controlling devices shall be indicated by continuous position indicators. The position of isolating valves, dampers or switchgear shall be indicated by high intensity light emitting diodes (LEDs).
- Operation of isolating valves, isolating dampers or switchgear from the mimic shall be by means of discrepancy switches, rotary switches or push-buttons designed to perform in a similar manner.

Mimic panels that are not located in a secure control room are required to have a means of securing the controls from unauthorized use.

### 2.4.5 EMERGENCY STOP PUSH BUTTONS

Red, mushroom pattern, mechanically latching push buttons, with key-switch reset and hinged protective hoods, hard wired to the plant control circuit, shall be adopted for emergency stop push buttons throughout the plant and in control rooms

### 2.4.6 PROGRAMMABLE LOGIC CONTROLLERS (PLCS)

#### 2.4.6.1 General

Where local control systems are of significant size or complexity they shall utilize PLCs. These shall be selected from the same product range, designed, manufactured and configured in accordance with recognized international standards and with proven prior applications in the power generation industry.

The PLC product range shall be scalable so that each installed system is suited to its application in terms of memory size, I/O capacity and I/O type. Selection of the PLC product range shall also consider the communication protocols and media supported by the range to ensure the PLCs can be seamlessly integrated with the PCS.

The PLCs shall be back plane mounted and of modular construction. Any of the modules shall be replaceable while the PLC is under power without disruption of any other modules within the system.

As well as the installed spare I/O capacity specified, the PLC systems shall allow for the addition of I/O modules wherever this is required for future system expansion.

Programming languages and techniques shall conform to a recognized international standard.



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### 2.4.6.2 PLC Configuration

Redundant PLC processors shall be installed for local control systems, the processors shall be synchronized such that switching over to a standby processor does not result in any disturbance to the PLC outputs and is transparent to the PCS operators.

The PLC systems shall be supplied complete with portable computers, programming software, licenses, connecting leads, etc. sufficient to allow maintenance, testing and reconfiguration of any of the installed PLC systems.

Configuration of the installed application software shall be protected by means of key-switch and password security to prevent unauthorized modification of the software.

The configuration tools shall include a facility for forcing I/O points for testing, commissioning and maintenance purposes.

Where redundancy exists in the equipment being controlled, I/O signals shall be segregated and configured such that failure of a single I/O module shall not jeopardize continued operation of that equipment.

Failure of any module shall be alarmed at the PCS.

The failure modes of the PLC modules and communication interfaces shall be configured specifically for each application, the failed state of any PLC output shall depend upon the equipment being controlled, its criticality with respect to continued power generation and the implementation of safety functions related to that equipment.

### 2.4.6.3 PLC Documentation

Application programs shall be designed and documented to facilitate user understanding and future modification by maintenance staff. Textual remarks shall be included throughout the program to explain or clarify the control logic.

As-built copies of the application programs shall be provided in hard copy and electronic formats. During the design and implementation phase, however, program listings shall not be required for review.

The PLC system design documentation to be submitted for review shall take the form of a functional design specification (FDS), which shall include the following:

- System overview;
- Functional block diagrams and descriptions of the controls, sequences, safety functions, etc.;
- Hardware to be supplied;
- Instruction on system hardware settings, software files and versions used, application files and how they are installed;
- Operational procedures and system set points;
- Interfaces: HMI, plant and system interfaces, communication protocol definitions, I/O lists;
- Availability data;
- Acceptance testing procedure;
- Training proposals.



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## 2.4.7 FIELD EQUIPMENT

### 2.4.7.1 General Requirements

Plant protection functions shall be implemented using redundant measurements, regardless of where the logic element of the safety function is implemented. This redundancy shall be in the form of multiple sensors with suitable signal processing and voting installed in the control and protection system. The turbine control systems shall be provided with the manufacturer's recommended protection functions.

In general, transmitters shall be employed for deriving process switching functions.

All instruments shall be protected by cases and positioned for ease of access and viewing. Cases shall have a minimum IP enclosure classification in accordance with the relevant international standards.

Electronic instruments shall not be located in locations liable to dripping or draining of water. Ambient temperature up to 55 °C shall not result in calibration difficulties or rapid deterioration of electronic components. For locations in direct sunlight, appropriate sunshades shall be provided.

Analogue signals shall be standardized at 4 to 20 mA DC in the field. Plant status and alarm signals shall be standardized to a DC voltage level between 22 to 50 volts. Pneumatic transmission and control signals where offered shall be of the 0.2 to 1.0 bar (3 to 15 psi) standard range.

Measurement and control instrumentation shall have high electro-magnetic and radio frequency interference immunity and low emission radiation to the appropriate international standards and shall not be affected by portable radio transmitters operated in the vicinity of the equipment.

All instruments whether for local indication or remote transmission shall be of good quality and shall have an accuracy and repeatability appropriate to their duty. The Contractor shall state the accuracy and repeatability of each instrument in the documentation.

The ranges of all instruments shall be arranged, where practicable, so that normal working indication is at approximately 60 % of full-scale deflection, with the exception of devices based on a square root relationship which shall normally work at 75 %.

Measurement and control instrumentation equipment shall be matched to the main plant equipment ratings in all respects. Installation codes of practice and precautionary measures for safety of the Plant and the operating and maintenance personnel shall be followed.

Each field mounted instrument or device shall be properly labelled as detailed elsewhere in the Specification. All instruments shall be identified by appropriate tag numbers; permanent, non-perishable, nameplates attached to each instrument shall be used for this purpose. Nameplates shall be attached by permanent mechanical fasteners.

Further, every such instrument or device incorporating an indicator shall also be labelled with its duty description.

### 2.4.7.2 Electronic Transmitters

All transmitters shall be fitted with an output indicator. Transmitters for process variables such as pressure or temperature shall be dedicated devices. Slave transmitter devices, driven from gauge mechanisms are unacceptable.

Transmitters shall be provided with all necessary isolating, vent and blowdown valves, thermometer pockets and interconnecting pipe work. Interconnecting pipe work shall be stainless steel. Transmitters subjected to high pressure (above 40 bars unless otherwise agreed) shall be provided with double isolation valves to all services.

All transmitters shall be supported in a vibration free manner independently of the plant connections and shall be mounted in the correct attitude. No stress shall be imposed through the connections between the plant and the transmitter.

Where practicable, transmitters shall be grouped together into enclosed racks or panels for easy access. Mechanical and electrical sections of these panels shall be segregated.

Facilities shall be provided for the connection of test instruments to the input and output of each transmitter to enable in-situ calibration to be carried out.

Bodies, primary elements and wetted parts shall be of a material that is corrosion resistant to the process fluid and the environmental conditions.

Differential pressure (DP) and DP flow transmitters shall be furnished with a close coupled equalizing five-valve manifold.

Variable area type flow transmitters shall be of all metal construction with an appropriate means of analogue signal transmission.

To maintain minimum spares holding, the range of transmitters used for general pressure and differential pressure applications shall have facilities for simple in-situ range changing without changing of components. Each type of transmitter within the range shall exhibit a minimum of 4:1 between maximum and minimum spans, but preferably 6:1. In addition each transmitter shall incorporate means of zero suppression or elevation allowing zero shifts equivalent to 100% of maximum transmitter span.

All differential pressure transmitters shall be capable of withstanding, without damage or calibration change, full rated line pressure as a differential input. Pressure transmitters shall withstand at least 150% of nominal input range without damage or calibration change.

Transmitters for use with electrical input signals such as thermocouples or resistance temperature detectors shall allow range changing in-situ. They shall incorporate electrical isolation between input and output.

### 2.4.7.3 Smart Transmitters

Smart transmitters that allow interrogation of transmitters by handheld communicators may be employed for all general-purpose duties such as flow, level, temperature, pressure etc. Additionally, these transmitters may be used for direct digital communication with the PCS, defining the communication protocol proposed.

The transmitters shall have been in operational service for a minimum of three (03) years and shall be sourced from a single manufacturer of international standing.

The number of portable communicators shall be subject to the approval from Employer; however, it shall not be less than one (01) communicator per 50 smart transmitters or part thereof.

SMART transmitters shall have the following features:

- Transmitters using the HART protocol are preferred
- All types shall be configured and re-ranged by a common communicator.
- The output shall be 4 to 20 mA linear.
- Digital output shall be available as an option.
- Self-diagnostics shall be provided.
- Self-tagging and identification.
- Protection shall be provided against radio frequency interference (RFI), voltage surges and reverse polarity.
- Input/output isolation.
- An integral output indicator shall be provided scaled 0 to100 %.
- Zero elevation or suppression.
- Microprocessor based electronics.
- Accuracy shall be better than 0.2% of span for 4 to 20 mA outputs.
- Built in ambient pressure and temperature compensation.

Other requirements shall conform to the table of minimum requirements for electronic transmitters.

#### 2.4.7.4 Temperature Measurement

Mercury-in-glass thermometers are not permitted.

##### 2.4.7.4.1 Electrical Temperature Measurement

Temperature measurement shall be carried out using resistance temperature detectors, (RTDs) unless conditions dictate RTDs are unsuitable, then thermocouples shall be used.

RTDs shall be Platinum Pt100 three wire type and all RTDs and thermocouples shall be duplex.

Temperature readings required for the calculation of performance data should have an accuracy of ±0.2 % in their normal operating range.

Where a temperature measurement is to be used for control purposes, head mounted transmitters with 4 to 20 mA output signals and local indication shall be provided. In other cases, the use of signal converters is allowable provided the length of cable run does not exceed 50 m.

In all cases a length of flexible cable of 1.5 m shall be connected between the head of the temperature sensor and a local junction box to allow for the withdrawal of the sensor from its pocket without disconnection of the cable.

Where thermocouple extension leads are provided these shall have the same conductor materials as those of the thermocouple. Wherever practicable thermocouple extension leads shall be terminated locally to the plant in groups and the Contractor shall state the method of cold junction compensation on the schematic diagram for each application.

Thermocouple compensating cable shall be appropriate to the thermocouple, right up to the point of cold junction compensation.

Resistance Thermocouple Detectors (RTD's) shall conform to IEC 60751 "Industrial platinum resistance thermometer sensors". They shall have a resistance of 10 ohms at 25°C.

Thermocouples shall comply with IEC 60584 "Thermocouples". Extension leads for all thermocouple devices shall run in compensating cable up to the point of the cold junction compensation.

High speed response pockets shall be provided for all applications involving control of critical process temperatures.

**2.4.7.4.2 Dial Type Temperature Measurement**

Filled system dial thermometers fitted with over-temperature alarm and trip contacts shall be used where specified for critical temperature measurement and shut down of plant. The dials shall be panel-mounted.

Additionally, filled system and bi-metallic type dial thermometers shall be used as appropriate for local indications in the field. The minimum dial size shall be 100mm diameter. The use of mercury as a fill material shall not be permitted.

The capillaries of filled system thermometers shall be armored, the material of capillary, armoring, fitting and case shall be 316 stainless steel.

**2.4.7.5 Pressure Measurement**

This clause applies to pressure, differential pressure and head-type level instruments.

All pressure instruments shall be capable of continuous operation at the maximum pressure indicated on the chart or scale. All pressure instruments shall have suitable over-range protection.

A pressure instrument installed for measurement of steady pressure shall normally operate at 75 % of its maximum range.

All local mounted pressure gauges shall comply with the appropriate international standard and shall have a dial size of 150 mm diameter.

In locations with high humidity all pressure and differential pressure gauge case materials shall be 316 stainless steel.

All pressure gauges shall be provided with instrument isolation vent and test (two-way) valve assembly. All wetted materials shall be 316 stainless steel. The assembly shall be additional to the primary isolation valve. All pressure gauges shall be of the heavy-duty process type and shall be liquid filled.

All differential pressure gauges shall be provided with five valve (five-way) manifolds. All wetted materials shall be 316 stainless steel. Liquid-in-glass manometers shall not be used for pressure and differential pressure gauges. Three-way valve assemblies shall not be used.

All pressure and differential pressure switches and transmitters shall be generally separate from and independent to gauges. Integral local gauge and switch/transmitter units shall not be used and separate devices shall be provided for the separate functions of local observation and of remote monitoring and of interlocking.

Not more than two pressure measuring devices shall be supplied from one tapping point. Each pressure measuring device shall have its own isolating valve(s) close at the tapping point.

Where pressure signals are used for control and/or interlocking systems each device shall have a dedicated tapping point.

### 2.4.7.6 Flow Measurement

Flow shall be measured in mass or volume rate according to the units of measurement normally associated with each type of service.

The accuracy of flow measurements shall be appropriate to the duty concerned and shall be subject to the Employer approval in cases where fiscal and critical control measurements are concerned.

Where flow meters are used with totalizers to provide total consumption for efficiency or fiscal purposes, then such flow meter circuits shall be provided with low flow cut-offs so that when the line is out of service or shutdown, the flow integrators do not increment due to instrument zero drift.

Differential pressure meters in conjunction with square edged concentric orifice plates (or flow nozzles) shall normally be used for the measurement of fluid flow in pipes except in the following cases:

- Where the requirement of accuracy cannot be met.
- Where wide ranges of flow rate exist.
- Where there are limitations of system pressure drop.
- Where piping configurations are restrictive, e.g. fully welded construction.
- Lines subject to pulsation.

Magnetic type flow meters, flow nozzles and venturi tubes may be considered as alternatives.

Eccentric or segmental orifice plates shall be used for measurement of fluids carrying suspended matter that might tend to cause build-up.

Orifice plates and flow nozzles shall be manufactured in 316 stainless steel unless otherwise specified or required by the nature of the process fluid.

Manufacturing tolerances and installation details for orifice plates and flow nozzles shall comply with ISO standards.

Positive displacement type or turbine type meters may be used as an alternative providing their use for such purposes is within the acceptable limits of the measurement requirements and approved by the Employer.

Ultrasonic, vortex, Coriolis, averaging pitot or other types of flow meters may be used under special circumstances subject to approval from the Employer.

Where the in-line portion of the flow meter is removable, upstream and downstream isolation valves, drains, vents and purge points shall be provided as necessary to enable dismantling and removal of the flow meter assembly. The location of such isolation points, drains and vents and the upstream and downstream piping layout shall conform to the requirements for ensuring best accuracy of the flow meter.

Flow straighteners and minimum upstream and downstream straight piping lengths shall comply with the ISO requirements for "zero additional uncertainty" in the flow coefficient; this applies to the criteria for the first upstream length between the meter and the first upstream fitting and the second upstream length between the first and second upstream fittings, as well as the downstream length.

Metering runs shall be kept to a minimum and shall conform to the appropriate international standard.

Meter run piping and isolation valves shall conform to not less than the main pipeline rating to which they are connected.

Tags on orifice plates shall be stamped with the basic design information (i.e. flow rate and direction, pressure and temperature of the passing fluid, the orifice diameter and the pressure differential generated). The tag shall indicate the upstream side of the orifice plate.

In general, orifice plates shall be designed for flange taps. Other tapping arrangements may be used, after approval from the Employer.

**2.4.7.7 Level Measurement**

Level measurement shall generally be made by either displacement or differential pressure measurement. However, for special applications techniques such as ultrasonic beams, capacitance probes, radar, etc., shall be considered, provided that suitable signal conditioning is supplied to generate the standard signal range.

Where the use of level switches has been specifically approved, simple float operated switches should be adopted. Switches shall have a snap action with limited hysteresis to prevent contact bounce caused by small fluctuations in level. Switches shall be fitted within external chambers provided with isolation valves, drains and vents. These chambers shall be in accordance with the mechanical piping specification. It shall be possible to isolate all level switches and to drain the chamber and to test the mechanical and electrical operation of the switch without its removal from the process and without shutdown of the process.

It shall be possible with both the displacer type and differential pressure type of transmitter to isolate the transmitter from the process by suitable tight shut-off valves conforming to the pressure rating of the vessel to which they are connected and allow removal of the transmitter for maintenance without causing shutdown of the process.

Switches that are operated by magnetic coupling by attachment of the switch to gauge tubes shall not be used for tripping but may be used for alarm only.

It shall be possible with both the displacer type and differential pressure type of transmitter to isolate the transmitter from the process by suitable tight shut-off valves conforming to the pressure rating of the vessel to which they are connected and allow removal of the transmitter for maintenance without causing shutdown of the process.

For measurement of large storage tanks, the level indication and where possible the sensing device and transmitting mechanism shall be located at the base of the tank to allow the system to be observed and maintained from ground level.

Tank gauging systems of suspended float type shall have all components of 316L stainless steel, unless otherwise specified or required by the nature of the process fluid; this includes the materials for wire, pipe, fittings, sheave, elbows, etc.

On differential pressure types of measurement where a reference leg of process fluid is used, the design of the system shall ensure that the reference leg is fully maintained at its prescribed height during all conditions of process level change and changes in process conditions and that the density of the reference leg does not vary from that of the process fluid because of temperature changes or other reasons.

For local indication of level, gauge glasses may be used providing they conform to the rated design criteria for the vessel, are equipped with quick closing isolation valves, lever handles and replaceable sets. Isolating valves for gauge glasses shall be fitted with ball checks.

Transparent or reflex type gauge glasses shall be used as and where service conditions allow.

All tubular glass type gauges shall be furnished with safety protective shields.

Connections shall be provided at the top and bottom of the gauge glass for draining and flushing purposes.

All types of level device shall be installed so that removal of the device is possible with the tank or vessel full and/or with the process in operation. This requirement applies to all types of storage tanks and process vessels.

#### 2.4.7.8 Actuators

##### 2.4.7.8.1 General

Actuators for valves shall be electrically operated. Self-contained hydraulic units may be considered where high thrusts or high speeds of operation are required.

Actuators for ON/OFF duty or manually positioned units shall generally be electric motor driven; however, the use of solenoid types on small valves shall be allowed, depending on the duty.

The various types and sizes of actuators shall be rationalized and as far as possible each type shall be from a common manufacturer to facilitate inter-changeability and to minimize spares holdings.

The operation of all actuators, control valves and driven units, shall be so arranged as to ensure the safety of the Plant under failure of control or actuating supplies.

Unless otherwise specified, the failure of a control signal or actuator power supply shall result in one of the following:

- Cause the actuator to move to a safe position.
- Freeze the actuator in its last operating position.
- Cause driven equipment to stop.

In any case the failure mode shall be suitably monitored and the operators informed by an alarm and the failure mode shall be selected to comply with the design and operational requirements of the Plant.

Where the type of actuator offered does not have the appropriate fail-safe facilities described above then the valve or damper shall have a second valve or damper in series or in parallel with it as appropriate to provide the correct failure response.

When an actuator freezes or moves to a safe position on failure detection, it shall not be possible to return to automatic control without resetting action by the operator after restoration of the power supply or control signal. Similarly, remote manual control should not be possible if this would allow the possibility of large disturbances to operating plant.

Each actuator shall be fitted with a position transmitter for indication of actuator position. This requirement applies irrespective of the operating mechanism, whether electric or hydraulic.

Where control requirements call for split range operation, the computing of the split range shall be carried out externally from the actuator such that standard signal inputs to the actuator are maintained.

All actuators shall incorporate a mechanical device to show the true position of the operating mechanism.

All actuators shall have a hand wheel or lever for direct manual operation. The diameter of the hand wheel and geared effort shall be such that they are reasonably operable by one operator. A lockable mechanical clutch mechanism shall be provided to inhibit power control of the actuators when the hand wheel is operated. The disengagement for hand control shall signal remotely to indicate that the normal operation of the actuator is inhibited.

For electric actuators two classes are covered in the sections below: actuators for ON/OFF, isolating duties and open loop control; and actuators of the switched type and continuous control type required for modulating, closed loop control. Unless otherwise agreed fully integrated or self-contained units shall be provided for all electrical actuators so that all components are located on the valve, within the actuator enclosure.

#### 2.4.7.8.2 Electric Actuators for Isolating Duties

In addition to general actuator features specified above, the following features shall be provided for each actuator:

- DC interposing relays for open and close (raise and lower) commands.
- Open and close travel limit switches (each with change-over contacts) for status feedback to the control system.
- Open and close indicating lamps.
- Open and close push buttons for local control.
- Power supply failure monitoring and alarm.
- Key switch for local/remote control mode selection.
- Analogue actuator position output signal.
- Thermal overload protection and thermal winding protection.
- The DC interposing relays shall operate at the normal control system I/O binary control voltage level.

#### 2.4.7.8.3 Electric Actuators for Modulating Duties

Two principal types are recognized:

- Switched Actuators - Each actuator shall be driven by a duration modulated switched power signal at the full AC supply voltage. The actuator shall feature either electromagnetic or mechanical braking. However, the latter shall only be accepted on low power single phase actuators and a brake life in excess of 107 operations shall be guaranteed by the Contractor. They shall not be used when full travel times of less than 15 seconds are required.
- Continuous Control Actuators - For each actuator the drive voltage and current or frequency of the AC power source shall be continuously varied to regulate the rate of operation. Each shall be capable of slow creep operations as well as rapid stroke action and the operating torque shall be sensibly independent of the speed of operation. Continuous control actuators shall be provided for all demanding modulating control applications in which high torque, a wide range of stroke rate and frequent correction is anticipated.

Static power amplifiers or switch units shall be provided for either type of modulating actuator.



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The actuator and associated power amplifier unit shall be manufactured as a composite system; this configuration shall have a minimum of three years of proven service reliability. The actuator and drive unit shall be rated continuously for the stalled condition and three phase motors shall be provided for all actuators with ratings above 250 watts.

The following features shall be provided for each actuator:

- The drive unit shall accept an analogue 4-20 mA actuator position demand signal or pulsed raise and lower signals if an external position loop is provided.
- An analogue actuator position feedback signal.
- A test facility.
- An override facility for stroking the actuator in either direction for binary control interventions.
- Monitoring of common fault conditions such as thyristor drive fault, motor temperature high, AC power supply failure, circuit continuity fault, etc.
- All necessary protection devices to protect the actuator and drive unit against abnormal operating conditions.

The Employer approval shall be required where different types of actuators are offered to those specified above or where the drive unit and actuator are selected from different ranges or manufactures. Additionally, these shall be subject to a type test to prove their satisfactory performance under equivalent operation conditions.

#### 2.4.7.8.4 Electro-Hydraulic Actuators

Generally, these actuators shall only be used where high thrusts are required, combined with fast operating times, and the application requirements cannot be met by the standard range of actuators used in the Project.

The units offered shall be of the self-contained, fully sealed types which allow removal of the complete unit to a clean room for any maintenance requirements.

Units accepting either 4-20 mA signals or pulsed input signals shall be acceptable.

Failure of the internal hydraulic supply shall result in the actuator locking in its last operating position or stroking to its fail-safe position and a suitable alarm shall be given to the operator.

### 2.4.7.9 Instrument Piping

Instrument piping shall be of copper or stainless steel.

### 2.4.7.10 Electrical Meters

All electrical meters shall comply with IEC 62052 and 62053 "Class 0.5, 1 and 2 alternating-current watt-hour meters", and shall be of industrial grade accuracy. Three phase power measuring instruments shall be of the 3-phase unbalanced load pattern wherever the current and voltage references permit. Volt meters shall be provided with selector switches.

### 2.4.7.11 Junction Boxes

Junction boxes shall be used for routing of control related signals and shall be constructed from sheet steel. Stainless steel shall be used for outdoor applications and where damp conditions may be expected.

Separate junction boxes shall be provided for the following circuits:

- AC and DC circuits.
- Instrumentation signals.
- Protection/safety circuits.
- Electrical power circuits.
- Intrinsically safe circuits.

All terminals and junction boxes used on intrinsically safe circuits shall be coloured light blue.

Terminals within junction boxes shall preferably be mounted vertically and arranged to provide ease of core termination and adequate routing space. The blocks shall be individually referenced and the terminals numbered according to the wiring diagrams. Terminals for power circuits shall be shrouded. Sufficient terminals shall be provided to terminate all signal wires (including spare wires) and for connecting the cable screens where appropriate.

All electrical interface connections such as instruments, pushbutton stations, etc. shall be terminated in a junction box.

No package wiring shall be connected to the field wiring side of the terminal blocks.

Terminations shall comply with the requirements stipulated for Control Panels.

### 2.4.8 NAMEPLATES

Each field mounted instrument or device shall be properly labelled and identified by appropriate tag numbers; permanent, non-perishable, nameplates attached to each instrument or device shall be used for this purpose. Nameplates shall be attached by permanent mechanical fasteners.

Name plates on orifice plates shall be stamped with the basic design information: flow rate and direction, pressure and temperature of the process fluid, the orifice diameter and the pressure differential generated. The name plate shall indicate the upstream side of the orifice plate.

### 2.4.9 EARTHING

The Contractor shall submit his proposed earthing arrangements for approval by the Employer.

The Contractor shall be responsible for ensuring compatibility and continuity of control system earthing across the entire plant. All earth connections for the control system shall be made via a single path to the station earth. Earths separate from the station system shall not be permitted for safety reasons.



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# SECTION 3 BASIC DESIGN CRITERIA

## 3.1 GENERAL

The design of all structures shall be carried out based on current internationally recognized standards and / or guidelines widely accepted and adopted by the hydropower engineering professionals. The design standards adopted should as far as possible, be from a single authority and be available in the language of EPC Contract. The design of the project will be submitted by the Contractor to the Employer for review and approval by the Employer.

The complete standards and design codes that will be proposed by the Contractor shall be subject to review of the Employer. A complete set of such standards and codes shall be kept on the Site for the use of the Project.

### 3.1.1 Design Criteria and Requirements

The detailed design shall be based upon the design criteria stated herein, the Design Memoranda submitted with Contractor's Proposal, and additional Design Memoranda and design analysis as necessary to complete the design of the works.

The permanent works shall be designed according to the latest version of international standards relevant to the particular section of works such as ACI-318-01 and allied codes. Temporary works shall be designed to be safe, reliable, and adequate for all loads and uses, and where they are to be incorporated into the permanent works temporary works shall be designed in strict compliance with the criteria adopted for the permanent works.

### 3.1.2 Compliance with Local Regulations

In addition to the Basic design criteria, the design shall also conform to the requirements of all relevant local, state and federal authorities where approvals for that section of works is needed from the relevant authorities.

### 3.1.3 Economic Life of Works

The design shall be based upon a useful economic life of fifty (50) years for all elements of permanent structural facilities assuming the Employer will perform normal routine maintenance; and not less than twenty-five (25) years for equipment, assuming the Employer will operate the works and perform normal routine maintenance in accordance with the works operation and maintenance manuals.

### 3.1.4 References and Standards

a. Except where specified, all design and construction work, including the materials used and methods applied, shall be in accordance with internationally recognized standards of practice as mentioned in Table 2-1.
b. The Contractor must make available two copies of such standards in English language.
c. Where there are differences between the various standards; the most stringent standards shall be adopted so that the completed work shall be safe, durable and adequate for intended purpose under most severe loading conditions
d. Should the standards referenced herein not be applicable, other relevant standards may be used subject to Employer's approval. The Contractor may propose alternative standards where desired, provided that standards prepared by internationally recognized organizations are proposed. Differences between the standards specified



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and the proposed alternative standards must be fully described in writing by the Contractor and submitted to the Employer for review and acceptance.

e. If other standards are chosen, the Contractor shall supply copies of those standards in English language only, clearly identifying or referring to the particular chapters or sections that shall be applied.

f. Where ever the term “or equivalent International Standards” is mentioned in the bidding documents; that is subject to approval of the client and valid for successful Proposer only after award of the contract.

g. Unless otherwise specified, all equipment in the Complex, including electro-mechanical and hydro-mechanical equipment and systems shall be designed, built/fabricated, installed, tested, and commissioned in accordance with the latest editions and amendments of Standards and Codes of the following institutions.

**Table 3-1: Reference Standards**

| | |
|---|---|
| DIN | Deutsche Industrie Normen |
| ASTM | American Society for Testing and Materials |
| AISI | American Iron and Steel Institute |
| EN | European Standard |
| ASME | American Society of Mechanical Engineers, Boiler and Pressure Vessel Code |
| IEC | International Electro Technical Commission |
| AISC | American Institute of Steel Construction |
| AWS | American Welding Society |
| AGMA | American Gear Manufacturers Association |
| AWWA | American Water Works Association |
| AISE | Guide for the Design and Construction of Mill Buildings |
| CMAA | Crane Manufacturers Association of America |
| ANSI | American National Standards Institute |
| ABMA | American Bearing Manufacturers Association |
| NEC | National Electrical Code |
| ASHRAE | American Society of Heating, Refrigeration & Air Conditioning Engineers |
| SSPC | Steel Structures Painting Council |
| IAPMO | Uniform Plumbing Code of International Association of Plumbing & Mechanical Officials |
| HI | Hydraulics Institute |
| MSS | Manufacturers Standardization Society of the Valve and Fittings Industry |
| NFPA | National Fire Protection Association |
| NFP (A) | National Fluid Power Association |
| NEMA | National Electrical Manufactures Association |
| IEEE | Institute of Electrical and Electronic Engineers |
| ICEA | Insulated Cable Engineers Association |
| OSHA | Occupational Safety and Health Administration |



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h. The following codes, standards, and specifications will generally be considered as part of these design criteria. The applicable version of each document will be the latest edition in force at the time the project design is started, unless noted otherwise.

1. Precast/Prestressed Concrete Institute (PCI), “Design Handbook for Precast and Prestressed concrete”
2. Post Tensioning Institute (PTI), “Post-Tensioning Manual”
3. Steel Specifications for Outdoor Stations, NEMA Section 568-200, Power and Equipment Standards
4. National Design Specifications (NDS) for Wood Construction
5. American Society of Civil Engineers (ASCE), “ASCE 7, Minimum Design Loads for Buildings and Other Structures”
6. American Welding Society (AWS), “Standard Welding Code”
7. American Welding Society (AWS), “Standard Welding Code”
8. American Association of State Highway and Transportation Safety Officials (AASHTO) Standard Specifications or an equivalent standard can be applied
9. Bulletin 95 International Commission on Large Dams, “Granular Filters and Drains for Embankment Dams”
10. Applicable local Pakistani building Standards and Codes, equivalent to the Standards and Codes listed above
11. Guides RCC Bridges and Culverts, CDO (WAPDA, Water) Publication No. 2.14, 1991
12. "Earth Manual", United States Department of Interior, Bureau of Reclamation (USBR)
13. Deere, D, 1989, "Rock Quality Designation (RQD) After Twenty Years" by Don U. Deere, U.S. Army Corps of Contractors, February 1989
14. Tunnels and Shafts in Rock EM 1110-2-2901 US Corps of Engineers
15. Barton, 1974, "Review of a New Sheer-Strength, Criterion for Rock Joints", Engineering Geology, Norwegian Geotechnical Institute, by N. Barton (1974), pub. 105, Oslo 1974
16. Alverez, T.A, Cording, E. and Fernandez. G. G., (1999), "Pressure Tunnels in Fractured Rock: Minimum Cover Criteria from the Stability of Rock Wedges", Proc. 3rd National Conference on Geo-Engineering for Underground Facilities, Urbana-Champaign, ASCE SP No. 90
17. ISRM, 1978a. Suggested method for petrographic description of rocks. International journal of rock mechanics and mining sciences & geomechanics abstracts, vol. 15, pp. 43-45
18. ISRM. 1978b. Suggested methods for the quantitative description of discontinuities in rock mass. International journal of rock mechanics, mining sciences & geomechanics abstracts, vol. 15, pp. 319-368
19. ISRM, 1979a. Suggested methods for determining water content, porosity, density, absorption and related properties and swelling and slake durability index properties. International journal of rock mechanics and mining sciences & geomechanics abstracts, vol. 16, pp. 141-156
20. , 1979b. Suggested methods for determining the uniaxial compressive strength and deformability of rock material. International journal of rock



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mechanics and mining sciences & geomechanics abstracts, vol. 16, pp. 135-140

21. ISRM, 1985. Suggested method for determining point load strength. International journal of rock mechanics and mining sciences & geomechanics abstracts, vol. 22, pp. 51-60
22. Bandis S. C. 1993. Engineering properties and characterization of rock discontinuities. Comprehensive rock engineering, J. A. Hudson ed. Pergamon, vol. 1, pp. 155-183
23. Barton N. 1995. The influence of joint properties in modeling jointed rock masses. Keynote lecture. 8th congress of ISRM, Rotterdam Balkema, vol. 3
24. Barton N. and Choubey V. 1977. The shear strength of rock joints in theory and practice. Rock mechanics, vol. 10, pp. 1-54
25. Bieniawaski Z. T. 1989. Engineering rock mass classifications. A complete manual for engineers and geologists in mining, civil, and petroleum engineering. John Wiley & Sons, Inc., 251 p.
26. Bieniawaski Z. T. 1993. Classification of rock masses for engineering: The RMR-system and future trends. Comprehensive rock engineering, J. A. Hudson ed., vol. 3, pp. 553-573
27. Hoek E. and Brown E. T. 1980. Underground excavation in rock. Institute of mining and metallurgy, London, 527 p.
28. Hoek E. and Brown E. T. 1997. Practical estimates of rock mass strength. International journal of rock mechanics, mining sciences, vol. 34, pp. 1165-1186. Hoek E. and Marinos P. 2000. Predicting tunnel-squeezing problems in weak heterogeneous rock masses. Tunnels and tunneling international, vol. 32 (11 and 12), pp. 45-51 and pp. 34-36
29. Pakistan Building Code prepared by NESPAK
30. "Uniform Building Code" - International Conference of Building Officials
31. ASTM relevant Standards
32. AASHTO relevant standards
33. American Concrete Institute (ACI) related to Concrete, Shotcrete etc.
34. U.S. Army Corps of Engineers (USACE)
35. Properties of Concrete by A.M Nevile
36. Flexible Gabion Structures in River and Stream training works, Section 1, Weirs for River Training and Water Supply by Officine Maccaferri S.P.A. - Bologna, 1985.
37. American Welding Society (AWS), “Standard Welding Code”, and
38. American Society for Testing Materials and Standards (ASTM).

l. Occupational Safety and Health Administration (OSHA) Standards such as OSHA 29 CFR 1926 Standard and others.

### 3.1.5 Functional Requirements

The Attabad Hydropower Project shall be designed to operate as run-of-river project with an installed capacity of 55.68 MW (at generator terminals) using the design discharge of 60 m3/s and rated gross head of 110.14 m. The Project shall be designed for local manual and automatic operations.

### 3.1.6 Design Documents and Construction Drawings

All construction drawings shall be presented in a format compatible with AutoCAD version as advised.

The Contractor shall have staff at the Site to make revisions of drawings and documents during construction as needed to document of “as-built” conditions.

All documents provided shall be in the English language.

### 3.1.7 Units and Systems of Measurement

The system of measurement to be used in the Project shall be in SI units. When required, conversion of units and site data shall be the responsibility of the Contractor. Angles shall be given in the 360-degree system.

The coordinate reference system to be used for all Works in the Project shall be defined by a quadrant grid system. Each drawing shall contain a scale reflecting the appropriate meter spacing.

### 3.1.8 Future Inspections and Maintenance

Provisions shall be made to permit inspection and maintenance of all Works. Easy access and safety shall be provided for these operations.

### 3.1.9 Seismic Design Requirements

The design of the Permanent Works shall incorporate seismic loads appropriate to the project's location and geological conditions. The Civil Works EPC Contractor shall be responsible for the structural seismic design of all permanent civil structures, including the powerhouse, foundations, and embedded structures, ensuring compliance with the required seismic performance criteria.

The E&M Contractor shall be responsible for ensuring that all electro-mechanical equipment, auxiliary systems, and supporting structures are designed, installed, and anchored in accordance with the specified seismic requirements. The E&M Contractor shall coordinate with the Civil Works Contractor to obtain relevant structural response data, including dynamic characteristics, load transfer mechanisms, and anchoring provisions, to ensure seamless integration of equipment within the seismic-resistant civil structures.

Seismic design of critical structures shall be based on dynamic analyses, considering both Operational Basis Earthquake (OBE) and Maximum Credible Earthquake (MCE) events. The OBE and MCE shall be determined using internationally accepted probabilistic and deterministic earthquake analysis methods.

The E&M Contractor shall provide analytical verification and structural interaction assessments for critical components to demonstrate compliance with seismic design requirements. Both EPC Contractors shall ensure that all seismic-related design, installation, and mitigation measures are aligned to maintain the structural and operational integrity of the Project under seismic loading conditions.



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# SECTION 4 USE OF SITE AND ENVIRONMENTAL ASPECTS

## 4.1 USE OF SITE

### 4.1.1 General

The Contractor shall be responsible for ensuring that, during all the project activities on site, there should be no adverse impact on the operations of any structures owned by government of Pakistan and Gilgit Baltistan and Private sector.

### 4.1.2 Boundary of the Site

The Site includes areas for site installations, residential colony, offices. Contractor's camp and warehouses, storage yards, etc.

The Contractor shall make his own arrangements for any required areas outside the land provided by the Employer.

Areas outside the boundaries shown on the drawings that are used for quarries, borrow pits and disposal areas or where work is carried out or materials are stored shall not be part of the Site.

### 4.1.3 Setting Out of Site Installation

Setting out of site installation shall be carried out in accordance with the detail design drawings.

Should in any instance discrepancies occur between the drawings and the actual conditions at Site (topography, geology, etc.) the Contractor shall immediately notify the Employer and prepare an alternative proposal.

### 4.1.4 Regular Maintenance and Cleaning of Site Installation

During the entire construction period and until the end of the Contractor has cleared Site after the Completion Date, the Contractor shall provide a daily refuse collection and disposal service including loading, transportation and dumping at areas, where prior permission from the concerned authority has been obtained, in order to keep the Site in a proper, clean and safe condition.

### 4.1.5 Permanent & Temporary Access

The construction and maintenance of permanent & temporary access roads from public roads to the Site (including crossings) as well as temporary roads within the site boundaries and permanent site roads used as temporary access shall be included in the site installation. The Contractor shall undertake proper construction & maintenance of all roads used by him during the entire construction period, both permanent and existing roads, as well as all temporary roads.

Maintenance and cleaning of all roads used during construction to minimize danger, enhance use and reduce breakdown, including existing public roads, and bridges, shall be performed promptly upon notification by the Employer and shall include removal of slides, road surface repair and drainage system cleaning and upgrading, over the total construction period.



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The design and construction or modification of access roads shall be according to Pakistani Standards for both, temporary or permanent roads. These roads will be triple surface treated, designed and constructed in accordance with the AASHTO specifications.

The work shall include the, provision of such traffic control signals, lighting and signs as the Contractor may require or as requested by public authorities. All roads shall also be for the use by the Employer.

### 4.1.6 Car Park Areas

Site installation shall include the construction, maintenance and removal of the temporary car park areas for the site transport of the Contractor, Employer.

### 4.1.7 Storage Areas

The Contractor's site installation shall include the construction, maintenance and removal of temporary storage areas at the Site and at off-site locations chosen by the Contractor. They shall be indicated in the general layout drawings, inclusive of any additional temporary storage areas in or about the Site required in connection with the construction works. Temporary storage area shall include drainage facilities, sumps, oil traps, separators and isolation in case of storing chemicals and oil. Any land not located within the Site which the Contractor considers necessary for his site installation, shall be acquired by the Contractor at his own expense.

Storage areas and all other areas which be used for any project's construction activity shall, as a minimum, be furnished with a drainage layer of sand and gravel with a minimum thickness of 8 inches.

### 4.1.8 Project Sign Boards

The Contractor shall design, supply, erect and maintain one signboard, approximately 2 m wide by 1.5 m high, at the entrance of the Site or at a location to be agreed by the. The Employer shall review and agree the Contractor's design. The Contractor shall employ an experienced sign-writer to prepare the signboard.

The Contractor shall remove the signboard and associated footings on completion of the Works and leave the site in the specified condition.

The Contractor shall not display any advertisements within or around the Site without the prior written approval of the Employer.

### 4.1.9 Site Clearance at Completion

After completion of the Works, the Contractor, with prior approval of the Employer shall:

- Remove all Contractor’s buildings, installation and temporary facilities,
- Shall fill with earth all basements and underground areas, clean up and restore the terrain to its original condition, and
- Treat the excavations executed for his own convenience, such as temporary roads, in a way acceptable to the Employer.

If the Contractor shall fail to remove the buildings, plant, equipment and installations or if the operation shall not be made as specified within two (2) months from completion of the Works, such buildings, plant, equipment and installations may be removed by the Employer and the removal costs shall be deducted from the Contractor's final payment.

The Employer shall have the right to take-over a part or all of such buildings and installations at no extra cost. All buildings and installations shall be handed over in good condition.

Prior to Taking-Over of the Works, permanent roads used by the Contractor during the execution of the Works shall be left in good condition. With regard to temporary roads constructed for the Contractor's use, the Employer shall indicate in which condition the areas shall be left, and the Contractor shall establish this condition at his own cost.

## 4.2 ENVIRONMENT, SOCIAL, HEALTH AND SAFETY REQUIREMENTS

In addition to the responsibilities mentioned in section 1.11.13, the Contractor shall be responsible for the following.

### 4.2.1 Legal Requirements

The Contractor shall comply with all legal duties and obligations regarding the protection of the environment as laid down Laws and Regulation of Governments of Pakistan and Gilgit Baltistan.

### 4.2.2 ESHS Policy and Objectives

Contractor shall have in place OHS and Environmental and Social (E&S) policy including assurance framework. The policy shall pay due regard to the accountability of individuals, environmental protection, incident reporting, safety meetings and training. Contractor shall also have established arrangements for monitoring this policy.

Contractor shall have in place a formal management system that demonstrates commitment to continuous improvement and excellence in ESHS issues and which follows the ESHS applicable Regulations.

Contractor shall review its management system at least annually and update it as necessary.

Certain activities pose a higher risk to the safety of personnel, property and the environment. Higher risk activities will accordingly demand a higher level of ESHS commitment from Contractor’s management. Where the use of a sub-Contractor involves the importation of higher risk activity, Contractor must be able to demonstrate appropriate higher level of ESHS commitment.

Risk can vary from location to location and, where the Work is being performed at more than one location, Contractor shall observe and comply with all relevant and current Proponent directives.

### 4.2.3 Organization and Responsibility

The Contractor shall be responsible for managing the ESHS aspects during the construction phase of the projects in accordance with the requirements set forth in the EMP provided in the EIA Report of the proposed Project. The Contractor shall be responsible to comply with all the requirements mentioned in this section.

The detailed questionnaire for the selection of Proposers is attached as Annex-A in this Section 4 of Special Provisions. The following Table 4-1 illustrates the requisite deployment of Contractor’s staff for Environment Social Health and Safety (ESHS) during construction phase of the Project.



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**Table 4-1: Contractor's Staff for ESHS**

| Sr. No. | Contractor Staff Designation | Number of Personnel | Duration | Duties |
|---|---|---|---|---|
| 1 | Environmental Expert | 01 | Whole Construction Phase | • Coordinate with Top Management to ensure the implementation of Environmental Provisions at site.<br>• To ensure the use of SOPs during every working activities.<br>• Ensure the record maintenance of each environment related occurrences and communicate with their authority on regular basis.<br>• Responsible for preparation of monthly, quarterly and completion reports (and other if any).<br>• Responsible for implementation of EMP, NOC and other contractual as well as regulatory requirements triggered during the project execution.<br>• Responsible for supervision/ monitoring of all the waste management operations and the associated staff. |
| 2 | Health and Safety Expert | 01 | Whole Construction Phase | • Coordinate with Top Management to ensure the implementation of Occupational Health Safety (OHS) Provisions at site.<br>• To ensure the use of Standard Operating Procedures (SOPs) during every working activities.<br>• Ensure availability and maintained of Personal Protective Equipment (PPE) to each and every worker at workplace.<br>• Ensure the record maintenance of each OHS related occurrences and communicate with their authority on regular basis.<br>• Responsible for preparation of monthly, quarterly and |



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| Sr. No. | Contractor Staff Designation | Number of Personnel | Duration | Duties |
|---|---|---|---|---|
| | | | | completion reports (and other if any).<br>• Responsible for implementation of EMP, NOC and other contractual as well as regulatory requirements triggered during the project execution. |
| 3 | Social Expert | 01 | Whole Construction Phase | • Review and validate the monitoring reports.<br>• Status of redressal of community complaints and time spent to resolve the community grievances.<br>• Carry out the consultations with local community, officials of project management and other concerned departments to share the feedback/ lessons learnt. |

Note: For disposal of Construction and Demolition (C&D) waste, it is the responsibility of Contractor to engage licensed district level waste Contractor for disposal of C&D waste after consultation with Local Authority. The proposed Contractor staff will be selected in collaboration with the Employer after the prior approval.

### 4.2.4 Risk Management

Unless otherwise agreed, Contractor shall submit a formal report quarterly and present in the Performance Review (PR) for the Work, Contractor ’s ESHS performance in the preceding reporting period and accumulated year to date. Following are the metrics for ESHS performance progress reports and regular reporting:

a. Environmental incidents or non-compliances with contract requirements, including contamination, pollution or damage to ground or water supplies;
b. Health and safety incidents, accidents, injuries and all fatalities that require treatment;
c. Interactions with regulators: identify agency, dates, subjects, outcomes (report the negative if none);
d. Status of all permits and agreements:
    i. Work permits: number required, number received, actions taken for those not received;
    ii. List areas/facilities with permits required, dates of application, dates issued (actions to follow up if not issued), dates submitted to resident engineer (or equivalent), status of area (waiting for permits, working, abandoned without reclamation, decommissioning plan being implemented, etc.);
    iii. List areas with landowner agreements required (borrow and spoil areas, camp sites), dates of agreements, dates submitted to resident engineer (or equivalent);



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e. Identify major activities undertaken in each area this month and highlights of environmental and social protection (land clearing, boundary marking, topsoil salvage, traffic management, decommissioning planning and implementation);

f. For quarries: status of relocation and compensation (completed, or details of monthly activities and current status).

g. Health and safety supervision:

   i. Safety officer: number days worked, number of full inspections & partial inspections, reports to construction/project management; and
   ii. Number of workers, work hours, metric of Personal Protection Equipment (PPE) use (percentage of workers with full PPE, partial, etc.), worker violations observed (by type of violation, PPE or otherwise), warnings given, repeat warnings given, follow-up actions taken (if any);

h. Worker accommodations:

   i. Number of expats housed in accommodations, number of locals;
   ii. Date of last inspection, and highlights of inspection including status of accommodations' compliance with national and local law and good practice, including sanitation, space, etc.; and
   iii. Actions taken to recommend/require improved conditions, or to improve conditions.

i. HIV/AIDS and COVID-19: provider of health services, information and/or training, location of clinic, number of non-safety disease or illness treatments and diagnoses (no names to be provided);

j. Gender (for expats and locals separately): number of female workers, percentage of workforce, gender issues raised and dealt with;

k. Training:

   i. Number of new workers, number receiving induction training, dates of induction training; Number and dates of toolbox talks, number of workers receiving Occupational Health and Safety (OHS), environmental and social training; and
   ii. Number and dates of Human Immunodeficiency Virus Infection and Acquired Immune Deficiency Syndrome HIV/AIDS and COVID-19 sensitization training, no. of Workers receiving training (this month and in the past); same questions for gender sensitization, flag lady/flag man training.

l. Environmental and social supervision:

   i. Environmentalist: days worked, areas inspected and numbers of inspections of each site, highlights of activities/findings (including violations of Environmental and/or Social best practices, actions taken), reports to Environmental and/or Social Specialist / Construction / Site Management;
   ii. Sociologist: days worked, number of partial and full site inspections, highlights of activities (including violations of Environmental and/or Social requirements observed, actions taken), reports to Environmental and/or Social Specialist/Construction/Site Management; and number of people met, highlights of activities (issues raised, etc.), reports to Environmental Specialist/Construction/Site Management.



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m. Grievances: list this months and unresolved past grievances by date received, complainant, how received, to whom referred to for action, resolution and date (if completed), data resolution reported to complainant, any required follow-up of:

   i. Worker grievances; and
   ii. Community grievances.

n. Traffic and vehicles/equipment:

   i. Traffic accidents involving project vehicles & equipment: provide date, location, damage, cause, follow-up;
   ii. Accidents involving non-project vehicles or property (also reported under immediate metrics): provide date, location, damage, cause, follow-up; and
   iii. Overall condition of vehicles/equipment (subjective judgment by environmentalist); non-routine repairs and maintenance needed to improve safety and/or environmental performance (to control smoke, etc.).

o. Environmental issues and mitigations

p. Spill clean-ups, if any: material spilled, location, amount, actions taken, material disposal (report all spills that result in water or soil contamination;

q. Waste management: types and quantities generated and managed, including amount taken offsite (and by whom) or reused/recycled/disposed on-site;

r. Details of tree plantings and other mitigations required undertaken this month; and

s. Details of water and swamp protection mitigations required undertaken this month.

t. Compliance:

   i. Compliance status for conditions of all relevant consents/permits, for the Work, including quarries, etc.): statement of compliance or listing of issues and actions taken (or to be taken) to reach compliance;
   ii. Compliance status of EMP and NOC requirements: statement of compliance or listing of issues and actions taken (or to be taken) to reach compliance

Other unresolved issues from previous months related to environmental and social: continued violations, continued failure of equipment, continued lack of vehicle covers, spills not dealt with, continued compensation or blasting issues, etc. Cross-reference other sections as needed.

### 4.2.5 Construction and Control

Employer reserves the right to audit Contractor(s) to assure itself that ESHS matters and Management Systems are being managed and controlled in accordance with the declared requirements of these ESHS provisions and Contractor(s) Management System.

Contractor(s) should allow Employer auditors for full access to the Work in progress, Personnel, records and documentation for the purpose of conducting audits.

ESHS inspections may be undertaken by Employer on Contractor's systems, as and when deemed necessary by Employer, and may be carried out without any prior notice to Contractor(s).



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### 4.2.6 Water Quality

The Contractor shall submit proposals for the Employer's approval for all waste water and foul effluent from offices, workshops and site accommodation to be collected and treated at a waste water treatment plant prior to discharge into open water courses or into ground water.

### 4.2.7 Waste Management

The Contractor is fully responsible for the day-to-day management on waste collection and disposal. The Contractor must make arrangements for waste management for the collection and the disposal of domestic and industrial refuse, by handling, transport or storage of schedules wastes outside the premises and its safe disposal at a location approved

by the Employer.

The Contractor must ensure that all the necessary utensils such as proper storage containers or bins for refuse and kitchen wastes, special storage containers for scheduled wastes, temporary sewerage plants or toilet facilities are provided at the premises.

The Contractor must also comply with the following environmental conditions throughout the construction stage:

a. All effluents produced must be treated to comply Law and Regulation of Government of Pakistan before discharge into area approved by the Employer. The effluent shall never be discharged into river/canal without treatment;
b. Temporary sewage treatment for toilet facilities in accordance with the specifications as prescribe by the Law and Regulation must be provided at the Contractor's site office and worker's camps before the commencement of any works;
c. Open burning of solid wastes including biomass waste and construction debris is strictly not permitted;
d. Handling and disposal of scheduled wastes must comply with the requirements of the Law and Regulation of Government of Pakistan;
e. Waste oil and grease arising from the earthworks and construction activities must not be disposed into any nearby watercourse. These wastes must be stored in proper drums/containers and either reused or disposed at the site as approved/licensed by the Director General of Environmental Quality.

### 4.2.8 Avoidance of Nuisance

The Contractor shall take all reasonable precautions to avoid causing a nuisance with dust noise or vibrations arising from his operations. This provision is in addition to but not in substitution for the provisions of the Conditions of Contract.

The Contractor shall not obstruct, as far as possible, the normal rights of way of the users of the public roads and where this is necessary and unavoidable, he shall provide barriers, roads signs, warning lights, etc. required for proper traffic control including getting the necessary permits from the Police Department and other local authorities and paying all fees in connection therewith.

The Contractor shall be responsible for clearing and cleaning all existing streets, roads, drains, etc. at regular intervals, or when directed by the Employer and keep the approaches to the site clear of mud and obstruction.



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The Contractor shall be liable and shall indemnify the Employer in respect of any claims or proceedings arising out of his neglect in taking care to avoid creating a nuisance when carrying out the Works.

### 4.2.9 Notice to Service Authorities

The Contractor shall make at his own expense all necessary arrangements for notifying the service authorities of required connections, removals and relocations of all public utilities and services affected by the Works.

Sufficient time shall be allowed for such notification as may be required by the relevant authorities so that appropriate action can be taken regarding the execution of the removals and relocation.

### 4.2.10 Utilities and Other Services

The Contractor shall be responsible for locating the position of all utilities, including mains, overhead and underground cables, pipes, sewers and drains, and where necessary shall adopt such methods of excavation as may be required by the appropriate authorities or Employer to ensure that no damage is caused to them.

The Contractor shall make good, at his own expense, any damage what so ever to existing utilities to the complete satisfaction of and in accordance with the instructions of the relevant authority or Owner concerned, and shall keep the Employer indemnified at all times from all claims, costs and expenses which may be brought against or incurred by the Employer for or on account of any damage (whether permanent, temporary or recurring) to the said utilities. All utilities, which are encountered in the course of the Works, shall be adequately supported, slung up, strutted or otherwise protected from damage to the satisfaction of the persons or authority in which they may be vested.

Due allowance shall be made by the Contractor for the effect on the phasing of the Works of relocations to existing public and private mains and utilities necessitated by the Works. The Contractor shall ensure that such existing mains and utilities are not interrupted without the written consent of the relevant authority or the owner of the utilities concerned.

If any privately-owned utilities for water, electricity, telephone, drainage. etc., passing through the Site are affected by the Works, the Contractor shall provide an approved equivalent alternative service in full working order to the satisfaction of the owner of the utility and the Employer, before the cutting of the existing utility, and until the completion of the permanent replacement of the utility.

### 4.2.11 Prohibition of Advertising

The Contractor shall treat the Contract and everything written as private and confidential. In particular, the Contractor shall not publish any information, advertisement, drawing or photograph relating to the Works and shall not use the Site for advertising purposes, except with the written consent of the Employer and subject to such conditions as prescribe.

### 4.2.12 Training, Awareness and Competence

a. Contractor shall ensure that electrical safety training shall be recommended, including necessary refresher courses;



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b. Contractor shall ensure that Personnel have passed the required ESHS training before going at workplace as defined by Employer. This course requirement shall include Personnel provided by Contractor ;

c. Contractor shall be responsible for ensuring that Personnel possess all required safety qualifications described by Employer;

d. Personnel shall be available at all times for periodic drills, instructions on survival, lifesaving and fire-fighting as requested and conducted by Employer at the Worksite;

e. Contractor ’s management and relevant Personnel shall attend ESHS training and courses as required; and

f. All costs, including but not limited to travel, accommodation, per diem, course fees, salary, related to training of all Personnel shall be borne by Contractor.

Contractor must be able to demonstrate competence assurance of Personnel, the scope of which will cover as a minimum training within relevant Company ESHS directives including, without limitation, safe working practices, permit-to-work systems and risk assessment including risk to the environment.

Employer has the right to remove from the performance of the Work, any Personnel who do not fulfil expected ESHS performance, which, in the opinion of Employer, misconduct themselves or are incompetent or negligent in the proper performance of their duties and such Personnel shall not be again employed upon the Work without Employer's Approval.

### 4.2.13 Workers Health and Safety

a. Contractor shall ensure access to an Occupational Health Service for follow up of sick leave, occupational illness/injury and other focus areas within occupational health and working environment;

b. The Contractor shall at all times take all reasonable precautions to maintain the health and safety of its Personnel. In collaboration with local health authorities, the Contractor shall ensure that medical staff, first aid facilities, sick bay and ambulance service are available at all times at the Site and at any accommodation for Contractor and Employer Personnel, and that suitable arrangements are made for all necessary welfare and hygiene requirements and for the prevention of epidemics;

c. The Contractor shall conduct an HIV-AIDS, Sexually Transmitted Diseases (STD) or Sexually Transmitted Infections (STI) and COVID-19 awareness programme via an approved service provider, and shall undertake precautionary measures to reduce the risk of the transfer of the HIV, STD/STI and COVID-19 virus between and among the Contractor ’s Personnel and the local community, to promote early diagnosis and to assist affected individuals; and

d. Contractor shall present periodic checks of basic medical such as hearing, eyesight etc. on all staff working under controlled environmental conditions.

### 4.2.14 Health and Safety Measures Specifications for Each Project Activity

The Contractor health and safety measures shall comply with the following sections:

#### 4.2.14.1 Engineering and Design

a. Contractor shall have a system to ensure that Risk, Emergency Preparedness, Environmental and Working Environment Analysis are carried out as an integrated part of the design and engineering process;

b. Contractor shall ensure that design; test and acceptance criteria are defined and documented;
c. Contractor shall adopt full life cycle perspective; and
d. Contractor shall apply inherently safer design principles.

#### 4.2.14.2 Environment

a. Contractor shall have implemented EMP described in main EIA report of proposed Project through an effective Environmental and Social Management System. If a system is not in place, a commitment to comply with the standard in the future is required; and
b. Contractor shall monitor amount and type of discharges according to National Environmental Quality Standards (NEQS), such as accidental, planned and permitted discharges.

#### 4.2.14.3 Chemicals

a. Contractor shall submit Material Safety Data Sheets (MSDS) for all chemicals included in the Contract and or used in the Contract period. The MSDS shall be quality checked in accordance with the ESHS regulations;
b. If the product is evaluated not to be classified according to Health Risk Classification, the label “Not required to be classified, shall be used. The label shall be of a size and color that is readable for the user. Reference is made to Regulation concerning labelling of hazardous chemicals;
c. Contractor shall supply client with relevant information for Evaluating, Purchasing and Handling Chemicals; and
d. Contractor shall submit a complete list of all the chemicals to be used for the Construction. The chemicals must be categorized in accordance with the applicable system of color coding.

#### 4.2.14.4 Dangerous Goods

Contractor shall have a Dangerous Goods handling system that ensures compliance with the Hazardous Substance Rule 2003, Factory Act 1934 and local applicable laws for transportation on road and railroad.

#### 4.2.14.5 Management System for Construction related activities

a. Contractor shall compile an interface document, as part of the Contractor Execution Plan, documenting that Contractor has an implemented and documented Management System in compliance with the existing regulations;
b. Contractor shall point out non-conformance’s / deviations related to the requirements as described above and demonstrate that the significance of the individual non-conformance’s / deviations have been assessed from a safety standpoint;
c. Contractor shall give necessary training in the understanding of the philosophy behind the applicable Acts, Regulations and Provisions;
d. Contractor shall identify Employer’s ESHS directives relevant to the Work. Personnel shall be trained in order to achieve necessary working competence within the identified Employer’s ESHS directives. Contractor shall keep records of the training Personnel have received; and



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e. Contractor shall have put in place objectives, actions and measurements encompassing all organizational levels at Contractor in order to ensure that a sound health, environment and safety culture is established and maintained for the Work.

f. Fall protection or fall restriction devices shall be used when working at heights over 6 feet with the exception of ladder use.

#### 4.2.14.6 Radioactive Sources

Contractor shall have a documented system to ensure that the activity is in compliance with regulations and provisions stipulated by the Country's Radiation Protection Authority for the use of radioactive material.

#### 4.2.14.7 Reporting

a. Contractor shall immediately inform of organizational changes relevant for the Contractor and/or the Work;

b. Contractor shall immediately forward internal and external audit reports conducted by the Contractor relevant to the Work;

c. On a monthly basis Contractor shall provide deviation permits applied for and nonconformity status; and

d. Contractor shall report to the Employer on a quarterly basis amount and type of chemicals supplied, used, discharged and re-injected. The report shall be made in the format as specified by Employer. Contractor shall assure that total annual use and discharge of chemicals supplied are within specified discharge permit.

#### 4.2.14.8 Security

a. Contractor shall comply with the Employer guidelines for Security Control. Alcohol concentration is not allowed;

b. Contractor shall be able to verify the identity of Personnel who shall perform Work at construction site, camps and offices, on installations and in premises employed by the Employer. When Contractor uses hired Personnel references from earlier employment shall be verified;

c. Contractor shall maintain prudent office security for office areas used for projects/activities and/or staff; including access control, ID badge usage, and burglar alarm / guard arrangement;

d. Contractor shall maintain information security regarding Employer and Project information; including clear desk policy, sensitive documents control and confidentiality measurements; and

e. Contractor shall maintain computer and communications security for any computer system and network being used for handling project information; including controlled computer access, virus protection, security updates, Firewalls and backup routines.

#### 4.2.14.9 Lifting Operations

a. Contractor shall have a system established to ensure that Personnel who are responsible for, or are involved in, maintenance/inspection of lifting equipment and execution of lifting operations;



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b. Contractor shall have a system implemented for systematic inspection and maintenance of lifting appliances and lifting gear in accordance with statutory requirements; and

c. Contractor shall ensure that all Plant and/or Equipment being supplied to any Worksite is to be either, placed and operated at height or placed and operated over an area where Persons are working below shall have:

   i. In place a Dropped Objective Survey or Inspection Procedure for the Plant;

   ii. Identified those items of Plant or Equipment or other components that, if fail, have a potential to injure Persons; and

   iii. In place a method for securing primary components or parts such that should failure occur of the all Equipment and their parts are not able to fall and injure Persons. This may be primary suitable means of security or secondary retention methods. Both should be in accordance with the manufacturer's recommendations and accompanied by a Hazard / Risk Assessment.

#### 4.2.14.10 Waste Handling and Tracking

a. Contractor shall ensure use of Authority approved waste treatment or disposal sites. Employer reserves the right to request Contractor to submit supporting documentation of approved sites. Employer reserves the right to reject the use of sites not found acceptable; and

b. Contractor shall have implemented a system for identifying, classifying and handling of waste. Hazardous waste shall be handled according to Authority regulations and household waste and production waste shall be source segregated for recycling purpose.

#### 4.2.14.11 First Aid

Contractor shall be responsible for the provision of first aid services for their workers, and for providing transport for injured persons to hospital or other appropriate destination as and when required. Vehicles that are generally used for site work shall carry a first aid kit complying with OHS regulations.

#### 4.2.14.12 Working Environment

a. Contractor shall undergo particular training with regard to relevant working environment factors related to implementation of Work, the use of work equipment & signaling and safety sign posting at the workplace shall be given to the individual employee and supervisor;

b. Contractor shall actively take part in the working environmental activities that are carried out at the Worksite; and

c. Contractor shall advise and assist Employer in a pro-active manner in the implementation of the annual working environment program and provide input for the subsequent year program.

### 4.2.15 Specific PPE to be used during construction Phase

PPEs are equipment worn to minimize exposure to a variety of hazards which cannot be avoided due to engineering measure (residual impact). It includes gloves, foot and eye protection, protective hearing devices (earplugs, muffs) hard hats, respirators, full body suits etc. Contractor shall be responsible to provide PPEs to his working staff the Employer's staff

and ensure its use. Contractor shall adhere to Employer's OHS requirements related to "Personal Protective Equipment (PPEs)" in respect of PPE. Contractor shall, at its own expense, provide Personnel for duty staff with all necessary protective clothing and equipment suitable for working conditions.

**Table 4-2 Recommended Personal Protective Equipment According to Hazard**

| Sr. No. | Type of Protection | Workplace Hazard | Suggested PPEs |
|---|---|---|---|
| 1 | Over All, Exterior garments | Entanglement, chemical spill safeguard etc. | Long pants, shirt with sleeves (no tank tops or shorts) |
| 2 | High Visibility Vests | Accidental hazard etc. | A reflective vest will be worn outside of any other garments |
| 3 | Foot protection | Falling or rolling objects, pointed objects. Corrosive or hot liquids | Safety toed footwear / boots/ shoes |
| 4 | Eye and Face Protection | Flying particles, molten metal, liquid chemicals, gases or vapors, light radiation | Safety Glasses, Spectacles and Goggles. Spectacles with side shield. Prescription Lenses. Sun Glasses. Special Helmets or shields/ Face shields. |
| 5 | Head Protection | Falling objects, inadequate height clearance, and overhead power cords. | Hard hats with top and side impact protection. Hard hats shall be worn with the brim pointed forward. |
| 6 | Hearing protection | Noise, ultra-sound | Earplugs, muffs |
| 7 | Hand Protection | Hazardous materials, cuts or lacerations, vibrations, extreme temperature | Gloves (Plastic, leather, fireproof and rubber) |
| 8 | Breathing Protection | Dusts, fogs, fumes, mists, gases, smokes, vapors | Facemasks |
| 9 | Falling Hazard Protection | Injury and death etc. | Safety Belt/Chains, Locks |

**Source:** General Guidelines by International Finance Corporation- Environmental, Health, and Safety (EHS)

In order to highlight the risk and identify potential hazards at workplace, Contractor shall be responsible for manage the following (not limited to) set of Safety Sign Posts and Markings in the working zones for the dual purpose of safety of workers as well as visitor/community.

- Authorized entry only (workplace hazards);
- Caution;
- Climb with caution;
- Work personnel only;



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- Contractor ’s gate;
- Danger;
- Dangerous conditions;
- Falling hazard;
- Hard hats;
- Hazardous area;
- Men at work;
- Moving equipment;
- Risk of serious injury;
- Emergency assembly point;
- Shock hazard;
- Trip hazard (wet/slippery surface);
- Visitors;
- Warning;
- Transport control signs; and
- Security barriers.

Contractor shall make arrangements for marking/signs of hazardous goods/materials which should be posted on the boxes for haulage. Tentative list is attached as “Annex B” in this section 4 of Specific Provisions but Contractor shall not limit to these only.

### 4.2.16 Emergency Response and Preparedness

Contractor shall ensure duty numbers to contact Persons are available at any time by means of a phone answering service in case of an emergency. The Contractor must have in place a process to identify internal and external resources that may be required to respond to an emergency at site.



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## Annex A to Section 4.2: Proposer HSE Management System Questionnaire

This sample questionnaire is a guideline questionnaire which will be a part of the bidding document and involved in evaluation process. The questionnaire is to be completed by the Proposer and submitted with their Proposal offer. The objective of the questionnaire is to provide an overview of the status of the EPC Contractor's HSE management system. EPC Contractor s will be required to verify their responses noted in their questionnaire by providing evidence of their ability and capacity in relevant matters.

Please be advised that if your Proposal is successful, you may be required to provide:

- A Risk Assessment for the Project;
- A Site Safety and Security Plan;
- Occupational Health and Safety Plan; and
- Job Safety Assessments or Safe Work Method Statements for individual activities that have a medium to high hazard level.

| **Certification: The information provided in this questionnaire is an accurate summary of the company's occupational health and safety management.** | |
|---|---|
| Company Name: | |
| Signed: | Name: |
| Position: | Date: |
| Contract Details: | |
| Contract Name. | Contract Number: |
| Name and Contact Details of Representative: | |

**N/A = Not applicable or relevant to this contract**

| Management Element | Proposer's Response to Clarification | Evidence/ Company's Clarification |
|---|---|---|
| **1. Leadership and Commitment** | | |
| a) What is the commitment of top management towards ESHS at workplace? | | |
| b) How does top management actively endorse a positive ESHS culture in the workplace? | | |
| c) What does top management do to ensure the health and welfare of employees is established, maintained and given priority like accommodation, meals, rotation, medical care, recreation facilities etc.? | | |
| **2. Policy and Strategic Objectives** | | |



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| Management Element | Proposer's Response to Clarification | Evidence/ Company's Clarification |
|---|---|---|
| **2.1 ESHS Policy Documents** | | |
| a) Has the organization's top management documented, authorized and issued an OHS and E&S Policy? | | |
| b) Does the policy address legal requirements for ESHS, commitment to the prevention of accidents and provide a framework for setting and reviewing OHS objectives? | | |
| c) Who has been identified and appointed in the organization for overall responsibility and accountability for ESHS? | | |
| **2.2 Availability of ESHS Policy Statements to employees?** | | |
| a) How do you communicate your policies requirements or any amendments thereof to your employees? | | |
| **2.3 ESHS contract strategic objectives?** | | |
| a) How are ESHS objectives set? | | |
| b) How are these objectives communicated? | | |
| c) How is accomplishment of these objectives tracked and monitored? | | |
| **3. Organization, Responsibilities, Resources, Standards and Procedures** | | |
| **3.1 Organization, structure to manage ESHS** | | |
| a) How is the organization structured and resourced to manage ESHS? | | |
| b) How are lines of reporting structured and roles and responsibilities defined? | | |
| c) How do you ensure the managers and supervisors understand their ESHS duties and responsibilities? | | |
| d) How have you made provision for ESHS communication meetings? | | |



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| Management Element | Proposer's Response to Clarification | Evidence/ Company's Clarification |
|---|---|---|
| **3.2 Training** | | |
| a) How do you identify training needs including training for high-risk activities and specialized training? | | |
| b) How do you ensure all employees have received appropriate ESHS training and that it is recorded and monitored? | | |
| **3.3 ESHS Competence** | | |
| a) What arrangements do you have to ensure new employees have the required knowledge of ESHS, and how is this knowledge kept up to date? | | |
| b) How are employees informed of the specific hazards arising out of the nature of their work? | | |
| c) How do you ensure people are competent to perform a job that involves hazards and risks? | | |
| d) How do you ensure ESHS advisors are competent in presentation skills? | | |
| **3.4 ESHS Standards (ISO14001 and ISO 45001)** | | |
| a) How do you identify, obtain, review and communicate ESHS legislation, regulations, external standards and other requirements affecting the organization? | | |
| b) How the company is assured that these requirements are met and verified? | | |
| **3.5 Assessment of suitability of sub-Contractors/ other Companies** | | |
| a) How do you assess the?<br>i) ESHS competence of sub-Contractors? | | |
| ii) ESHS performance record of the sub-Contractors and companies with whom you place contracts? | | |



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| Management Element | Proposer's Response to Clarification | Evidence/ Company's Clarification |
|---|---|---|
| b) Where do you spell out the ESHS requirements you require your EPC Contractor s to meet? (What standards apply?) | | |
| c) What are the ESHS terms and conditions dictated in your sub contract agreements? | | |
| d) How do you ensure these requirements are met and verified? | | . |
| **4. Hazards and Effects Management** | | |
| **4.1 Hazards and effects assessment** | | |
| a) How do you identify and document risk? | | |
| b) How do you ensure the proper controls are in place, applied and complied with? | | |
| **4.2 Occupational health exposure** | | |
| a) What occupational health monitoring do you do? | | |
| b) In which areas of your business do you focus this occupational health monitoring? | | |
| c) What health exposures do you measure and record? | | |
| d) How do you manage occupational health exposures? | | |
| **4.3 Handling of chemicals, noise, asbestos, and radiation and other occupational health hazards** | | |
| a) How do you evaluate the health risks presented by the transport, storage, handling and disposal of chemicals? | | |
| b) How do you evaluate the health risks presented by noise, radiation and/or asbestos where applicable? | | |
| c) How do you ensure that minimal use is made of chemicals which are potentially harmful to the environment? | | |



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| Management Element | Proposer's Response to Clarification | Evidence/ Company's Clarification |
|---|---|---|
| d) How do you ensure the quality of the material safety data sheets (MSD)? | | |
| **4.4 Personal protective equipment** | | |
| a) How do you manage PPE requirements? | | |
| **4.5 Waste management** | | |
| a) How have you identified your waste streams? | | |
| b) How do you manage your hazardous waste? | | |
| **4.6 Drugs and alcohol** | | |
| a) How do you manage alcohol and drug abuse? | | |
| b) Explain how you manage the health and wellbeing of your workforce? | | |
| **5. Planning and Procedures** | | |
| **5.1 ESHS Operations manuals** | | |
| a) Please attach an electronic copy of your ESHS manual and ESHS plan? | | |
| b) How do you implement these requirements? | | |
| c) What are the company arrangements for managing safe systems of work? | | |
| d) How are you assured that the ESHS system is fit for purpose? | | |
| e) How are safety rules communicated and compliance monitored in the work place? | | |
| f) How are safety behaviors applied and monitored in the work place? | | |
| **5.2 Equipment control and maintenance** | | |
| a) Describe the ESHS Critical equipment specifically identified? | | |
| b) How do you ensure plant and equipment is inspected, certified, valid and safe for use? | | |



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| Management Element | Proposer's Response to Clarification | Evidence/ Company's Clarification |
|---|---|---|
| c) Do you have a preventive maintenance system? | | |
| d) Explain your equipment inspection regime! | | |
| **5.3 Road Safety Management** | | |
| a) How do you manage road safety for all company vehicles? | | |
| b) How do you manage commuting to and from work? | | |
| c) What standards are applied to your road safety management program? | | |
| d) How often do you audit against the applied standard? | | |
| e) How do you monitor non-compliance with road safety standards and rules in the company? | | |
| f) What actions are taken by management when violations are identified or reported? | | |
| g) How many drivers of vehicles are trained in defensive driving? | | |
| h) How do you manage vehicle load restraining where applicable? | | |
| i) How many Motor Vehicle incidents have you had in the last two years? | | |
| **6. Implementation and Performance Monitoring** | | |
| **6.1 Implementation and active performance monitoring of work activities** | | |
| a) How do you monitor ESHS performance in the work place? | | |
| b) What types of ESHS performance indicators/measures are used in your company? Give examples! | | |
| c) Provide examples of trending of your key ESHS performance indicators! | | |



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| Management Element | Proposer's Response to Clarification | Evidence/ Company's Clarification |
|---|---|---|
| d) How is health performance recorded? | | |
| e) What arrangements do you have to ensure personnel are fit to work in their designated role? | | |
| f) How is environmental performance recorded? | | |
| **6.2 Statutory notifiable incidents** | | |
| a) How many reportable accidents have you had in the last five years? (Provide annual figures) | | |
| **6.3 Improvement or prohibition notices (in accordance with the regulations pertaining to safety and occupational health procedures)** | | |
| a) Provide details of any work prohibitions from government or client imposed on the company? | | |
| b) Have you ever had a contract cancelled due to poor ESHS performance? | | |
| **6.4 Incident investigation and reporting** | | |
| a) How do you identify the critical factors, immediate causes, underlying causes and latent (hidden) management system failures? | | |
| b) Who normally conducts incident investigations? | | |
| c) How do you determine who should lead the investigation? | | |
| d) How do you ensure that the learning's from all incidents, including near misses, are communicated? | | |
| **7. Auditing** | | |
| **7.1 Auditing** | | |
| a) How do you plan and schedule audits and what range of auditing is covered? | | |
| b) How are audit findings tracked and closed out? | | |
| c) Who in your organization is trained and certified to conduct | | |



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| Management Element | Proposer's Response to Clarification | Evidence/ Company's Clarification |
|---|---|---|
| internal management system audits? | | |
| **8. ESHS Management Performance Reviews** | | |
| a) How often are board level management performance reviews conducted? | | |
| g) How do you communicate corporate ESHS performance findings to workers? | | |

| **9. Insurances: Please provide copy of Certificate of Currency** | | | | | |
|---|---|---|---|---|---|
| **Insurance** | **Insurer / Not Applicable** | **Policy Name** | **Policy No** | **Expiry Date** | **Coverage** |
| Workers Compensation | | | | | |
| Public Liability | | | | | |
| Professional Indemnity | | | | | |
| Other | | | | | |

| **10. Certificates / Licenses / Industry Training: Please provide copies or samples** | | | | |
|---|---|---|---|---|
| **License/Certificate** | **Licensee** | **License No.** | **Expiry Date** | **Notes** |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

| **11. Company Reference (Please provide the four (04) most recent relevant contracts completed by company)** | | | | | |
|---|---|---|---|---|---|
| **Five (05) Contracts for International Competitive Proposers, and Three (03) Contracts for National Proposers** | **Contract 1** | **Contract 2** | **Contract 3** | **Contract 4** | **Contract 5** |
| Contract Description | | | | | |
| Client | | | | | |
| Client's Contact | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Contract No. | | | | | |
| No. of Key ESHS Personal | | | | | |
| ESHS Staff/Worker intensity | | | | | |
| No. of Lose Time Injury | | | | | |
| No. of Person Days on Contract | | | | | |
| Total No. of Days Lost | | | | | |
| Contract Completion Certificate (attached Copy) | | | | | |

**Quality check**

- All relevant questions are answered: YES/NO
- Evidence of all necessary element are attached: YES/NO
- Information about insurance plan is enclosed with evidence: YES/NO
- Information about certificates/licenses/training is enclosed with evidence: YES/NO
- Information about company references is enclosed with contract completion certificate: YES/NO
- All ESHS key personals are identified for the contract: YES/NO

Signed by

Proposer Name: Date:

Name of Person: Position:



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## Annex B to Section 4.2: Hazard Warning Signs/Marking

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## Annex C to Section 4.2: Bill of Quantities (BOQ)

| List of Items for HSE | | |
|---|---|---|
| **Sr. No.** | **Item** | **Quantity** |
| **Consumable** | | |
| 1 | First Aid Kits | 10/year |
| 2 | Personal Protective Equipment | 10/lot |
| 3 | Fire Extinguishing Agents | 10 for 2 years |
| 4 | Safety Lights | 10/year |
| 5 | Emergency Lights | 10/year |
| 6 | Torch | 10/year |
| 7 | Safety Tape | 10/year |
| 8 | Safety Training | 10/year |
| 9 | Breathing Appliances | 5/year |
| **Non-Consumable** | | |
| 10 | Ladders | 10 |
| 11 | Fire extinguishers | 5 |
| 12 | Fire Alarm system | 5 |
| 13 | Safety Signs | 10 |
| 14 | Logout/Tagout System | 5 |
| 15 | Fall Protection | 10 |
| 16 | Traffic Control Signs | 10 |
| 17 | Protective Barriers | 10 |
| 18 | Emergency Ambulance | 1 |
| 19 | Sprinkler Systems | 3 |
| 20 | Gas Detectors | 5 |
| 21 | Foam Systems | 5 |
| 22 | Spill Response | N/A |
| 23 | Foam Making Equipment | 5 |
| 24 | Fire Brigade | 01 |
| **Solid Waste Handling** | | |
| 25 | Solid waste trucks | 01 |
| 26 | Solid waste handlers (waste disposal services) | 10 |
| 27 | Incinerators | 01 |
| 28 | Garbage cans | 10 |
| 29 | Refusal collection containers | 10 |
| 30 | Wheel barrows | 10 |



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| List of Items for HSE | | |
|---|---|---|
| **Sr. No.** | **Item** | **Quantity** |
| 31 | Skips for wood and timbers | 10 |
| 32 | Waste segregation bins with color coding at construction sites | 10 |
| 33 | Drums for hazardous waste | 10 |
| 34 | Steel mesh cage for recyclable waste | 10 |
| 35 | waste skips and loaders | 10 |
| 36 | Recycling truck | 01 |
| 37 | Waste bins for medical waste | 05 |
| 38 | Sharp containers | 05 |
| **Liquid Waste Monitoring** | | |
| 39 | Water Quality Lab for testing of wastewater | 01 |
| 40 | Chemicals | N/A |
| 41 | Maintenance of equipment | N/A |
| **Air and Noise Monitoring** | | |
| 42 | Hygrometer or Psychrometer | 02 |
| 43 | Thermometer or Stevenson Screen | 02 |
| 44 | Noise level Meter | 02 |
| **HSE Staff** | | |
| 45 | HSE Experts | 01 |
| 46 | Environmental Expert | 01 |
| 47 | Social Expert | 01 |
| 48 | Sanitary Workers | 03 |
| 49 | Medical Staff | 01 |



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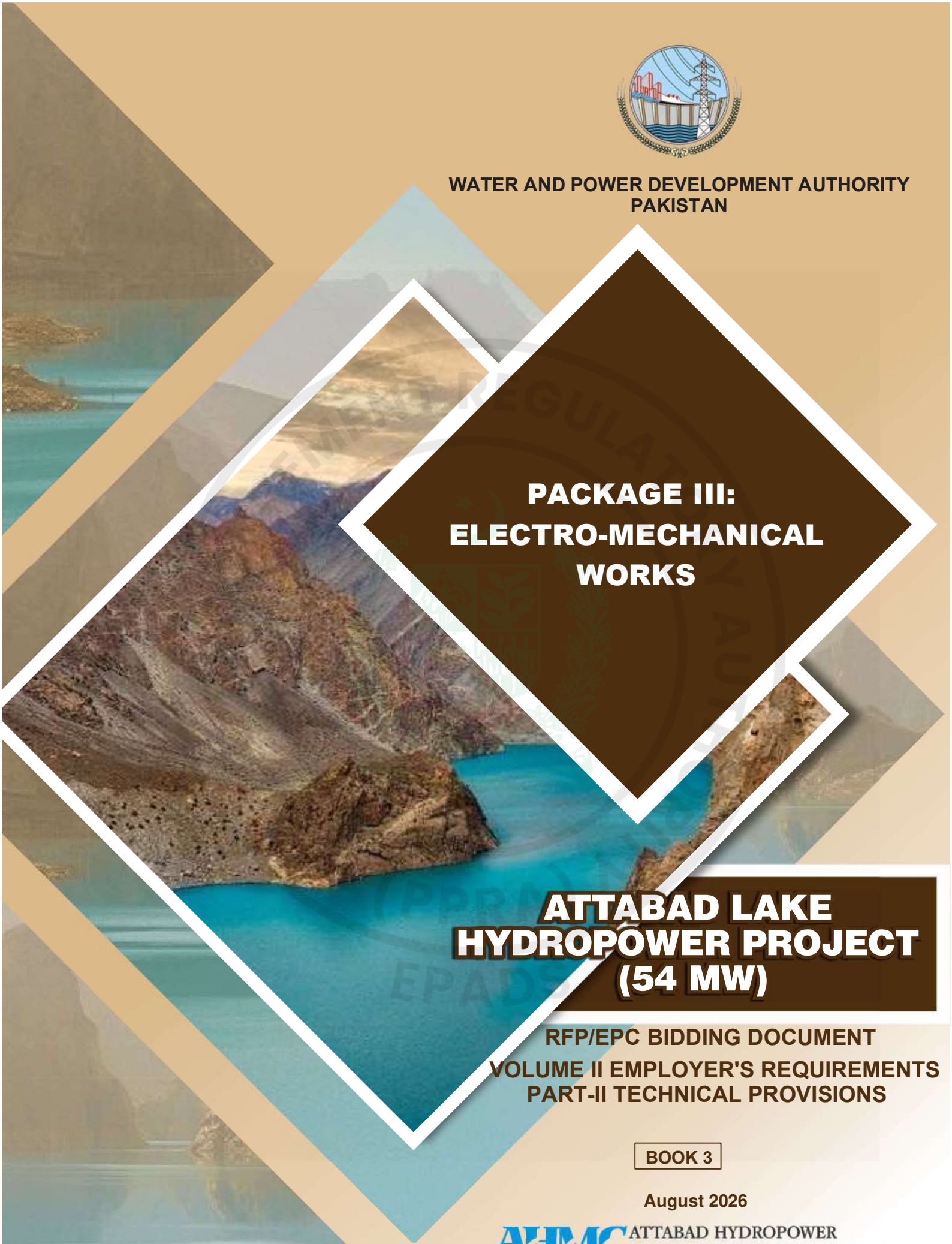

# PACKAGE III: ELECTRO-MECHANICAL WORKS

# ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

## RFP/EPC BIDDING DOCUMENT

## VOLUME II EMPLOYER'S REQUIREMENTS
## PART-II TECHNICAL PROVISIONS

BOOK 3

August 2026

AHMC ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

NESPAK PES DOLSAR ENGINEERING

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**EPC BIDDING DOCUMENTS OF**
**ATTABAD LAKE HYDROPOWER PROJECT (54 MW)**

**PACKAGE-III: ELECTRO-MECHANICAL WORKS**

**INDEX TO BIDDING DOCUMENTS**


VOLUME-I: BIDDING PROCEDURES AND CONDITIONS OF CONTRACT

Part-I: Bidding Procedures

Part-II: Conditions of Contract and Standard Forms

VOLUME-II: EMPLOYER'S REQUIREMENTS

Part-I: Specific Provisions

**Part-II: Technical Provisions**

Part-III: Conceptual Drawings

VOLUME-III: ADDITIONAL INFORMATION

Part-I: Feasibility Study Report (2021)

Part-II: Feasibility Review Report (2022)

Part-III: Topographic Survey Map Book (2023)

Part IV: Updated Environmental Impact Assessment (EIA) Report


PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

# EPC BIDDING DOCUMENTS OF ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

## PACKAGE-III: ELECTRO-MECHANICAL WORKS

## VOLUME-II: EMPLOYER'S REQUIREMENTS
## PART-II: TECHNICAL PROVISIONS

## TABLE OF CONTENTS

**LIST OF ABBREVIATIONS ..... V**

**SECTION 1 HYDRO-MECHANICAL EQUIPMENT ..... 1-1**

1.1 TURBINES ..... 1-1
1.2 GOVERNORS AND AUXILIARIES ..... 1-27
1.3 TURBINE MAIN INLET VALVES (MIV) ..... 1-35
1.4 POWERHOUSE CRANE ..... 1-43
1.5 MECHANICALAUXILIARY SYSTEMS ..... 1-50
1.6 MECHANICAL WORKSHOP EQUIPMENT ..... 1-59

**SECTION 2 HYDRAULIC STEEL STRUCTURES ..... 2-1**

2.1 GENERAL ..... 2-1
2.2 POWER TUNNEL INTAKE ..... 2-2
2.3 FLUSHING TUNNEL INTAKE ..... 2-14
2.4 POWERHOUSE DRAFT TUBE OUTLET AREA ..... 2-18
2.5 PAINTING SCHEDULE FOR HSS WORKS ..... 2-20

**SECTION 3 ELECTRICAL PLANT EQUIPMENT ..... 3-1**

3.1 GENERATORS ..... 3-1
3.2 EXCITATION SYSTEM ..... 3-11
3.3 SEGREGATED PHASE BUS (SPB) ..... 3-23
3.4 GENERATOR STEP-UP TRANSFORMERS ..... 3-26
3.5 MEDIUM VOLTAGE SWITCHGEAR ..... 3-32
3.6 PROTECTION AND RELAY EQUIPMENT ..... 3-44
3.7 DC AND UPS SYSTEM ..... 3-49
3.8 11/0.4 KV STATION AUXILIARY TRANSFORMER(S) ..... 3-56
3.9 LOW VOLTAGE SWITCHGEAR ..... 3-62
3.10 CABLES ..... 3-68
3.11 EMERGENCY DIESEL GENERATING UNITS (EDG) ..... 3-73
3.12 ELECTRICAL AND INSTRUMENTATION WORKSHOP ..... 3-79

**SECTION 4 PLANT CONTROL AND INSTRUMENTATION SYSTEM ..... 4-1**

4.1 GENERAL ..... 4-1
4.2 STANDARDS AND CODES ..... 4-1
4.3 SCOPE ..... 4-2
4.4 DOCUMENTATION ..... 4-3
4.5 FUNCTIONAL REQUIREMENTS ..... 4-3
4.6 CONTROL LEVELS ..... 4-5
4.7 DESCRIPTION OF EQUIPMENT ..... 4-6
4.8 DESCRIPTION OF OPERATION ..... 4-8



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4.9 TECHNICAL REQUIREMENTS ..... 4-11
4.10 CONTROL ROOM EQUIPMENT ..... 4-17
4.11 PACKING AND SHIPMENT PREPARATION ..... 4-17
4.12 TESTS ..... 4-18
4.13 SPARE PARTS, MAINTENANCE EQUIPMENT AND TOOLS ..... 4-18

**SECTION 5 PLANT TELECOMMUNICATION EQUIPMENT ..... 5-1**

5.1 TELEPHONE SYSTEM (EPABX) ..... 5-1
5.2 IP PABX TELEPHONE SYSTEM - (PUBLIC TELEPHONE SYSTEM) ..... 5-2
5.3 PUBLIC ADDRESS SYSTEM (PAS) ..... 5-15
5.4 VIDEO SURVEILLANCE (CCTV) SYSTEM ..... 5-18
5.5 VHF RADIO SYSTEM ..... 5-20
5.6 SPARE PARTS ..... 5-22
5.7 TESTS / INSPECTION ..... 5-22

**SECTION 6 132 KV SWITCHYARD ..... 6-1**

6.1 SCOPE OF WORK ..... 6-1
6.2 ENVIRONMENTAL CONDITIONS AND APPLICABLE STANDARDS ..... 6-2
6.3 132 KV SWITCHYARD DESIGN ..... 6-12
6.4 STEEL STRUCTURES ..... 6-19
6.5 HIGH VOLTAGE BUS WORK ..... 6-28
6.6 CIRCUIT BREAKERS ..... 6-36
6.7 DISCONNECTORS AND EARTHING SWITCHES ..... 6-47
6.8 CURRENT TRANSFORMERS ..... 6-55
6.9 COUPLING CAPACITOR VOLTAGE TRANSFORMERS / CAPACITOR VOLTAGE TRANSFORMERS / VOLTAGE TRANSFORMERS ..... 6-61
6.10 SURGE ARRESTERS ..... 6-67
6.11 LINE TRAPS ..... 6-72
6.12 PROTECTION SYSTEM ..... 6-75
6.13 SUBSTATION AUTOMATION SYSTEM ..... 6-99
6.14 TELECOMMUNICATION AND SCADA SYSTEM ..... 6-135
6.15 CONTROL AND POWER CABLES ..... 6-175
6.16 EQUIPMENT GROUNDING ..... 6-186
6.17 AC AND DC AUXILIARY SUPPLIES ..... 6-187
6.18 POWER TRANSFORMER (10/13 MVA, 132/11.5 KV) ..... 6-207
6.19 HIGH TENSION SWITCHGEAR ..... 6-213
6.20 ERECTION, TESTING AND MAINTENANCE EQUIPMENT AND SPARE PARTS ..... 6-222
6.21 ERECTION, TESTING AND COMMISSIONING ..... 6-226

**ANNEXURE-I: TECHNICAL SCHEDULES (E&M WORKS) ..... 1**



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## LIST OF TABLES

Table 1-1: Standards ..... 1-1
Table 1-2: Parameters ..... 1-2
Table 1-3: Stresses ..... 1-4
Table 1-4:Paint Schedule ..... 1-23
Table 1-5: Piping Schedule ..... 1-24
Table 1-6: Spare Parts ..... 1-25
Table 1-7: Spare Parts ..... 1-31
Table 1-8: Spare Parts ..... 1-39
Table 1-9: Spare Parts ..... 1-47
Table 1-10 : Bench Lathe Facilities ..... 1-60
Table 2-1*: Spare Parts* ..... 2-1
Table 2-2: Spare Parts ..... 2-2
Table 2-3 Paint Schedule ..... 2-20
Table 3-1:Standards and Codes ..... 3-2
Table 3-2: Key Technical Parameters ..... 3-2
Table 3-3: Temperature Rise Limits ..... 3-3
Table 3-4: Insulation Voltage withstand Levels ..... 3-4
Table 3-5: Spare Parts and Tools ..... 3-10
Table 3-6: Standards and Codes ..... 3-11
Table 3-7: Spare Parts and Tools ..... 3-22
Table 3-8: Spare Parts and Tools ..... 3-31
Table 3-9 Spare Parts and Tools ..... 3-43
Table 3-10 Standard and Codes ..... 3-44
Table 3-11 Spare Parts and Tools ..... 3-48
Table 3-12 Standard and Codes ..... 3-49
Table 3-13 Battery Technical Parameters ..... 3-51
Table 3-14 Spare Parts and Tools ..... 3-55
Table 3-15 Standards ..... 3-57
Table 3-16 Technical Parameters ..... 3-58
Table 3-17 Technical Parameters ..... 3-59
Table 3-18 Spare Parts ..... 3-62
Table 3-19 Standards ..... 3-63
Table 3-20 Technical Parameters ..... 3-63
Table 3-21 Spare Parts ..... 3-68
Table 3-22 Standards ..... 3-69
Table 3-23 Spare Parts ..... 3-73
Table 3-24 Spare Parts ..... 3-79
Table 4-1: Spare parts maintenance equipment and tools ..... 4-18
Table 6-1: Spare Parts and Tools ..... 6-212



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## LIST OF ABBREVIATIONS

| | |
|---|---|
| AC | Alternating Current |
| ACI | American Concrete Institute |
| AHMC | Attabad Hydropower Management Consultants |
| AIS | Air Insulated Substation |
| ALHPP | Attabad Lake Hydropower Project |
| AR | Arterial Road |
| ASME | American Society of Mechanical Engineers |
| ASTM | American Society of Testing Materials |
| AVR | Automatic Voltage Regulator |
| BOQ | Bill of Quantities |
| C&D | Construction and Demolition |
| CCTV | Closed Circuit Television |
| CD | Compact Disc |
| CE | Construction Earthquake |
| CT | Current Transformer |
| DC | Direct Current |
| DCS | Distributed Control System |
| DISCOs | Distribution Companies |
| DR | Direct Road |
| E&M | Electro-Mechanical |
| EHV | Extra High Voltage |
| EIA | Environmental Impact Assessment |
| EMC | Electromagnetic Compatibility |
| EMP | Environmental Management Plan |
| EOT | Electrically Operated Travelling |
| EPA | Environmental Protection Agency |
| EPABX | Electronic Private Automatic Branch Exchange |
| EPC | Engineering, Procurement, and Construction |
| ERT | Electrical Resistivity Tomography |
| FAT | Factor Acceptance Test |
| ESHS | Environmental, Social, Health and Safety |
| GCBs | Generator Circuit Breakers |
| GoGB | Government of Gilgit Baltistan |
| GPS | Global Positioning System |
| HIV | Human Immunodeficiency Virus |
| HMI | Human Machine Interface |
| HSS | Hydraulic Steel Structure |
| HT | High Tension |
| HVAC | Heating, Ventilation and Air Conditioning |
| IEC | International Electrotechnical Commission |



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| | |
|---|---|
| IEEE | Institute of Electrical and Electronics Engineers |
| ISO | International Organization of Standardization |
| LT | Low Tension |
| MW | Mega Watts |
| MCB | Miniature Circuit Breaker |
| NDT | Non-Destructive Testing |
| NGC | National Grid Company (Former NTDC) |
| NTDC | National Transmission and Dispatch Company |
| O&M | Operation and Maintenance |
| P&ID | Piping and Instrumentation Drawings |
| PAS | Public Address System |
| PCM | Pulse Code Modulation |
| PCS | Plant Control System |
| PVC | Polyvinyl Chloride |
| QA | Quality Assurance |
| QC | Quality Control |
| RTD | Resistance Temperature Detector |
| RMR | Rock Mass Rating |
| SAS | Substation Automation System |
| SCADA | Supervisory Control and Data Acquisition |
| SPC | Stored Program Control |
| TDM | Time Division Multiplexing |
| ToRs | Terms of Reference |
| UPS | Uninterruptible Power Supply |
| USACE | United States Army Corps of Engineers |
| VA | Volt-Amps |
| VR | Village Road |
| VT | Voltage Transformer |
| WAPDA | Water and Power Development Authority |

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# SECTION 1 HYDRO-MECHANICAL EQUIPMENT

## 1.1 TURBINES

### 1.1.1 General

This section specifies the requirements for design, engineering, manufacture, transportation, storage, erection, shop testing, site testing, commissioning and supply of spare parts of the turbines to be furnished. General arrangement of the turbines is shown in the attached powerhouse layout drawings.

### 1.1.2 Applicable Standards

The turbines shall conform to the applicable requirements of the latest edition of the following Standards:

**Table 1-1: Standards**

| Description | Standard |
|---|---|
| Hydraulic turbines, storage pumps and pump - turbines - Model acceptance tests | IEC 60193 |
| Field acceptance tests to determine the hydraulic performance of hydraulic turbines, storage pumps and pump-turbines | IEC 60041 |
| Guide for Commissioning, Operation, and Maintenance of Hydraulic Turbines | IEC 60545 |
| Cavitation, Pitting Evaluation in Hydraulic Turbines, Storage Pumps and Pump-Turbines | IEC 60609-1 |
| Guide for field measurement of vibrations and pulsations in hydraulic machines (turbines, storage pumps, and pump turbines) | IEC 60994 |
| Standard for Hydraulic Turbine and Generator Integrally Forged Shaft Coupling and Shaft Runout Tolerances | IEEE 810 |
| Mechanical Vibration-Evaluation of machine vibration by measurements on rotating shafts | ISO 7919 (Parts 1-5) |
| Standard Specification for Castings, Iron- Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application | ASTM A743M |
| Standard Specification for Pressure Vessel Plates, Carbon Steel for Moderate- and Lower-Temperature Service | ASTM A516 |
| Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless | ASTM A53M |
| Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications | ASTM A240 |
| Standard for Welding | AWS (D1.2, D1.3, D1.6, A 2.4, A 3.0) |



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| Description | Standard |
|---|---|
| Standard for Coupling Bolts tolerance system | ASME B 4.1 |
| Standard for pressure vessel and piping system | ASME Boiler and Pressure Vessel Code Section IX |

### 1.1.3 Operating Conditions

Vertical Francis turbines shall be manufactured for run-of-river and peaking / base load continuously between the guaranteed minimum and maximum output and within the head range specified, without exceeding the permissible stresses and bearing temperatures and without undue cavitation.

Loss of metal due to cavitation shall be within the specified limits. The working stresses, under the worst transient conditions, shall be moderate. No undue deformation shall occur and smooth running, without harmful vibration, shall be considered and the most unfavorable alternative shall be used as design parameters for the various components.

The Contractor shall be required to carry out his own water quality, petrographic and sedimentation analysis where necessary for verification and confirmation of contractual guarantees. The Contractor is required to take sedimentation into consideration in the design.

### 1.1.4 Key Technical Parameters of Turbines

**Table 1-2: Parameters**

| Description | Unit | Quantity |
|---|---|---|
| No of Units | no. | 3 |
| Type of Turbine | type | Vertical Shaft Francis Turbines |
| Rated Turbine Output at Shaft | MW | 18.94 |
| Rated Net Head | m | 104.0 |
| Rated Turbine Speed (n) | rpm | 375 |
| Turbine Runaway Speed ($n_r$) | rpm | 655 |
| Unit Discharge ($Q_{unit}$) | $m^3$/sec | 20.0 |
| Runner Diameter | m | 1.68 |
| Min. Turbine Efficiency ($\eta$) | % | 93 |

### 1.1.5 Life of Plant, Maintenance Cycles and Reliability

The Plant shall be designed for a service life of not less than fifty (50) years, considering daily start-ups and shutdowns during operations. Maintenance on each unit will be done annually on a rotational basis. Between annual maintenance periods, the units will be expected to operate with 100% availability.



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The design shall be such that dismantling shall not be necessary in the first ten (10) years of operation.

Starting reliability shall be at least 99% as logged by the Control and Indication System. If “Failure to Start" events in excess of 1% due to defective components or systems supplied by the Contractor occur during the defects liability period, the components shall be replaced with more reliable equipment, at no cost to the Employer.

### 1.1.6 Speed and Balance

The synchronous speed shall be 375 rpm. The direction of rotation shall be clockwise when viewed from generator side.

The complete rotating assembly (turbine and generator) shall be designed to accommodate the maximum runaway speed, which can occur under any steady or transient condition. Such conditions shall include the failure of the guide vanes and the Main Inlet Valve to close on load rejection. Friction and wind losses of the generator shall be allowed for in the calculation of runaway speed.

The first critical speed of generator and turbine combined shall be at least 30% above the maximum runaway speed. The Contractor shall check the critical speed and torsional vibration characteristics of the combined turbine and generator rotating system. In the calculations, higher harmonics and combined critical speeds shall be considered. Calculations shall be presented in an easily understandable and concise manner. Amplitudes of vibration as measured on the turbine or generator bearing housings shall be in accordance with ISO 10816 and ISO 7919.

The number of guide vanes, stay vanes, and runner blades shall be such as to ensure vibration-free operation.

### 1.1.7 Resonance

Based upon the results of the hydraulic model tests and the Contractor's experience of similar units in size, operating head range and output, the Contractor shall conduct resonance studies covering the complete range of normal operation of the turbines up to and including full load rejection. These studies shall include but not be limited to:

a. Penstock hydraulic resonance due to excitation from part load and full load draft tube pressure pulsations.
b. Power swings due to excitation from part load and full load draft tube pressure pulsations and governor oscillations coupled with the generator natural frequency.
c. Resonances due to unfavorable coupling of the passing frequencies of runner blades, guide vanes and stay vanes.
d. Resonance caused by rotating pressure waves in the vaneless space between runner and guide vanes.
e. Resonance of the stay vanes and runner blades due to Karman vortex shedding from the blade trailing edges.
f. Resonances caused by wearing ring pumping.



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### 1.1.8 Regulation

The total stored energy of the combined turbine and generator shall be the minimum necessary for stable governing and the attainment of the specified and guaranteed pressure and speed regulation.

Speed Rise: The maximum transient speed, which can occur during a power station load rejection at any head and output, shall not exceed 150% of synchronous speed.

Pressure Rise: Under all conditions of normal and transient operation, the maximum permissible pressure rise, which can occur in the waterway system during any transient event, shall not exceed 30% at the spiral case inlet.

### 1.1.9 Noise

Maximum noise level resulting from any of the operating conditions shall not exceed 85 dB (A) at any place 1.0 m away from operating equipment in the machine hall.

### 1.1.10 Oil Type and Grade

The same type of oil shall be used in lubrication of the turbine-generator bearings and in the governor hydraulic oil system. As a general specification, all lubricating oil shall typically be to either ISO VG46 or ISO VG68 at 40ºC according to ISO 3448 and shall be readily available in Pakistan.

### 1.1.11 Stresses and Materials

Liberal factors of safety shall be used throughout the design and especially in the design of all parts subject to alternating stresses or shock. The design of equipment shall include an allowance for the earthquake loading stipulated in the Employer Requirements. Under the most severe loading conditions expected in normal operation (including load rejection), stresses in the materials shall not exceed the values listed in the following Table 1-3.

**Table 1-3: Stresses**

| Material | Tension | Compression | Shear |
|---|---|---|---|
| Cast Iron | 10% of ultimate strength | 70 MN/m² | 21 MN/m² |
| Cast Mild Steel | 83 MN/m² | 83 MN/m² | 50 MN/m² |
| Alloy Cast Steel | 20% of the ultimate strength or 33% of the yield point, whichever is less | 20% of the ultimate strength or 33% of the yield point whichever is less | 60% of the allowable tensile stress |
| Plate Steel for Spiral Case or Other Principal Parts | 25% of the ultimate strength but not to exceed 100 MN/m² | 25% of ultimate strength but not to exceed 100 MN/m² | 60% of the allowable tensile stress |

For materials not listed in the table the maximum stresses in tension or compression under the most severe normal and transient operating conditions shall not exceed 33.3% Yield or 20% Ultimate Tensile Strength (UTS).

Maximum shear stresses in other ferrous materials shall not exceed 60% of the allowable stresses in tension, except that the maximum torsional shear stresses in the turbine main shaft shall not exceed 50% of the allowable stress in tension in normal operation including



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load rejection. Maximum combined stresses in the shaft under generator short circuit conditions shall not exceed 50% of the material yield stresses.

Under maximum runaway speed or under the hydrostatic test conditions, stresses shall not exceed 66.67% of yield stress.

Stresses at the junction of the runner vanes and crown shall not exceed 25% Yield under any operating condition. To the calculated thickness for this condition shall be added an allowance of 3 mm for attrition.

Stresses in the guide vanes, guide vane stems and guide vanes stem levers at the breaking point of the shear pin friction device combination shall not exceed 66.67% Yield.

The exception to the above will be pre-tensioned bolts. These shall be stressed to the extent necessary to ensure that the joint face remains closed under all operating conditions.

Calculations shall be presented by the Contractor to prove their proposed pre-tensioning for all pre-tensioned bolts and means shall be provided for monitoring and verification of the pre-tensioning.

Finite element calculations shall be submitted to show compliance with the above requirements for all major components.

The material for all important stressed parts including stay ring, spiral case, front and rear covers, shaft, and runner shall have adequate impact value and the Contractor shall submit details of such critical components for approval by the Employer. All steel plates for these items shall be ultrasonically tested at the mill.

### 1.1.12 Turbine Model Tests

The Contractor shall use and provide the results of an appropriate existing model test, homologous to the prototype turbine of Attabad Lake HPP, to determine the operational characteristics of the prototype and prove that guarantees can be met. The model test should have been conducted in accordance with IEC 60193 standard.

Whenever the reference model requires modifications to eliminate cavitation over the whole operating range, modifications to the profiles based on CFD analysis shall ensure that runner will not be damaged by cavitation.

The Proposer shall together with his Proposal supply documents demonstrating a satisfactory design and validity of the guarantees given by providing test results based on site tests on homologous, or nearly homologous, turbines. The site tests should have been conducted in accordance with IEC 60041 and related standards.

The Proposal shall contain all relevant technical information about any such previous model or prototype tests that is used for demonstrating the validity of the guarantees and technical information given. The performance of the model tests shall be as per IEC 60193 in all aspects. Hydraulic performance tests shall be made at various gate openings to determine machine characteristics including regimes of safe operation, zones of cavitation and vibration, etc. Prototype efficiencies shall be derived from model tests as per procedure contained in IEC 60193 for Francis turbines. The prototype efficiency shall be taken equal to model efficiency and no scaling up of efficiency shall be applied. Model tests shall simulate all possible normal operating conditions of the prototype for entire range of heads.



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#### 1.1.12.1 Existing Model or Field Test Report

The test report shall be submitted to the Employer and shall comprise of at least following information on model or field performance tests:

- Place of model or field tests,
- Year of model or field tests,
- Designed rated turbine output,
- Rated net head,
- Rated speed.

The test report shall comprise but shall not be limited to the following:

i. Model drawings of hydraulic passages and photographs;
ii. Test-stand description, including systematic and random error evaluation at best efficiency;
iii. Dimensional control of the reference model including runner seal clearances;
iv. Efficiency tests and determination of the best efficiency;
v. Model turbine hill charts;
vi. Transposition of model test results to Attabad prototype performances;
vii. Sigma break curves, cavitation observations and margin evaluation;
viii. Entrance cavitation observation;
ix. Hydraulic stability tests;
x. Runaway tests under cavitation-free conditions and at plant sigma;
xi. Hydraulic thrust tests;
xii. Wicket gate hydraulic torques;
xiii. Runner and wicket gate finite element analyses

### 1.1.13 Model Characteristics Curves (Hill Charts)

The reference model hill chart shall be plotted with discharge factor $Q_{11}$ as the vertical axis and speed factor $n_{11}$ as the horizontal axis with a plot of:

i. Original curves of constant efficiencies;
ii. The curves of constant wicket gate opening;
iii. Original entrance cavitation limits;
iv. Vortex-free zone (specify corresponding plant sigma used to establish it);

#### 1.1.13.1 Prototype Characteristics Curves (Hill Charts)

The prototype hill charts shall be derived from the model hill chart using the step-up formula given in the IEC 60193 standard and CFD adjustments, for homology deviations and performance transposition from Model to Prototype in accordance with IEC 62097-2019. Turbine (prototype) design must demonstrate stable operation at all operating conditions between full load to part load (i.e., 40% of rated capacity) according to prevailing changes in head/discharge due to seasonal variations, load variations and combinations of Unit operation (single/parallel) at Attabad Lake HPP.

A chart shall be plotted for calculating net head from gross head. Similarly, one hill chart shall be plotted with unit discharge in $m^3/s$ as the vertical axis and the net head in meters, as the horizontal axis. Another hill chart shall be plotted with the shaft output at generator coupling



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in MW or in Brake Horse Power (BHP) as the vertical axis and the net head in meters as the horizontal axis.

The total thrust bearing losses will pertain to the generator, whatever the hydraulic thrust and turbine rotor weight. Turbine efficiency shall only include estimated mechanical losses at the turbine guide bearing.

Both hill charts shall include plots of:

i. The curves of constant turbine efficiencies
ii. The curves of constant wicket gate opening
iii. Operating limits of the turbine
iv. Runaway speed
v. Entrance Cavitation Results
vi. Hydraulic Torque on Wicket Gates

The Employer will have the right to request any additional documentation or clarification that he deems necessary to his satisfaction.

### 1.1.14 Re-Model Tests

Should the prototype exhibit any unacceptable vibrations, resonance or operational characteristic, which necessitates a modification to the hydraulic passage of the turbine, which is outside the dimensional tolerances specified in IEC 60193, then the model shall be modified accordingly and retested. The retest of the model shall be done before the prototype is modified and shall cover all parameters measured in the original model test. Modifications to the prototype shall only be accepted if the performance of the retested modified model is totally within all the guaranteed values.

All modifications of the model and prototype and re-testing of the model shall be at no cost to the Employer.

### 1.1.15 Efficiency

In addition to pure hydraulic losses, turbine efficiency shall include mechanical and volumetric losses attributed to the turbine supply.

For the bearings the distribution of losses attributed to the generator and to the turbine will be proportioned in accordance with IEC 60041. Calculations of guide bearing losses will initially be in accordance with IEC 60041 and subsequently measured at site in accordance with IEC 60034.

Turbine efficiency shall be subject to performance guarantees for the entire turbine operating range and shall be verified by site efficiency tests in accordance with IEC 60041 by the acoustic or thermodynamic method. The test method shall be subject to the prior Employer approval.

The following weighting factors shall be applied to evaluate the site efficiency tests:

| Turbine Power (% of maximum attainable power at prevailing reservoir levels) | 100% | 80% | 60% | 40% |
|---|---|---|---|---|
| Weighting Factor | 59 | 20 | 12 | 9 |



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The guaranteed turbine weighted average efficiency shall be calculated by applying the weighting factors given above to the respective guaranteed efficiency values (i.e., A, B, C and D).

$$= 0.01(59xA + 20xB + 12xC + 9xD)$$

The turbine efficiency for each such turbine power value shall be determined by measurement and computation in accordance with IEC 60041, but without any tolerance or uncertainty. The measured turbine weighted efficiency shall be determined by applying the weighting factors to the efficiency values determined by the site tests.

The guaranteed turbine efficiency for each of the turbine power values nominated in the above table shall be determined from the guaranteed turbine prototype performance diagrams (Hill Chart), for the net head conditions applying at the time of the site efficiency tests.

The guaranteed turbine weighted efficiency shall be determined by applying the weighting factors nominated above to the respective guaranteed efficiency values.

The measured turbine weighted efficiency shall be compared to the guaranteed turbine weighted efficiency, and the amount that the measured value is less than the guaranteed value, if any, shall be the Turbine Weighted Efficiency Shortfall, and shall be subject to liquidated damages pursuant to Schedule of Performance Guarantees.

If the Weighted Efficiency Shortfall exceeds 2% points, then the Employer may reject the associated turbine runner; in which case the Contractor shall design, model test, construct, supply and install a replacement runner free of charge to the Employer a new runner with satisfactory performance. Further, in this case the Contractor shall carry out site efficiency tests of all units.

### 1.1.16 Guarantees

#### 1.1.16.1 General

Guarantees for each turbine shall be given for prototype conditions as given in the Schedule of Performance Guarantees and Technical Plant Data, and shall be based upon the levels, heads and turbine settings specified herein. Possible deviations and the reason hereof shall be clearly stated by the Contractor in his Proposal.

The guarantees for efficiency, maximum load and cavitation as well as axial hydraulic load, runaway speed, guide vane torque, vibration levels etc., shall be verified by site commissioning tests according to IEC 60041 and related standards.

The Contractor shall together with the Proposal supply documents demonstrating a satisfactory design and the validity of the guarantees given by providing test results based on site tests on homologous, or nearly homologous, turbines. The tests should be conducted in accordance with IEC 60041 and related standards.

Numerical simulations can demonstrate the effect of deviations/ improvements from the reference turbines.

The Contractor may as an alternative or additionally carry out model tests on a turbine model to demonstrate a satisfactory design and the validity of the guarantees given. The tests shall be conducted in accordance with IEC Publication no 60193, latest revision including amendments and supplements.

The Proposal shall contain all relevant technical information about any such previous model or prototype tests that is used for demonstrating the validity of the guarantees and technical information given.

The Employer will have the right to request additional documentation, which he deems necessary to demonstrate to his satisfaction the Contractor's compliance with the pertinent parts of the Specifications.

#### 1.1.16.2 Turbine Output Guarantees

The prototype turbine output / maximum flow shall be guaranteed in the sense that the Contractor shall be bound to modify the turbine within a period of six months after the site completion test, in order to achieve the guaranteed output, if the measured turbine output is below the corresponding guaranteed output value. If, after modifications have been carried out, the turbine still fails to achieve the guaranteed output, or if it is mutually agreed to waive the modifications or if modifications are not possible, a sum equal to that stated in the Schedule of Performance Guarantees shall be deducted from the Contract Price.

The output test results shall be converted to the design net head values and compared with the guaranteed value. All measurements shall be conducted in accordance with IEC Publication no 60041 "Code for Field Acceptance Test of Hydraulic Turbines" (latest revision). Output values shall be stipulated on basis of net heads measured at the downstream side of the inlet valve and at tailrace level measured in the draft tube.

#### 1.1.16.3 Cavitation Guarantees

The Contractor shall guarantee the runners and discharge rings against cavitation pitting or erosion due to suspended solids for 8,000 operating hours from the date each unit is placed in commercial operation. Testing will be undertaken in accordance with IEC 60609-1.

Excessive pitting shall be defined as the removal of metal from the turbine runner resulting from the impact of cavitation at a rate in excess of the amount as given in IEC 60609-1. The method of measuring the loss of material due to cavitation shall be volumetric as determined by above IEC Code.

If cavitation pitting exceeds the guarantees, the Contractor shall repair and rectify by welding, grinding and polishing. If after a further period of 8,000 operating hours the cavitation pitting exceeds permissible limits, the runner may be rejected in which case the Contractor shall redesign, model test, construct and supply free of charge to the Employer a new runner with satisfactory cavitation performance. In addition, the Contractor shall also be liable to bear the cost of revenue loss to the Employer due to loss of generation.

In case of delay, through no fault of the Contractor, in placing a turbine in commercial operation, the period of the cavitation warranty shall terminate not later than 60 months from the date of final delivery of each unit.

#### 1.1.16.4 Cracking Guarantees

The Contractor shall guarantee the runners and discharge rings against crack formation for a period of not less than 8,000 operating hours from the date each unit is placed in commercial operation. The Contractor's guarantee shall be based on operation for not more than 50 hours at output greater than the guaranteed maximum output at a given head.

Cracks will be detected by ultrasonic magnetic particle and/or dye penetrant inspection. The acceptance standard will be the same as used for the manufacture of the runner and



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discharge ring. The Contractor will repair the damaged area in situ. Any repairs required under the cracking guarantee shall be performed entirely at the expense of the Contractor.

On completion of the rectification work the guarantee period will recommence. If cracks requiring repair are still found in the runner after 24,000 operating hours, then the Employer reserves the right to reject the runner in which case the Contractor shall supply and install a new runner free of charge to the Employer in place of the rejected runner.

The Contractor will investigate causes of the cracking and propose modifications to the turbine which will be implemented entirely at the Contractor's expense.

### 1.1.17 General Arrangement and Construction of Turbines

The turbine shall be of the spiral casing type so constructed as to allow all the removable parts to be dismantled conveniently. The turbine will be vertical shaft installed and connected with the generator. Rotation of the unit shall be clockwise when viewed down from the top.

The main shaft, runner, head cover, bearing, shaft seal and guide vane etc. shall be able to remove from the generator stator inner hole by the powerhouse crane. The runner, bottom ring, draft tube and guide vane etc. shall be able to remove from the bottom through draft tube cone.

#### 1.1.17.1 Runner

The Francis turbine runner shall be of martensitic stainless-steel grade CA6NM to ASTM A743M standard, one-piece design, either cast or made of a combination of plate steel and cast components accurately assembled and welded together in the shop with a material content of at least 13% chromium and 4% nickel. All shop welds shall be stress relieved. Material and the method of construction shall be to the approval of the Employer. The welding filler for runner blades with crown and bands shall be Martensitic. CNC milling machines shall be used for the turbine runner manufacturing.

The Proposal shall contain all relevant information of the make, grade and properties of the proposed material and runner manufacturing, testing and installation requirements.

The runner shall be designed to withstand the forces encountered during all normal and abnormal conditions up to and including the guaranteed runaway speed. It shall also be designed to support its own weight and that of the turbine rotating parts including the shaft when resting on the shoulder of the discharge ring.

The runner of the first unit shall be strain-gauged and the dynamic stresses measured. Should the stresses thus measured be above those for infinite fatigue life (allowing for measuring tolerances as agreed with the Employer) then the Employer reserves the right for modifications to be made to this and the runners of all subsequent units. Such modifications shall be made by the Contractor entirely at no cost to the Employer.

All surfaces exposed to the flow of water shall be finished smooth over the entire plane by grinding or other means so as to be free from hollows, depressions, cracks and projections. The average surface finish shall be 4 microns or finer in areas subject to possible cavitation as shown in the model tests. All other areas shall be finished to 10 microns or less.

The runner shall be statically balanced in the shop to a precision of at least 100 kg-m. Lead filled boxes shall not be used for balancing purposes. The balancing method shall be submitted for approval of the Employer.

All runners shall be interchangeable among all the units covered by these Specifications.



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### 1.1.17.2 Turbine - Generator Shafts and Coupling

The turbine - generator shafts shall be of forged steel conforming to ASTM A668 Class D standard properly heat-treated with flange at both ends. The complete shaft assembly shall be designed to operate safely at any speed up to the maximum runaway speed without detrimental vibration or distortion. The maximum torsional shear stress shall not exceed 50% of the allowable stress in tension.

The amount of shaft-runout shall be checked by rotating the finished shaft in a lathe or aligning device in the Manufacturers shop, and shall not exceed the tolerances recommended for shafts in the IEEE 810 Standard. Shaft coupling shall conform to ANSI Standard B-49-1 “Shaft Couplings integrally forged type for hydraulic units”.

The Proposal shall contain details of fabrication, testing and installation requirements.

### 1.1.17.3 Turbine Guide Bearing

The turbine guide bearing shall be of the multi-shoe babbitt-lined, self-aligned and self-contained lubricating type shall be located above the runner and shall consist of removable bearing segments and a bearing support. The design shall permit ready access for maintenance and replacement.

Bearing and bearing housing shall be designed to support the radial loads at any conditions of operation including runaway speed. The bearing shall be capable of continuous operation without injury at any speed between 50 and 110% of normal speed, and for at least 30 minutes at any speed from 110% of normal speed to the maximum runaway speed, and for at least 30 minutes at any speed between 1 rpm and 50% of nominal speed.

The same type of oil shall be used in lubrication of the bearing and in the governor oil system. Final selection of oil type will be coordinated with the generator manufacturer to have the same type of oil in the generator bearings.

The Contractor shall specify in his Proposal the lubrication and oil cooling arrangement and equipment required there.

### 1.1.17.4 Shaft Seal

The shaft seal shall prevent the entering of water from the turbine housing into the guide bearing or into the turbine pit above the guide bearing. The shaft seal shall be of the axial sliding ring type or preferably a combination of labyrinth type and axial sliding ring type.

A pneumatically inflatable seal shall be provided below the turbine shaft seal to facilitate dismantling and servicing of shaft seal without dewatering the Unit. The system shall be complete with instrumentation and valved piping for air supply from the station compressed air system available outside the turbine pit.

The shaft seal shall be supplied by water from the raw water-cooling loops cleaned by twin strainer hydro cyclone micro filter. The filter set shall be equipped with flow controls, including alarm contacts. The flow detector shall be installed on the inlet side.

The seal shall be equipped with a wear indicator.

### 1.1.17.5 Head Cover

The head cover shall be of cast steel or of welded construction of suitable stainless steel (ASTM A240 UNS S41500). It shall be provided with replaceable stationary wearing rings of stainless-steel plate within the range of the guide vanes and be fitted with self-lubricating



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metal bushings and collars at the guide vane stems. The collars can be arranged alternatively on the Bottom Ring.

The cast cover shall be normalized. The plate material for the welded cover shall be normalized and the cover stress relieved before machining.

The water side of the head cover shall be designed so as to minimize friction and eddy losses and to provide a flow of water to the runner free and uniformly streamlined as far as practicable.

The cover shall be sufficiently rigid to withstand all extreme operational pressures and forces.

The space between head cover and runner shall be drained by means of a drainage pipe with throttles to prevent excessive pressure, i.e., hydraulic axial thrust.

At the place where the turbine shaft passes through the head cover, a shaft seal shall be provided as described above.

The necessary fittings for the guide vane bearings and equipment for operation as well as arrangement of the regulating ring shall be provided in the head cover.

The stationary labyrinth seal rings on the upper and lower turbine cover shall be of multi-part design and replaceable without dismantling of the generator rotor. Via the same way the counter labyrinth rings attached on the runner shall be replaceable. The stationary labyrinth ring seals shall be provided with connections for supply of cooling water in view of a possible synchronous condenser operation.

Four (04) sockets for connection of pressure gauges, measuring pressure fluctuations between guide vanes and runner shall be provided.

Shaft seal leakage water shall be conveyed to the powerhouse drainage by gravity with a suitable pipe passing through the closed section of the spiral case or through the stay vanes.

Drainage of the top cover shall be by gravity through the holes in two stay vanes. The cover shall be designed such that water cannot collect in pockets. If impractical to discharge all the collected water by gravity, the top cover shall be equipped with collected water two automatically operating supplementary electric motor driven pumps located in a sump to which all such water shall be directed.

In any case the head cover drainage system shall be sufficient to remove twice the leakage resulting from the complete removal of seals in the shaft seal, under the worst operating conditions, without flooding the head cover.

#### 1.1.17.6 Bottom Ring

The bottom ring shall be of cast steel or of welded construction of suitable stainless steel (ASTM A240 UNS S41500) and shall be provided with replaceable stationary wearing rings of stainless-steel plate within the range of the guide vanes. It shall be designed by the same criteria regarding stiffness, deformations, splitting etc. as specified for the head cover.

Special arrangements shall be provided to enable assembly and dismantling of the self-lubricating bushings for the guide vane stems without dismantling of the guide vanes. For this, an inspection gallery shall be provided below and around the bottom ring.

The section between the runner and the guide vanes shall be drained properly to reduce motoring power demand during synchronous condenser operation.



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The casted bottom ring shall be normalized. The plate material for the welded bottom ring shall be normalized and the bottom ring stress relieved before machining.

#### 1.1.17.7 Discharge Ring

The discharge ring made of stainless steel shall have a minimum thickness of 20 mm and a minimum length of 500 mm; it shall be inserted in the first part of the draft tube directly below the runner. Easy replacing of the discharge ring is required.

The ring shall be bolted to the draft tube cone and dismantlable to facilitate removal of runner for repair and maintenance and replacement of workout rings.

The discharge ring shall be provided for admission of air for stabilization in zones of unstable flow later on, if required.

The discharge ring shall be cast steel or of welded design. The cast discharge ring shall be normalized. The plate material for the welded design shall be normalized and the discharge ring stress relieved before machining.

#### 1.1.17.8 Wearing Rings

A set of replaceable stationary labyrinth seal rings of stainless material shall be securely fastened and placed to the head cover and bottom ring by approved means. Wearing rings shall be made of suitable corrosion and wear resistant metals with sufficiently dissimilar characteristics of the stationary and moving parts as to prevent galling or tearing of the metal in case of accidental rubbing. The material to be selected shall have a hardness of at least 50 Brinell lower than the rotating rings of the runner.

Provisions shall be made to enable renewal of the stationary labyrinth seal rings without dismantling the generator rotor. There shall be two sets of wearing rings per turbine, one upper and one lower, designed for minimal leakage and long service life.

#### 1.1.17.9 Additional Requirements for Abrasion Protection of Turbine Water Passage Components Against Sediment Erosion

During the tendering stage, additional information regarding the sediment characteristics of the Attabad Lake Hydropower Project (54MW) has become available. The Employer has observed that the Attbad Lake water carries significant quantum of abrasive sediment during high-flow period, which may result in accelerated wear of the hydraulic passages of the turbine, if appropriate protection measures are not incorporated into the design by the EPC Contractor.

Any sediment information supplied is for reference only and shall not relieve the EPC Contractor from carrying out its own assessment of sediment characteristics, erosion mechanisms and protective measures.

As per Sub-Clause 1.1.3 of Technical Provisions, Part-II, Volume-II, of the RFP/EPC Bidding Document, the EPC Contractor shall independently assess the sediment conditions and shall be solely responsible for selecting appropriate materials, coatings, and protective measures necessary to satisfy the guaranteed performance, efficiency, reliability, availability, and service life requirements specified in the RFP/EPC Bidding Document. No additional payment or claim shall be entertained on account of sediment-induced erosion that could reasonably have been addressed through proper design and material selection.



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Accordingly, the following requirements shall form part of the Employer's Requirements and shall be considered by all Proposers in the preparation of their Technical and Financial Proposals.

**1.1.17.9.1 General**

The EPC Contractor shall design, manufacture and supply Vertical Shaft Francis turbines suitable for continuous operation under sediment-laden water conditions prevailing at the Attabad Lake Hydropower Project (54 MW).

The turbine design shall incorporate suitable erosion-resistant measures to minimize abrasive wear, maintain hydraulic efficiency throughout the service life, and reduce maintenance frequency.

The Proposer shall include all costs associated with such protection in the Proposal Price.

**1.1.17.9.2 Hard Coating Requirements**

The EPC Contractor shall provide a proven abrasion-resistant protection system suitable for severe hydro-abrasive service. The proposed coating system shall be fully compatible with CA6NM stainless steel and shall not adversely affect the metallurgical, mechanical, or hydraulic performance of the base material. The Proposer shall substantiate such compatibility by submitting documentary evidence, including manufacturer's technical data, material specifications, test reports, and/or documented references demonstrating successful application on CA6NM stainless steel under comparable service conditions, for the Employer’s review.

High Velocity Oxygen Fuel (HVOF)-applied Tungsten Carbide (WC-Co, WC-CoCr) is the preferred solution.

High Velocity Oxygen Fuel (HVOF) is a thermal spray technology in which powder is fed into a spray gun. A fuel gas (such as propane) is combusted with oxygen to generate a high-temperature, high-velocity gas stream. The powder particles are heated and accelerated to supersonic velocity before impacting the substrate to form a dense, strongly adherent coating.

**1.1.17.9.3 Coating Test Method**

The coating system shall be tested and qualified in accordance with IEC 62364, Hydraulic Machines – Guide for Dealing with Hydro-Abrasive Erosion in Kaplan, Francis, and Pelton Turbines.

The EPC Contractor shall apply the protective coating to the turbine runner, guide vanes, facing plates, wearing rings and any other turbine water passage components identified as susceptible to hydro-abrasive erosion, in order to extend the service life of turbine runners and associated components.

After application of the coating, the coated components, including the runner and guide vanes, shall be inspected during each annual maintenance outage. Where necessary, localized repairs shall be carried out at site in accordance with the coating manufacturer's approved repair procedures.

The EPC Contractor shall state and guarantee the expected service life of the coating system under the specified sediment conditions and shall specify the expected inspection intervals, maintenance requirements, repair methodology, and recoating intervals throughout the design service life of the turbine.



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### 1.1.17.9.4 Minimum Coating Locations

The EPC Contractor shall identify all erosion-prone surfaces through hydraulic analysis, sediment erosion assessment, and operating experience and provide suitable protection. As a minimum, the following locations shall be considered:

- Turbine Runner blades
  - Leading edge
  - Pressure side
  - Suction side
  - Trailing edge
  - Crown transition
  - Band transition
  - Runner outlet region
- Turbine Guide Vanes
  - Leading edges
  - Trailing edges
  - Upper and lower sealing faces
  - Side faces exposed to leakage flow
- Turbine Facing Plates
- Turbine Wearing Rings
- Turbine Labyrinth Rings
- Stay Vanes (where considered susceptible to hydro-abrasive erosion)
- Other underwater metallic components identified by the EPC Contractor as susceptible to abrasive erosion.

### 1.1.17.9.5 Coating Material and Thickness

The coating shall consist of a Tungsten Carbide based material suitable for severe hydro-abrasive service.

Typical acceptable systems include:

| Parameter | Specification |
|---|---|
| **Coating Material** | WC |
| **Type** | (WC-Co, WC-CoCr) |
| **Composition** | Tungsten carbide (WC) 86%, Cobalt 10%, Chrome 4% |
| **Porosity Rate of Coating** | < 1% |
| **Bonding Strength of Coating** | To be provided by the EPC Contractor and Supported by Test Certificates |
| **Thickness** | To be provided by the EPC Contractor |
| **Hardness of Coating** | To be provided by the EPC Contractor |

-The coating surface roughness after spraying: To be provided by the EPC Contractor



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The EPC Contractor shall determine coating thickness based on its own assessment of sediment characteristics, including sediment concentration, particle hardness, particle size distribution, operating head, flow velocity and expected service life etc.

The proposed coating thickness shall be justified through design calculations, coating manufacturer's recommendations, laboratory test results (where available), and documented successful operating references and shall be subject to the Employer's review.

**1.1.17.9.6 Design Responsibility**

The EPC Contractor shall ensure that:

- coating application shall not adversely affect hydraulic efficiency;
- coating shall not alter designed hydraulic profiles;
- coating shall remain intact throughout the guaranteed operating period
- coating repairs, if required, can be carried out using standard maintenance procedures. There are typical criteria to determine overhaul time due to abrasion erosion in the IEC 62364 standard will be followed.

The EPC Contractor shall also specify the minimum remaining coating thickness requiring repair or recoating.

**1.1.17.9.7 Technical Requirements/ submittals by EPC Contractor**

The EPC Contractor shall submit the following for the Employer's review:

- Method Statement for coating application
- Surface Preparation procedure
- Surface Roughness Measurement procedure
- Coating Material Specification
- Coating Chemical composition
- Hardness test reports
- Bond Strength test reports
- Porosity test reports
- Coating Thickness measurements
- Erosion Resistance test results
- Cavitation Resistance test results
- Quality Control procedure
- Coating Inspection and Acceptance procedure
- Repair procedure for damaged coating
- Quality Certificates from the coating Manufacturer

All coating parameters shall comply with internationally recognized standards.

**1.1.17.9.8 Guarantee**

The EPC Contractor shall be fully responsible for achieving the guaranteed turbine efficiency, reliability, availability, abrasion resistance, and service life under the actual sediment conditions encountered at the Project.

The selection of coating material, coating thickness, application process, coating quality and protected areas shall remain entirely the EPC Contractor's responsibility.



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Any abnormal coating failure, delamination, excessive erosion, or loss of hydraulic performance during the Defects Notification Period attributable to inadequate coating design, material selection, application process, quality control or workmanship shall be rectified by the EPC Contractor at no additional cost to the Employer.

The Contractor shall also guarantee that the coating system shall not crack, peel, blister, or delaminate under normal operating conditions during the Defects Notification Period.

### 1.1.17.10 Coating Requirements for Spare Parts of Turbine Water Passage Components

As per Sub-Clause 1.1.20.2, Mandatory Spare Parts, Technical Provisions, Part-II, Volume-II of RFP/EPC Bidding Document. The EPC Contractor shall ensure that all spare parts supplied under the Contract for the hydraulic water passage components identified in this Addendum are provided with the same erosion-resistant coating system as the corresponding installed components.
The coating material, application process, coating thickness, quality control requirements, inspection requirements and acceptance criteria for the spare parts shall be identical to those applied to the permanent Works.
The requirement shall include, but not be limited to, spare parts for the following components but not limited to,

- Turbine Runner
- Turbine Guide Vanes
- Turbine Facing Plates
- Turbine Wearing Rings
- Turbine Labyrinth Rings
- Other coated hydraulic components supplied as recommended or mandatory spare parts.

The EPC Contractor shall adequately protect the coated spare parts during manufacture, transportation, handling, and storage to prevent mechanical damage, corrosion, contamination, or deterioration of the coating prior to installation.
No additional payment shall be made for coating of spare parts, and all associated costs shall be deemed to be included in the Proposal Price.
The EPC Contractor shall provide appropriate protective packing and handling procedures to ensure that the coating integrity of spare parts is maintained throughout storage until installation.

### 1.1.17.11 Alternative Coating System – Submission, Evaluation and Approval Requirements

The Employer/ Employer representatives may consider an alternative coating system proposed by the Contractor, subject to the completion of a detailed sedimentation study and assessment of the actual sediment characteristics and operating conditions at the Project. Such alternative coating shall only be considered subject to the Contractor demonstrating, through adequate technical documentation and satisfactory test results, that the proposed alternative provides performance equivalent to or superior to that of the specified hard coating system.

Any such alternative proposal shall be submitted for the Employer review and approval prior to its implementation and shall, as a minimum, include complete technical details of the proposed coating system, manufacturer's technical data, applicable standards and test



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procedures, coating thickness, surface preparation requirements, adhesion/bond strength, hardness, abrasion and erosion resistance, chemical and environmental resistance, expected service life, application procedure, quality control requirements, inspection and testing records, and relevant references demonstrating successful application under comparable hydropower operating conditions

The Contractor shall also provide documented evidence from the coating manufacturer and/or an independent accredited testing laboratory confirming the suitability and performance of the proposed alternative under sediment-laden water conditions representative of the Project. Where considered necessary, the Employer may require additional laboratory testing, qualification testing, or verification of the proposed coating system prior to granting approval.

It is emphasized that acceptance of an alternative coating system shall be subject to the Employer satisfaction that the proposed solution does not compromise the durability, reliability, hydraulic performance, maintainability, or intended service life of the equipment. The Contractor shall remain fully responsible for demonstrating the technical equivalence or superiority of the proposed alternative and for ensuring its compatibility with the base material and the operating conditions of the equipment.

### 1.1.17.12 Draft Tube

The draft tube of the turbine shall consist of two (02) sections; included in the scope of supply for this Part:

- exposed steel plate conical section in the inspection gallery,
- steel lined section embedded in concrete.

**a) Exposed Steel Plate Section**

The exposed steel plate conical section shall be fixed in a suitable manner to the steel lined section and the turbine bottom ring. The construction shall be of such type, that no undue vibration and jarring occur under all operating and transient conditions. Provisions shall be made to enable renewal of the lower fixed and rotating labyrinth seal rings without dismantling the bottom ring and to support the turbine rotor by disengaged intermediate shaft during maintenance. The lower part of the conical exposed steel plate section shall be provided with a flanged type connection joint for the connection to the draft tube steel lined section.

The following welded arrangements shall be provided:

- One manhole at least 800 mm diameter with flush mounted cover opening into the inspection gallery. Hand holds shall be fixed above the manhole to facilitate entry. Manhole cover shall be of hinged design and flush shaped with the internal shape of the draft tube.
- One check cock per manhole shall be arranged below the manholes for water level check before opening the manhole.
- Provisions for attachment of a maintenance platform in the draft tube, below the turbine runner shall be arranged. These provisions shall be provided with flush mounted inside covers, easy dismantlable from outside.
- Maintenance platform to be installed into the draft tube below runner. For easy handling, they shall be made of aluminum, capable of withstanding a specific load of 5000 N/m².



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- All necessary connections, piping and valves for the admission of stabilization air to the draft tube inlet.
- All necessary connections, piping and valves for water level depression and for devices to monitor the water level below the runner.

**b) Steel Lined Section**

The draft tube shall be steel-lined from the turbine centerline in a vertical downstream direction to a section with a water flow velocity lower than 6.00 m/s under rated conditions.

The liner and anchorage shall be designed for the external hydrostatic pressure from water seepage equivalent to the maximum tailwater level. All welded seams shall be watertight. In addition, it shall be designed to ensure a proper rigidity against vibrations.

The liner shall be reinforced strongly on the outside by suitable structural steel and provided with adequate means for securely anchoring it to the surrounding concrete of the powerhouse structure to prevent deformation during concreting and operation.

The reinforcement shall be strong enough to ensure, that the shape of the lining remains rigid with a reasonable amount of sharing support on the inside, whilst placing the surrounding concrete.

The draft tube shall be completely assembled and match marked in the shop and shall be shipped in as few units as practicable to facilitate field erection and dimensional accuracy.

A sufficient number of levelling screws and holding-down bolts with turn-buckles shall be provided to permit centering, levelling and securely maintaining the lining in alignment during embedding until concrete has achieved the specified strength.

Grouting and vent holes with closing plugs tapped for pipe connections shall be provided as required to facilitate the placing of concrete under the lining and for air release.

The steel lined section and draft tube concrete section shall be provided with the following welded arrangements and equipment:

- Connection flange to the exposed draft tube steel plate conical section, ring box type, half embedded into the bottom of the inspection gallery.
- A sufficient number of pipes for statical pressure measurement in the draft tube outlet, in accordance with the requirements of the relevant IEC Standards. The stainless-steel measuring sockets shall be separately connected via piping to a common pressure header securely installed on the turbine floor.
- Draft tube dewatering pipe at the deepest point of the draft tube to be fed into the corresponding pump sump, equipped with removable flush mounted screen made of stainless steel, a manually operated valve and a float operated throttling valve to prevent submerging of the drainage gallery under all operating conditions.

### 1.1.17.13 Spiral Casing with Stay Ring

The spiral casing and stay ring shall be designed for design pressure considering maximum static head and maximum pressure ris including water hammer effects. The horizontal thrust of the spiral case on the spiral case inlet area shall be transferred to the concrete structure via circumferential collar, attached to the connection pipe.

Pressure vessel steel shall be used for spiral case and connection pipe. The spiral casing shall be manufactured from steel plate sections as a welded construction. The number of



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sections shall be suitably chosen so that the water does not abruptly change its flow direction. The stay vanes and stay rings may be of cast steel or welded steel plate design. The stay vanes shall have a favorable hydraulic profile.

Four equally spaced stainless-steel taps 25 mm in diameter shall be provided for head measurement and two taps provided for Winter Kennedy flow measurement. Pipes from each tapping shall be led to an easily accessible location and terminated by stainless steel valves of the globe type.

A manhole of 600 mm clear diameter with flush mounted cover and thrust screws will be provided at an appropriate location in the connection pipe with access from the turbine floor.

**i) Design**

The design, construction and non-destructive testing shall conform to the applicable requirements of the ASME Boiler and Pressure Vessel Code, Section VIII, Division 2 or latest approved edition.

**ii) Fabrication**

All welds shall be 100% radiographed except at locations which do not lend themselves to radiographic examination where they shall be ultrasonically examined. The efficiency of the welds shall be assumed to be 100%. The spiral case shall be furnace stress relieved after welding and before machining.

Welding of spiral casing shall conform to ASME Boiler and Pressure Vessel Code Section IX for procedure and welder qualification. For structural joints, AWS D1.1 will be preferred. All welding shall be carried out using approved WPS and PQRs. Weld quality shall be verified through NDT as per agreed ITP. Only qualified welders and operators shall be employed.

**iii) Pressure Test**

Before encasing in concrete, the complete spiral case shall be pressure tested under a pressure of 1.5 times the maximum design pressure at site. The pressure test head together with all required tools, seals, jacks, bolts and nuts shall be provided. The hydraulic pressure pumping equipment, gauges, valves and piping shall be supplied to perform the test.

During the test, stress gauges shall be fastened to prove that no stresses exist beyond the permissible limits. In particular gauges shall be fixed at the top and bottom flanges of the stay ring, at the baffle vane of the spiral case, and at locations to be stipulated during future negotiations.

The pressure test is a proof of water tightness as well as of stability of the spiral case, and successfully performed pressure test shall be recorded in writing.

Water for the pressure test will be supplied by the Contractor for Civil Works who will also drain the casing after embedment.

### 1.1.17.14 Guide Vanes and Regulating Mechanism

Guide vane bearings, the bearings of the regulating gear, bearing strips for the regulating ring and guide bearing up thrust rings shall be self-lubricating. The self-lubricating element of the bearings shall be of the sintered metal matrix type in which the graphite lubricant is contained within a bronze alloy matrix.

The guide vanes shall be of cast or forged stainless steel, with a content of 13% chromium and 4% nickel, and thereby resistant to cavitation and corrosion. They shall be designed to



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form a single unit, consisting of guide vane and vane stems. The guide vanes shall be normalized. All guide vanes shall be interchangeable.

The surface of guide vanes shall be finished to 12 microns or finer and surface undulations shall not cause S/L to exceed 0.01 where S is deviation from design form measured normal to the surface and L is the distance along the surface over which S occurs.

Each guide vane shall be provided with three self-lubricated bushes, one located in the bottom ring and the other two in the top cover. Shrunk-on stainless steel sleeves shall be provided on the guide vane stems where they pass through the bushes. The sleeves shall be seal welded around their circumference. The upper stems of guide vanes shall be provided with bolted thrust blocks to prevent their upward movement. The thrust blocks shall rotate with the guide vanes against a machined surface on the upper section of head cover.

The guide vane regulating ring shall be guided and supported by renewable self-lubricated strips. The bearing strips shall also be designed to prevent lifting of the guide vane regulating ring under all operating conditions. A guide vane indicator plate shall be provided on the regulating ring scribed in 5% steps of guide vane opening up to 110% opening (100% corresponding to rated output).

All parts of the guide vane mechanism having relative motion shall be provided with self-lubricated bushes.

Each guide vane shall be connected to the regulating ring by means of a link and lever system incorporating a shear pin and eccentric pin to facilitate guide vane adjustment and a friction device or slipping clutch mechanism. In the event of blocked guide vane and failure of the shear pin the friction device will permit movement of the operating mechanism but shall limit the movement of the free vane. The design capacity of the shear pin/friction device combination shall be based upon the results of the turbine model test and shall be such as to limit movement of the free vane under all misaligned vane positions under both opening and closing conditions. The shear pin/friction device combination shall be shop tested and means shall, be provided for adjusting and checking the friction device setting on site. This device shall remain with the Employer for periodic checking as necessary. End stops beyond the guide vane fully open and fully closed position shall also be provided on the head cover.

An electrical or pneumatically operated detector system shall be provided for each turbine to indicate failure or cracking of the shear pins.

The guide vanes and the guide vane mechanism shall be designed for operating forces up to and including full runaway speed. They shall also be designed for forces resulting from an obstacle preventing closure or opening of the vanes up to the combined resistance of the shear pin/friction device. For stressing of the guide vanes, the obstacle shall be assumed to be in the most unfavorable position along the length of the vane.

The entire control mechanism regulating the guide vanes shall be designed so, as to be easily accessible for maintenance inspection and repair as well as to enable the safety elements to be easily reset and the entire regulating mechanism dismantled. It shall be carefully executed and assembled to prevent excessive play. All joints of the regulating apparatus shall be of the self-lubricating metal type.

The vane opening or the regulating ring position shall be indicated by a pointer as a percentage on a dial.



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### 1.1.17.15 Servomotors

The regulating ring shall be actuated by two (02) double-acting servomotors arranged suitably to achieve a simple oil piping layout and accessibility.

The servomotors shall be equipped with adjustable slow-closing devices to retard the rate of closure between the approximate speed-no-load position and the closed position so as to minimize pressure rising in the penstock during load rejections and shock loads in the regulating ring mechanism when the guide vane bodies contact each other.

The servomotors shall be provided with screw type mechanical locking devices to securely hold the guide vanes in the open and closed position, and they shall be arranged to also serve as a stroke limiting device against the maximum hydraulic torque that the vanes can experience plus the force that can be transferred to the locking device through the servomotors with the maximum governor oil operating pressure. The combination locking device and stroke limiter shall be manually operated with ease and shall be designed to prevent accidental position change. The guide vane stroke limiting arrangement shall have provisions to be locked in its position to positively limit the vane opening.

The servomotor shall be amply dimensioned for the maximum regulating forces occurring. The base plate shall be fixed to the steel platform. The servomotor shall be supported to avoid unnecessary wear on the piston rod.

The servomotor shall be equipped with a linear (mm) scale indicating the servomotor stroke conveniently legible when the turbine operates.

An orifice built in the servomotor cylinder wall shall determine the maximum closing rate of the guide vanes. Once adjusted to the correct diameter and installed, it shall be secured properly so that it cannot be removed unintentionally during overhauls, neither shall it become loose if the pipe coupling is broken.

The servomotor shall have pressure tapings for venting or measuring the pressure on both sides of the piston during operation. The Contractor shall provide the pressure measuring equipment, not being a part of the supply, during commissioning.

The stroke of the servomotor, including the guide vane apparatus, shall mechanically be designed for a 10% higher opening than the theoretical opening corresponding to rate conditions.

Leakage oil from the servomotors shall be collected and directed to a sump from where it will be pumped back to the governor pumping set sump.

### 1.1.17.16 Turbine Flow Meter

Each turbine shall be provided with a flow metering equipment of the acoustic type for local indication and recording at the unit local and remote-control panels in the control room. The flow meter shall be capable of measuring instantaneous flow in cubic meter per second from 10 to 125 percent of maximum turbine discharge with error not exceeding 0.5 percent. The instrument shall be calibrated during field acceptance tests and serve as index test.

The Contractor shall submit for approval of the Employer, detailed arrangement drawings of flow meters at each penstock in consultation with their designer and equipment manufacturer to identify suitable location of the flow meters (the location of flow meters as shown in the Conceptual Drawings are indicative). Schematic diagram of the turbine flow measurement system shall also be submitted for approval of the Employer.



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#### 1.1.17.17 Interface with Penstock

The penstock will be supplied by the Contractor for Civil Works and will be left over-length where it enters the powerhouse. The Contractor shall supply a loose flange sized and drilled to suit the Main Inlet Valve upstream flange. The Contractor shall cut back the over-length penstock pipe, and weld the loose flange to the penstock such the penstock and MIV flanges are aligned. A comprehensive weld procedure document shall be submitted for approval by the Project Manager.

### 1.1.18 Painting Schedule and Piping Materials

#### 1.1.18.1 Painting Schedule turbine & Auxiliaries

Painting of the turbine and auxiliaries shall be generally in accordance with General Mechanical Requirements and the following paint Schedule.

**Table 1-4:Paint Schedule**

| Surface | Surface Preparation | Treatment |
|---|---|---|
| Exterior surface of the draft tube, spiral case, and all surfaces to be embedded in concrete | Mechanical cleaning as required (SSPC SP-2 or 3) | None |
| Wetted surfaces of the spiral case and draft tube | Mechanical cleaning SSP SP-2 or 3) and commercial blast cleaning (SSPC SP-6) as required | 2 coats of coal tar epoxy SSPC Paint 16 each coat to have 200 microns dry film thickness |
| All non-mating surfaces of removable parts exposed to water | Near white blast cleaning (SSPC SP-10) | 2 coats of coal tar epoxy SSPC Paint 16 each coat to have 200 microns dry film thickness |
| Edge preparations for field welding and/or prefabrication priming of parts to be field welded and painted | As required | One coat of zinc chromate vinyl butyral wash primer. SSPC Paint 27 or similar protective coating |
| All finished surfaces of ferrous metals. including screw threads that will be exposed during shipment or while awaiting installation | Solvent cleaning (SSPC SP-1) | Heavy coating of rust preventing compound removable with solvent |
| All parts exposed to atmosphere except machine surfaces | Near white blast cleaning (SSPC SP-10) or pickling (SSPC SP-8) | Zinc rich primer undercoat minimum dry film thickness 80 microns followed by 2 gloss finish coats of water base epoxy or acrylic dry film thickness each coat 50 to 80 microns. Total dry film thickness not less than 220 microns |



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| Surface | Surface Preparation | Treatment |
|---|---|---|
| Interior of bearing and parts in contact with oil | Near white blast cleaning (SSPC SP-10) or pickling (SSPC SP-8) | 4 coats of white oil resistant vinyl paint total dry film thickness 150 microns |
| Exterior surfaces of Electrical cubicles. control and instrument cubicles and excitation cubicle etc. | Near white blast cleaning (SSPC SP-10) or pickling (SSPC SP-8) | Treatment 4 coats of vinyl paint SSPC- Paint 9, for total of 150 microns dry film thickness. finish color as directed |
| Interior surfaces control cubicles of cabinets. etc. | Commercial blast cleaning (SSPC SP-6) | Manufacturer's standard |
| Auxiliary items of equipment such as compressors, air receivers. pumps etc. | Standard commercial cleaning | Manufacturer's standard finish with finish colors at site as directed |
| Walkways and stairs | Commercial blast cleaning (SSPC SP-6) | Galvanize |
| Platforms and walkways | Commercial blast cleaning (SSPC SP-6) | Galvanize then 1 coat etch primer. 2 coats zinc rich primer total dry film thickness 100 microns then 1 coat non-skid epoxy paint dry film thickness 30 microns |

### 1.1.19 Piping Materials for Mechanical Auxiliary systems:

Piping materials for turbines, auxiliaries and mechanical auxiliary systems shall be generally in accordance with the following schedule:

**Table 1-5: Piping Schedule**

| Service | Piping Material | Schedule & Finish |
|---|---|---|
| Cooling Water piping in sizes 150 mm and smaller | Stainless Steel. ASTM A312/A312M, Type 304L, seamless | Schedule 40 |
| Cooling Water piping in sizes greater than 150 mm | Steel. ASTM A53, Grade B. seamless | Schedule 40 |
| Drainage piping in sizes 150 mm and smaller | Stainless Steel. ASTM A312/A312M, Type 304L, seamless | Schedule 40 |
| Drainage piping in sizes greater than 150 mm | Steel. ASTM A53, Grade B. seamless | Schedule 40 |
| Lubricating oil piping | Stainless Steel. ASTM A312/A312M, Type 304L, seamless | Schedule 40 |
| High pressure oil piping | Stainless Steel. ASTM A312/A312M, Type 304L, seamless | Schedule 80 |



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| Service | Piping Material | Schedule & Finish |
|---|---|---|
| High pressure compressed air piping | Stainless Steel. ASTM A312/A312M, Type 304L, seamless | Schedule 80 |

### 1.1.20 Spare Parts

#### 1.1.20.1 Recommended Spare Parts

The Proposer shall recommend additional spare parts required for five (5) years of plant operation.

Prices for recommended spare parts shall not be included in the Total Proposal Price.

#### 1.1.20.2 Mandatory Spare Parts

The Proposer shall provide the following mandatory spares for turbine and include its cost in the Price schedule:

**Table 1-6: Spare Parts**

| Sr. No. | Description | Qty. |
|---|---|---|
| 1 | Spare Runner | 01 No. |
| 2 | Guide vanes | 02 sets |
| 3 | Complete sets of all other packing, gaskets, O-rings and seals | 03 sets |
| 4 | Guide bearing pads with Babbitt metal | 03 sets |
| 5 | Complete set of stuffing box seals | 01 set |
| 6 | Complete set of spare parts for the shaft seal | 02 sets |
| 7 | Servomotor Complete | 02 No. |
| 8 | Complete set of seals for the servomotors | 01 set |
| 9 | Self-lubricated bushes / bearing (complete set for one unit); for regulating mechanism | 02 set |
| 10 | Guide vane levers | 01 set |
| 11 | Link for guide vane | 01 set |
| 12 | Shear Pin | 02 set |
| 13 | Complete set of oil coolers for generator, turbine bearing, generator bearing | 01 set |

### 1.1.21 Tests

The Contractor shall submit a detailed testing and commissioning plan / protocol including factory acceptance tests (FATs), site testing & commissioning procedures in accordance with following requirement and latest applicable international standards for approval of the Employer. Testing shall be carried out as per the approved plan.

#### 1.1.21.1 Assembly and Tests in The Workshop

Assembly, inspections and tests in the workshop shall be performed in accordance with the following observations.



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Inspection and testing of the runner shall be performed at the foundry and at the turbine manufacturer's workshop.

Inspection and testing of the shafts shall include the following:

- Chemical analysis including hydrogen content measurement
- Thermal treatment inspection (including stress-relieving)
- Tensile tests (yield point, strength, elongation, reduction of area)
- Charpy V-notch impact test
- Ultrasonic inspection on finished surface
- Baroscopic examination (no indication of segregations, inclusions or cracks)
- Surface roughness inspection
- Magnetic particle testing (liquid or dry method) at coupling flanges

The shafts will be subject to rejection in case of traveling indications or any other indications which have complete loss or back reflection (ultrasonic inspection). Porosity indications will not be allowed beyond a level to be stated after common agreement with the Employer.

Shop assembly shall comprise the whole turbine including pit lining, manifold, runner, complete operating mechanism, etc.

Hydrostatic pressure testing shall be performed on the spiral case. Welding seams of the manifold shall be tested 100% ultrasonically. In addition, 100% of these welds including all intersection points shall be tested radiographically.

#### 1.1.21.2 Field Installation and Tests at Site

Installation, commissioning and testing at site shall be performed according to specifications and requirements mentioned hereafter.

The Contractor will inform the Employer in writing and in due time about the tests which are intended to be carried out.

**a) Installation**

The turbine spiral case / manifold shall be aligned and welded. Welding seams shall be tested 100% ultrasonically and radiographically. The turbine parts shall be embedded in concrete in accordance with a method statement agreed among the Contractor, Civil Contractor and Employer.

All permanent materials required for anchoring and supporting of the embedded turbine parts during concreting shall be delivered on time in order to be embedded in the first stage concrete.

The jacks, tie rods, turnbuckles, anchor loops, leveling screws, supporting columns, sole plates, etc. shall be designed to withstand the uplift of the manifold in liquid concrete of a density of not less than 2,400 kg/m³, during embedment.

The permissible tolerances of straightness and verticality of the turbine shaft/generator shaft assembly shall be in accordance with IEEE Std 1095; IEEE Guide for Installation of Vertical Generators and Generator Motors for Hydroelectric Applications.



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**b) Commissioning Tests**

Load rejection and load acceptance tests shall be performed during commissioning. These tests shall verify that pressure and speed rises, as well as pressure drops and speed drops are within the guaranteed range.

If requested by the Employer, load rejection or load acceptance tests shall be repeated or completed, without extra payment, during the turbine acceptance tests.

**c) Trial Operation**

After successful completion of all commissioning tests, the turbines and associated equipment shall be subject to a Trial Operation. The Trial Operation shall be carried out under the supervision and responsibility of the Contractor. During the Trial Run period, the Employer's staff shall be made fully familiar with the operation and routine maintenance of the hydraulic turbines.

**d) Acceptance Tests**

Field acceptance tests shall be carried out according to the international code for the Field Acceptance Tests of Hydraulic Turbines, IEC Publication no. 60041. The purpose of these tests is to determine whether or not the Contractor's guarantees have been fulfilled.

All accessories for the turbines, necessary to perform the tests, shall be supplied by the Contractor at no extra cost. The tests will be performed on all three units.

The field acceptance tests shall be carried out within or shortly after the trial run period. The tests shall be performed using the "Thermodynamic Method". Measurement of the pressure at the turbine inlet shall be made by precision pressure gauges with continuous automatic recording of the pressure. The Contract documents shall include a description regarding the tests, specifying the measuring methods and instruments to be applied. All provisions required for other parts of the plant and equipment which are not included in the Contract shall be stated clearly (e.g., provision for determination of generator losses, generator output, etc.).

All technical details of the tests shall be agreed between the Contractor and the Employer, not later than six months after Commencement Date. Preliminary notice of the date for the acceptance tests shall be given by the Employer three (3) months in advance and final notice three (3) weeks in advance.

The Employer reserves the right to order the field acceptance tests to an independent Expert experienced in performing measurements of that kind. The whole costs shall be borne by the Contractor, but limited to the costs, included in the Contract. In case the turbines do not fulfill the guaranteed output and efficiency values, the costs of these tests shall be borne by the contractor.

## 1.2 GOVERNORS AND AUXILIARIES

This specifies the requirements for design, engineering, manufacture, transport, storage, erection, shop and site testing and commissioning and spare parts of the speed governing units and their auxiliaries to be furnished for the Francis type turbines.

The supply and services for each of the three governor systems shall include the following scope:

- Digital governor



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Complete dual redundancy in the electronic circuitry of the governor, with standby PLC coming into operation on failure of the prime circuit.

- Sensing equipment

  Speed measuring and power measuring.

- Electric feedback transmitters

  For all injector servomotors and the deflector servomotors.

- Governor actuator

  For electro-hydraulic interface and hydraulic amplification.

- Pressure oil system

  Oil tank with pump sets and air/oil or Nitrogen/oil accumulator.

- Mechanical-type over-speed device, directly acting on the governor hydraulic circuits.
  - Shop testing, site testing and commissioning of the governor equipment.

  The following supply and services shall be provided for the governors:

- Preparation of block diagrams, schematic diagrams, logic diagrams and component arrangement drawings of the oil hydraulic equipment and control equipment for review / approval by the Employer before manufacturing.
- Supply of complete component list(s) with technical data and product description of electric devices. Supply of cross-sectional drawings of main control valves.

### 1.2.1 Type and Description

The governors shall be of digital electro-hydraulic type. Each governor system will be composed of a digital governor, governor actuator, pressure oil system and associated control instruments.

The main components shall be arranged on the following floor elevations:

- Turbine floor: governor actuator and pressure oil unit
- Machine Hall floor: digital governor panel

The speed signals shall be obtained from a voltage transformer located on the output terminals of the generator and from a toothed wheel on the turbine shaft operating with proximity transducers.

The signal for power control shall be obtained from the generator instrumentation.

Flow control signals shall be obtained from matrices in the digital governor derived from model test results.

The digital governor shall allow the following control modes:

- speed control (PID)
- power-frequency control (PI)
- opening control (PID)

In speed control mode three sets of PID parameters shall be provided: one set for no-load, one set for isolated operation and one set for network operation.



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In power-frequency control mode a linear network frequency stabilization function (power-frequency droop) shall be implemented.

Opening control mode (without frequency influence) shall be locally selectable at the governor panel for test and maintenance purposes.

Interfacing with the supervisory and control system (SCS) as well as with application software shall be provided for joint control of the turbines.

The digital governor panel shall be equipped with the necessary control components and instrumentation for the relevant safety aspects.

Speed signal from generator frequency. The generator voltage metering transformer shall be used as the signal source for measuring the frequency. Inductive proximity switches with toothed wheel on the turbine shaft for speed control during starting and stopping, for speed signal display, and back-up of the frequency measurement.

Speed switches, adjustable in the speed range of 0 to 200 %, shall signal the speed criteria to control the generator brakes, excitation “on”, etc., and shall also signal over-speed, stand-still, etc.

### 1.2.2 Applicable Standards

The governors shall conform to the applicable requirements of the latest edition of the following Standards:

- IEC 60308 International Code for Testing of control system for Hydraulic Turbines.
- ASME PTC 29 Speed Governing Systems for Hydraulic Turbine Generator Units.
- IEEE 125 Recommended Practice for Preparation of Equipment Specifications for Speed-Governing of Hydraulic Turbines Intended to Drive Electric Generators.
- IEEE 1207 Guide for the Application of Turbine Governing Systems for Hydroelectric Generating Units.
- IEC 61362 Guide to Specification of Hydraulic Turbine Control Systems.

### 1.2.3 Operating Conditions

All equipment shall be provided for fully automatic operation. An automatic start-up control system shall enable start-up and synchronizing of the generating sets in less than one (1) minute counting from the start command up to parallel switching under the condition of frequency fluctuations of 1% in the grid. For this purpose, two (2) head-dependent start-up openings shall be provided. Digital governor’s frequency response shall conform to Pakistan Grid Code.

The positioning times for the set points of speed, power, turbine wicket gate positions of the governor shall be adjustable during commissioning in accordance with governor settings and requirements due to hydraulic transients at power changes. In order to attain a satisfactory optimization of the governor, the amplification and integral action time shall be as smoothly adjustable as possible over a large range.

The governor shall ensure stable operation under all operating conditions. Therefore, a distinction shall be made between parallel operation with the system (parallel operation with the other machines in the system) and isolated operation.

If the speed band is violated the digital governor shall switch automatically to the speed control mode using the isolated mode parameters. The PID parameter setting shall be optimized during commissioning.

Bump-free switch-over from one control mode (speed, power-frequency, opening) to another control mode and vice versa shall be guaranteed. The power shall be controlled at an accuracy of 1%.

The speed controller shall respond to deviations in frequency less than 0.01 Hz. In addition to the set-point adjuster, it shall be possible for a superimposed device to transfer binary signals of speed, power, wicket gate positions. The set points of speed, wicket gate positions, and power shall not be affected by alterations of the speed droop.

### 1.2.4 Functional Requirements

The governing system shall be capable to fulfil the following functions as a minimum:

- Speed control at no load operation.
- Automatic start and stop sequences, including automatic synchronization.
- Power output control; operation at output limitation with power feed-back.
- Frequency regulation.
- Flow control
- Load sharing between the units in “joint control” mode.
- Quick shutdown in case of mechanical failures.
- Emergency shutdown on electrical failures.
- Pressure oil unit will be of air/oil or Nitrogen/oil accumulator and piping system

### 1.2.5 Technical Parameters

- Servomotor dead time (Less than) 0.2 (s)
- Speed dead band (Less than) 0.02 (%)
- Permanent speed droop bp 0 ~ 10 (%)
- Temporary speed drop bt 1 ~ 200 (%)
- Integral time constant Td 2 ~ 20 (s)
- Derivative time constant Tn 0 ~ 2.0 (s)

### 1.2.6 Pressure Oil System

The operating pressure of the Pressure Oil System will not be greater than 160 bar. Pressure oil unit and accumulator shall be arranged on the turbine floor near the governor actuator.

The Pressure Oil System for each governing unit comprises but not limited to following Parts:

Pressure oil unit, air/oil or Nitrogen/oil accumulator and piping system. The pressure oil unit shall be composed of oil sump tank, governor oil pumps, filters and cooler (if required).

### 1.2.7 Piping

All piping, tubing, flanges, fittings, valves, hangers, brackets, fasteners, and all necessary items for a complete, self-contained hydraulic pressure and actuator system shall be designed, manufactured and installed by the Contractor. All the piping and fittings will be manufactured from stainless steel material suitable for high-pressure hydraulic service, with minimum corrosion allowance.



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### 1.2.8 Spare Parts

#### 1.2.8.1 Recommended Spare Parts

The Proposer shall recommend additional spare parts required for five (5) years of plant operation.

Prices for recommended spare parts shall not be included in the Total Proposal Price.

#### 1.2.8.2 Mandatory Spare Parts

The Proposer shall provide the following Mandatory Spares given for Governor System and include its cost in the Price Schedule:

**Table 1-7: Spare Parts**

| Sr. No. | Description | Qty. |
|---|---|---|
| 1 | Electrical cabinet | 1 No. |
| 2 | Proximity Switch with disk and speed switches Magnetic pickup | 1 No. |
| 3 | Auxiliary relays | 1 No. for each type |
| 4 | Speed Setting device P.C.B./Speed sensor | 1 No. each |
| 5 | Displacement Sensors (Governor & Operating Ring) | 04 Nos. each |
| 6 | PLC along with modules | 01 set |
| 7 | Electronic card/modules of each type | 02 Nos. |
| 8 | Complete set of oil cooler for governor | 01 set |
| **OIL PRESSURE UNIT AND PUMPS** | | |
| 5 | Oil screw pump with motor for pressure oil supply | 03 Nos. |
| 6 | Seals / Packing (all types) | 03 sets |
| 7 | Twin filter for oil | 03 Nos. |
| 8 | Solenoids / coils | 03 sets |
| 9 | Springs (all types) | 03 sets |
| 10 | Limit switches | 03 sets |
| 11 | Micro switches | 03 sets |
| 12 | Level relays | 03 sets |
| 13 | Pressure switches | 03 sets |
| 14 | Ball bearings (all types) | 03 sets |
| 15 | Safety relief valve together with pump Un-loader valve. | 03 sets |
| 16 | Guide metal for oil distribution head | 03 sets |



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| Sr. No. | Description | Qty. |
|---|---|---|
| 17 | Gate position Transmitter | 06 pcs |
| **INSTRUMENTS AND SAFETY DEVICES** | | |
| 18 | Resistance type temperature detectors | 06 Nos. |
| 19 | Flow relays | 03 Nos. of each type |
| 20 | Level Switches | 03 Nos. of each type |
| 21 | Dial type thermometers | 03 Nos. of each type |
| 22 | Coils / Contacts / Springs for auxiliary Relays solenoids and switches etc. | 03 Nos. of each type |
| 23 | Float switches | 03 Sets of each type |
| 24 | Pressure Gauges | 03 for each type |
| 25 | Site gauge glass for pressure oil tank, Sump tank | 03 for each type |

### 1.2.9 Tests

The Contractor shall submit detailed testing and commissioning plan / protocol including factory acceptance tests (FATs), site testing & commissioning in accordance with following requirement and latest applicable international standards for approval of the Employer. Testing shall be carried out as per the approved plan.

#### 1.2.9.1 Assembly and Tests in the Workshop

The inspections and tests shall be performed in accordance with these Technical Specifications. The Contractor shall prepare a table, listing all components to be tested and the tests to be performed. Requirements outlined in IEC Publication 60308 and other publications shall be adequately included in the tests. The Employer reserves the right to request additional tests if necessary. Test certificates for materials and equipment shall be provided in triplicate to the Employer. This shall include the following:

- Material tests and chemical analysis of steel and other principal metals used.
- Plate steel for oil accumulators shall be ultrasonically tested.
- Welds shall be physically inspected, and radiographically and/or ultrasonically tested as specified.
- Hydraulic pressure tests on oil accumulators, safety valves and pressure pipes. The test pressure shall be not less than 1.5 times the design pressure.
- Insulation tests, operating tests, heating tests, load tests, etc. on electric motors in accordance with IEC standards.

All equipment shall be assembled for the inspection of functional tests. Exceptions may be permitted only if approved by the Employer. All. parts shall be correctly dowelled and matchmarked to facilitate assembly at the Site. The Contractor shall intimate the Employer in writing of the date and place of inspection and testing not less than two weeks before the parts are ready, and give the Employer full facilities for conducting or witnessing the tests. Three copies of the test reports shall be provided to the Employer.



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At least the following components shall be assembled and presented to the Employer:

- Digital governor
- Governor actuators including at least one servomotor of each type with feedback system.

The governor assemblies and components shall be inspected and tested in the workshop.

Function check of:

- digital governor panels and control functions with start-/stop simulation
- electro-hydraulic converters
- feedback transmitter
- pump motors
- oil pumps

Inspection of:

- speed sensing device
- mechanical over-speed device
- equipment to oil-hydraulic actuator cabinet.

The Contractor shall submit for approval a detailed list of tests based on the above descriptions, considering IEC-Publication No. 60308 and other applicable IEC recommendations.

The tests shall include the following:

- Pump performance tests
- Opening and closing functions
- Electrical check of correct internal wiring and cabling continuity.
- Measurement of insulation level of electrical equipment using a calibrated Megger.

Checking the governor system characteristics by means of simulation. The governor shall be tested and at least the following data recorded, preferably using a multi-channel chart recorder:

- Speed
- Servomotor positions
- Transducer position
- Dead band, dead time, inaccuracy
- Checking range and influences of governor parameters
- Checking of all signals, instruments, relays and operating times
- Checking of following-up behavior from speed to power controller and vice versa
- Checking the harmonic response and transfer functions for different settings of P, D and I values
- Checking of behavior by load rejections and load acceptance during power and speed control mode
- Checking the set-points



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### 1.2.9.2 Tests on Completion

Installation, testing and commissioning at site shall be performed according to with these Technical Specifications. The Contractor shall inform the Employer in due time about the tests to be carried out.

**a) Pre-Commissioning Tests (Dry Tests)**

The governor shall be tested and at least the under-noted recorded, if practicable by using a multichannel chart recorder.

The Contractor shall submit for approval a detailed list of tests based on the IEC Publication No. 60308 and the technical specifications before start of the tests. The following parameters shall be tested:

- Speed signal,
- Servomotor position.
- Transducer position,
- Dead band, dead time, inaccuracy,
- Checking range and influences of governor parameters,
- Checking of all signals, instruments, relays and operating times,
- Checking of follow-up behavior from speed to power controller to opening controller
- in different sequences and vice versa,
- Checking the harmonic response and transfer functions for different settings of P, 0
- and I value,
- Checking of behavior by load rejections and load acceptance during opening,
- Power and speed
- Control mode,
- Checking the set-points of starting up procedure (step one and step two setting).

The functions of oil pressure units, air/oil pressure vessels and oil sump tanks shall be checked in detail. Each pump shall run continuously for at least six (6) hours.

During this operation test calibration of valves, checking of oil leakage through pilot and control valve at steady conditions, checking the change-over procedure from one cooler or filter element to the other, and adjustments for the closing and opening times of the servomotors shall be performed.

All functions shall be checked regarding movement of servomotors, electrical feedback devices, adjustment of set-points, automatic replenishment of oil and air in the air/oil pressure vessel, function of switch points for the un-loader valves and pumps, closing and opening times for injectors and deflectors, function of locking systems and hydraulically-actuated main oil valve at the inlet / outlet from the air/oil pressure vessel; switch-over behavior from pumps as well as filters and coolers.

The Contractor's supervisor shall carry out the correction of any malfunctions or deviations from the Specifications before receiving the permission to start the commissioning tests.

**b) Commissioning Tests (Wet Tests)**

The commissioning tests shall be carried out in conjunction with the turbine tests, in accordance with the requirements given in turbines section. However, the Contractor shall



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submit a detailed test program for demonstrating at site that the governors meet the stipulated requirements.

### 1.2.10 Trial Operation

After successful completion of all commissioning tests, the governors and associated equipment shall be subject to a Trial Operation. The Trial Operation shall be carried out under the supervision and responsibility of the Contractor.

## 1.3 TURBINE MAIN INLET VALVES (MIV)

This specifies the requirements for design, engineering, manufacture, transport, storage, erection, shop and site testing and commissioning and spare parts of three (3) inlet valves of butterfly type and their auxiliaries to be furnished for the Francis turbines.

The scope of supply for each inlet valve shall include the following:

- Butterfly Valve (Internal Diameter 1.8m)
- Bypass Valves Assembly
- Extension Pipes
- Dismantling Joint
- Counter Weight
- Hydraulic Operator
- Associated Piping

### 1.3.1 Location

Turbine main inlet valves will be provided in the powerhouse upstream of each turbine spiral case intake as indicated in the powerhouse general arrangement drawings.

### 1.3.2 Operation

The inlet valves shall be capable of closing against the maximum flow that can occur under any turbine operating condition including runaway. The inlet valves shall be operated in the opening direction by an oil pressure servomotor whereas closure shall be by counterweight. In the closed position the counterweights shall not restrict access on the valve floor.

The inlet valves opening and closing times shall be independently adjustable but the adjustments shall be of a form that cannot be readily or inadvertently altered. In the interests of minimizing the time necessary to shut down in an emergency, the closing times shall be the minimum consistent with safe operation. The valves shall be opened under balanced conditions provided by opening of their bypass valves.

The MIV shall close after each turbine shut down and its operation shall be controlled by the normal start up and shut down sequences of the generating units.

The oil pressure accumulator system shall be dimensioned to handle three (3) full strokes of the valve (close-open-close) with the remaining pressure during the last stroke sufficient to close the valve.

### 1.3.3 Guarantee

#### 1.3.3.1 Performances

**A. Leakage**

There shall be zero visible leakage when the valve is new and fully closed under rated pressure.

**B. Pressure surge**

The Contractor shall guarantee that, turbine MIV closure under any discharge condition shall not generate a transient head higher than its maximum design pressure.

#### 1.3.3.2 Rejection

If the guarantee is not met, the Contractor shall modify the valve within thirty (30) days of the test. The Employer reserves the right to reject a valve should the Contractor fail to meet the guarantee within 45 days following completion of the test.

### 1.3.4 Valve Type

The Main Inlet Valves shall be of lattice disc butterfly type.

### 1.3.5 Thrust Forces

The downstream end of the penstock shall be located within a thrust block that shall provide axial restraint against hydraulic forces. The main inlet valve foundation and its dismantling joint shall accommodate any residual axial movement of the penstock part exists between the thrust block and the MIV.

### 1.3.6 Bypass Valve and Piping Assembly

A by-pass line assembly of 200 mm nominal pipe diameter shall be provided across each Inlet Valve and designed against maximum applicable pressure. The assembly shall be complete with a 200 mm electrically / hydraulically operated by-pass needle valve and one 200 mm manually gear operated maintenance gate valve including slip joint upstream of the bypass valve suitable for pressure conditions. The bypass line will be used to fill the conduit and spiral case downstream of the main inlet valves. All piping, bolts, nuts, gaskets and a suitable dismantling coupling for a complete installation shall be furnished.

The bypass valve shall be motorized to allow automatic operation by the control system, alternatively the bypass valve can be actuated by the governor hydraulic system. Manual operation provision shall also be provided.

The bypass valve discharge shall be suitably angled so that a cushion of water shall minimize the effects of erosion on surfaces within the spiral casing.

All wearing parts of the bypass valve(s), including those susceptible to erosion or cavitation, shall be renewable, and those in contact with water shall be of stainless steel or bronze. The bypass shall be formed to avoid cavitation damage to the valve and piping.

The bypass valve shall have two (2) limit switches to operate in the closed position and one (1) for 100% opening.

### 1.3.7 Dismantling Joint

A flanged dismantling joint complete with nuts, bolts and jointing shall be provided, located immediately on the turbine side of the valve. The dismantling joint shall permit installation and removal of the valve and, when in position, shall form a positive connection which shall allow sliding movement of the valve relative to the spiral casing.

The dismantling joint shall be provided with lifting lugs to facilitate removal and installation.



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### 1.3.8 Upstream and Downstream Connection Pipes (Extension Sections)

Upstream and downstream connection pipes shall be furnished with each main inlet valve. Upstream connection pipe will be provided between the end of steel penstock and the loose flange of main inlet valve. The connection pipe end at steel penstock side will have a length with margin to adjust and prepare the joint with steel penstock.

Downstream connection pipe will be provided between the inlet of spiral casing and loose flange of dismantling joint.

Upstream and downstream connection pipes shall be provided with suitable flange connections for the by-pass line. Drain valves of DN200 will be provided on both the connection pipes.

Each downstream connection pipe section shall be provided with one (1) 150 mm air-vacuum valves and also supplied with a shutoff manually gear operated gate valve. The valves shall be suitable for operation at the maximum applicable pressure. The gate valve shall be capable of being locked in the open position.

Four pressure taps of stainless steel shall be furnished and equally spaced around the upstream extension on diameters at 45 degrees to tile vertical, for net head measurements and for connections to a pressure gauge to be mounted on the control cabinet. All required piezometer piping, manifolds, and fittings shall be furnished.

### 1.3.9 Foundation Plates

The foundation plates shall be provided with the necessary devices to facilitate level and position adjustment. The sliding faces shall preferably be equipped with self-lubricating bearing surfaces but if appropriate materials are not available then they shall be provided with grease grooves and greasing nipples.

### 1.3.10 Valve Body

The valve body shall be cast steel or fabricated in boiler plate quality steel. It shall be rigidly built and adequately ribbed to minimize distortions. The valve body shall be provided with flanges for bolted connection with upstream and downstream mating flanges as indicated on the valve chamber general arrangement drawings.

Cast or welded valve body parts shall be normalized before machining. The body shall include two horizontal trunnion bearings. The bearing housings shall be integral with the valve body.

The supporting feet shall be designed, machined and surface treated to allow movement of the valve within the elastic extension of the upstream manifold pipe.

### 1.3.11 Valve Disk and Seal

The valve disc shall be of the lattice or “through flow” type designed for minimum head losses. The valve disk shall be of cast steel or welded construction, equipped with bolted-on trunnions (with locked screws) and replaceable trunnions (with locked screws). The disk shall be of lattice construction.

The design of the disk shall be  to minimize head losses. The rotor position shall be indicated on a scale of reasonable size. Rotor position shall also be indicated to the control system.

The disc sealing elements shall be of natural rubber, or other suitable elastomeric, sealing against corrosion-resistant metal seat. The seal retaining fastening devices shall all be made of suitable corrosion resistant metal. The adjusting may be accomplished either in the seal



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retaining element or the seal seating element. The seals shall also be removable and replaceable without removing the valve.

### 1.3.12 Trunnions and Bearings

The trunnions shall be made of forged steel, horizontally arranged, and designed for bolted connection to the valve disk. The sealing areas of the trunnions shall be of stainless steel.

The bearings shall permit the necessary adjustments from outside of the bearing housing. The trunnions shall be hydraulically balanced. The replaceable bearing bushes, supporting the radial and residual axial loads shall be of corrosion resistant material, and shall be replaceable without dismantling the valve. The bearings shall be of self-lubricating metal. The trunnion seals shall prevent water from entering the bearings and shall be optimized for operation in silty water conditions.

### 1.3.13 Operating Servomotors

The servomotors shall be sufficiently sized to ensure that valve opening / closure can be obtained at the minimum guaranteed operating pressure under worst-case conditions. The piston rods shall be forged steel having hard chrome plated surface.

The servomotors and their mountings, pressure piping and control valves shall be adequate for the pressure produced in the servomotor with the most adverse conditions of unbalanced closure against maximum flow, including emergency and runaway conditions.

A manually operated mechanical lock for securing the main inlet valve in the closed or open position shall be provided and shall be of adequate strength to resist both the thrust of the servomotor in the opening direction and the force from the weights in the closing direction. The locks shall embody provision for padlocking in the inserted and withdrawn positions to ensure operational safety during maintenance.

The initiation of opening of the inlet valve shall be interlocked with the establishment of a pressure in the spiral casing substantially equal to penstock pressure.

The inlet valve is not required to be latched open. The piping arrangement shall be such that the servomotor cannot empty under any operating conditions, including loss of power or control signal failure.

#### 1.3.13.1 Operating Mechanism

The operation of valves shall be through servomotors which use hydraulic oil at pressure not greater than 160 bar. The pressurized oil shall be taken from the pressure oil system. The pressure oil system design and equipment shall be similar to those for the hydraulic governor pressure oil system given in Section 4 of this Volume including redundancy, alarms and safety devices.

Inlet valve closing shall be counter weight actuated and opening shall be by oil pressure actuated hydraulic cylinder connected to the counterweight lever assembly. By means of orifices, the same hydraulic cylinder shall also restrict the closing velocity of the valve.

Each valve control panel shall also be provided to allow local control of the valve, bypass, as well as indication of system oil and Nitrogen pressures.



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### 1.3.14 Pressure Oil System and Control Equipment

Each valve shall have its dedicated oil pressure system / equipment. The pressure oil supply system and the control equipment shall be accommodated in one cabinet located adjacent to each MIV. Each oil pressure system comprises of the following:

i. Oil reservoir tank
ii. Two oil pumps
iii. One hand operated piston oil pump for emergency operation
iv. Control instruments and limit switches, including pressure switches and alarms
v. Oil pressure accumulator system
vi. Connecting tube between valve, pumps and control cabinet
vii. Internal electrical wiring of the control panel, complete with terminal blocks and labeling

### 1.3.15 Instrumentation

The valve shall be provided with the limit switches or other devices to provide the control system with information on the valve position.

A pressure gauge with an isolating tap shall be provided on the valve upstream flange, suitable for the maximum design pressure of the penstock.

### 1.3.16 Spare Parts

#### 1.3.16.1 Recommended Spare Parts

The Proposer shall recommend additional spare parts required for five (5) years of plant operation.

Prices for recommended spare parts shall not be included in the Total Proposal Price.

#### 1.3.16.2 Mandatory Spare Parts

The Proposer shall provide the following Mandatory Spares given for turbine main inlet valve and include its cost in the Price Schedule:

**Table 1-8: Spare Parts**

| Sr. No. | Description | Qty. |
|---|---|---|
| 1 | Complete sets of disk seals | 01 set |
| 2 | Sets of screws and plates for the seals | 01 set |
| 3 | Complete set of gaskets, “O” rings and packings | 01 set |
| 4 | Valve of each size | 01 set |
| 5 | By pass valve assembly | 01 set |
| 6 | Air release valve assembly | 01 set |
| 7 | Pressure switch, Limit switch and relays | 01 set |
| 8 | Self-lubricating trunnion bearing | 01 No. |
| 9 | Sets of piston seals for the cylinders | 01 set |
| 10 | Sets of each solenoid valves | 02 set |
| 11 | Sets of each no-return valve and flow control valve and manual valve | 01 set |



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| Sr. No. | Description | Qty. |
|---|---|---|
| 12 | Complete set of pump and motor | 01 set |
| 13 | Complete assembly of valve lock for open position | 01 No. |

### 1.3.17 Tests

The Contractor shall submit detailed testing and commissioning plan / protocol including factory acceptance tests (FATs), site testing & commissioning in accordance with following requirement and latest applicable international standards for approval of the Employer. Testing shall be carried out as per the approved plan.

#### 1.3.17.1 Assembly and Tests in the Workshop

**a) Material Tests**

Based on these requirements, the Contractor shall prepare a list showing all components of the supply to be tested and the corresponding tests to be performed.

The Employer, however, reserves the right to request further tests without additional cost, if he deems such tests necessary.

**b) Workshop Assembly and Workshop Tests**

All parts of the supply shall generally be assembled in the Contractor's factory to the extent necessary for the purpose of inspection, testing and otherwise, to ensure that the equipment will function satisfactorily. Exceptions may be permitted, if approved by the Employer. All parts shall be correctly doweled and match marked to facilitate the assembly at site.

At least, the following parts of each spherical valve shall be assembled at the Contractor's workshop and be presented to the Employer:

- Complete assembly of butterfly valve with operating mechanism, including attachment of upstream transition pipe
- Complete assembly of by-pass system
- Complete assembly of oil accumulator, pressure oil system and local control panel
- Assembly of control piping as far as practicable.

In the above-mentioned assembled condition, the following shop tests shall be performed on the valve by the Contractor in the presence of the Employer:

- Pressure test of 150% of applicable design pressure shall be applied on completely assembled butterfly valve. The pressure shall be applied for an hour at least.
- Pressure test of 150% of applicable design pressure shall be applied on the upstream transition pipe, the pressure shall be applied for an hour at least.
- Pressure test with 150% of the applied working pressure of closing and opening cylinder of the operating servomotors. On each cylinder, the pressure shall be applied for an hour at least.
- Functional test of the butterfly valve with performance of opening and closing movements as well as application of the seals.
- Pressure and tightness test of the entire by-pass system with the same pressures and times as indicated above for the main inlet valve.



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- Pressure test of the hydraulic part of the control cabinet, including piston accumulator, with double the normal working pressure; pressure to be applied during one hour at least.
- Hydraulic and electrical function tests of the control panel under maximum and minimum working pressure.

Pressure test of the control piping at double the normal working pressure as far as practicable.

**c) Required Performance**

The valve and operating mechanism shall be free of abnormal friction or other power consuming deficiencies. All seals shall be drip tight.

**1.3.17.2 Field Installation and Tests at Site**

**a) Installation Requirements**

The following particular requirements shall apply for the installation of the butterfly valves:

The valves shall be brought to the final installation place by means of the powerhouse bridge crane. There the valves shall be placed, perfectly aligned and prepared for embedment of the base plates and for field welding of the upstream transition pipe to the penstock branch pipe, and connection of the dismantling pipe to the turbine manifold. Making-up and welding of the upstream field joint shall be done by the Contractor.

After final placement of the butterfly valve the complete installation of the control equipment and piping, including welding of the pipe work, shall be performed. The scope of installation activities comprises also the supervision of the embedment of the base plates and site painting. For the issue of the "Complete and Ready for Commissioning Certificate", the following checks shall be performed:

- Verification of all parts of the supply.
- Verification of perfect alignment of the butterfly valve and dismantling pipe.
- Check of all important clearances with particular view to the dismantling flange system.
- Non-destructive testing of the field welding and material testing shall be in accordance with specified standards. The field welding shall be checked by radiographic examination on its total length, i.e., 100%.
- TIG welding (tungsten inert gas welding) shall be carried out
- Performance of pressure testing of the control piping with double the normal working pressure.
- Check the pre-stressing, perfect locking and securing of all nuts.

**b) Commissioning Tests**

The Contractor shall supervise and direct the following commissioning tests, as applicable to ensure that the equipment has been correctly installed, all necessary adjustments and settings are made, and that it is in sound condition to operate. The tests listed hereafter are divided into preliminary tests, operation and performance tests. Commissioning of the equipment shall take place, together with the corresponding generating unit according to the commissioning program agreed by the Employer.



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**i. Preliminary Tests (Dry Tests)**

- Electrical control of correct wiring and cabling of all control, alarm and auxiliary power circuits.
- Testing and setting of all relays, limit switches, etc.
- Function test of the Butterfly valve control system in local and remote control modes.
- Dry check of automatic start and stop sequences in conjunction with the Francis turbine.
- Dry check of opening and closing movements, preliminary adjustment of opening and closing time of spherical valve rotor and bypass valve in accordance with approved setting values.

**ii. Operation and Performance Tests**

- Filling of penstock manifold and upstream conduit in a controlled manner. Subsequent filling and deaeration of all control pipes and control valves.
- Tightness test of the valve seal at pressurized penstock.
- Performance of various opening and closing sequences of the by-pass valve under automatic and manual control.
- Checking of opening and closing time of butterfly valve rotor and automatic by-pass valve under dead water conditions.
- Various opening and closing movements under dead water conditions in order to check the correct functioning of the control system, butterfly valve and bypass system in local and remote control.
- Definite adjustment of limit switches and verification of the correct functioning of the various pressure measuring instruments.
- Any additional tests required by the Employer to ensure the completeness and safety of the equipment when operated without additional cost to the Employer.

Following the tests listed above, the subsequent performance tests shall be carried out:

- Closing of the butterfly valve under 25, 50, 75 and 100% of the maximum turbine discharge, in order to prove the vibration-free and safe closing of the valve.

For each closing, the closing time and the corresponding pressure rise shall be measured and recorded. The details of the measurement methods, the conditions and performance of the tests at site shall be agreed upon between Employer and Contractor, and laid down in a separate program, defining the sequence of the tests, the equipment preparation and the corresponding operation procedure prior to commencement of the tests.

After successful termination of all tests on completion the butterfly valves shall be subject to a trial run operation period.

Should by mutual agreement between the Employer and the Contractor one or several performance tests be postponed, this should not prevent beginning of the trial operation.

### 1.3.18 Trial Operation

Trial operation shall be carried out under the supervision and responsibility of the Contractor, in accordance with the Contract Conditions. During this period, the Employer's staff shall be made fully familiar with the operation and the routine maintenance of the plant.

Within one month after commencement of trial operation the valve shall be tested to determine its ability to close tightly against the maximum specified flow and head or maximum flow and head obtainable, if less than specified and the results shall be documented and submitted to the Employer.

## 1.4 POWERHOUSE CRANE

### 1.4.1 General

This specifies the requirements for design, engineering, manufacture, transport, storage, erection, shop and site testing and commissioning and spare parts of the Powerhouse Electric Overhead Traveling EOT Crane to be furnished complete including all accessories and auxiliary systems in accordance with these Specifications.

### 1.4.2 General Requirements

The powerhouse crane will be used for unloading, assembly, erection and future maintenance of the turbines, generators, inlet valves and other mechanical and electrical equipment throughout the service life of the plant. The crane shall travel within the powerhouse serving all three units and erection bay. It shall be operated from an open cabin hanging under the bridge at the downstream wall. In addition, it shall be possible to operate the crane from any location in the powerhouse by means of a portable radio control panel.

The tentative capacity of crane (main hook) is 70 tons. However, Contractor shall determine the actual capacity of the Crane during his basic design which shall be subject to the Employer approval. The capacity of the crane (main hook) shall be appropriate to handle the heaviest assembly including dynamic factors and erection tolerances.

The crane shall be of the overhead travelling type with hook, rails for the runway, and each shall be equipped with one hoist with gear and one auxiliary hoist travelling under one of the girders. The crane will run on a set of rails extending throughout the length of the powerhouse. The crane shall be provided with a cabin of simple, open design for one person, and shall be equipped with chair, controllers and electric socket for 230 V, lighting and fan, and a foot operated horn/bell.

The bridge crane shall be designed and tested in accordance with the requirements of Federation Europeenne De La Manutention (FEM).

FEM classes for the cranes shall be as follows:

**Crane structure design**

| Crane | Class |
|---|---|
| Powerhouse EOT Crane | A3 |

**Crane mechanisms design**

| Crane | Class |
|---|---|
| Powerhouse EOT Crane | 1 Bm |



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### 1.4.3 Extent of Supply

The scope of supply shall include but not be limited to:

i. One (01) top running, double girder electric overhead travelling crane for powerhouse with main hook tentative lifting capacity is 70 ton appropriate to handle the heaviest assembly with appropriate lifting height and factor of safety.
ii. One (01) 10 ton. auxiliary hoist.
iii. One (01) complete set of crane rails for the crane including rail fasteners and buffers.
iv. One (01) open operator's cabin with access ladders and safety handrails.
v. One (01) set of electrical control equipment.
vi. All necessary anchors, bolts, screws, framing, pipes, handrails, oil, grease, temporary and permanent devices for alignment and fixing.
vii. All components, accessories, items and equipment not specifically mentioned above, but necessary for the safe and proper manufacture, transportation, testing, commissioning operation and maintenance of the supply.

### 1.4.4 Technical Requirements

The design and principles for the design shall be in accordance with the General Mechanical Requirements and the requirements given in this Chapter. Reference is also made to General Mechanical Requirements regarding seismic loads applicable to the Project location.

### 1.4.5 Space Requirements

In general, the hook approach distances from the lateral and end walls as well as the space requirements above the crane beams should be kept as small as possible, to obtain maximum working area for the crane.

The Proposer shall submit information about space requirements, hook approaches, lifting heights, etc., as stated in Technical Schedules of Tender Documents.

### 1.4.6 Adjustments

If, for some reason, the length or width of the powerhouse will be adjusted during final design, the length of the crane runways and crane girders will be adjusted correspondingly. No price adjustments will be made for changes of crane span or runway length.

### 1.4.7 Major Components of Crane

#### 1.4.7.1 Crane Girders

The crane girders shall be strong, welded steel construction. Standard size girder rails and trolley stops shall be provided on each girder. Bumpers shall be provided on the trolley. The crane girder shall be provided with the necessary walkways with hard rails, platforms etc., to permit easy access for lubrications, inspection and maintenance. Access to the walkway and the powerhouse crane operator's cabin shall be allowed by ladders as shown on Drawings.

#### 1.4.7.2 Crane Drive

The crane traveling drives shall be variable frequency drive type, and the number of driving wheels shall be in accordance with FEM Standards. The driving and control mechanisms shall be designed and constructed so that the crane travel will be steady and free from undue noise, vibration or rocking in any parts of the structure at rated speed and load. An electrical



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release, spring-set, friction shoe brake with a capacity of at least 150% of the full load torque of the crane drive motor shall be provided.

The brake shall operate immediately after the power of the driver motor is cut off and shall be equally effective in both directions of travel.

#### 1.4.7.3 Trolley Frame

The trolley frame shall be of rigid welded steel construction and shall provide equal load on all wheels without undue deflection. Bumpers shall be placed at the ends of the trolley frame. The frame shall be equipped with supports allowing maximum sag of 20 mm in the event of any wheel assembly breaking.

#### 1.4.7.4 Trolley Drive

The trolley drive shall be designed so that the travel under all operating conditions will be steady and free from undue noise, vibration or rocking in any part. At least one wheel on each rail shall be connected to the trolley drive. An electrically released, spring-set, friction shoe type brake, having the same characteristics as stipulated for the crane drive, shall be provided.

#### 1.4.7.5 Hoist and Gear

The hoist and gear shall be mounted on the trolley frame and be driven by suitable electric motors to obtain the required hoisting speeds. Drums and sheaves shall be designed according to approved standards. The reduction gear shall be fitted with ball/roller bearings, running in oil baths within an oil and dust-tight gearbox, equipped with level sight glasses.

All rotating and moving parts shall be protected by sheet metal guards or other convenient protection devices. Limit switches shall be provided to prevent the hook traveling beyond the predetermined highest and lowest positions.

The hoist shall be equipped with an electrical release, spring-set friction shoe type holding brake with a capacity not less than 150% of the full load torque of the motor.

The load blocks shall be designed to protect the hoisting ropes and prevent them from leaving the sheaves under operating conditions.

#### 1.4.7.6 Auxiliary Hoist

The auxiliary hoist shall be driven by a suitable electric motor and gears to obtain the required speeds. Drums and sheaves shall be designed according to approved standards. The reduction gear shall be fitted with ball/roller bearings, running in oil baths within an oil and dust-tight gearbox.

All rotating and moving parts shall be suitably protected by sheet metal guards or other convenient protection devices Limit switches shall be provided to prevent the hook and carriage traveling beyond the predetermined limits of position. The carriage shall be provided with suitable end bumpers.

The hoist shall be equipped with an electrical release, spring-set friction type holding brake with a capacity not less than 150% of the full load torque of the motor.

The load block shall be designed to protect the hoisting ropes and prevent them from leaving the sheaves under operating conditions.



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#### 1.4.7.7 Crane Tracks

The crane tracks shall be mounted on the concrete beams along the powerhouse.

The columns will be provided with brackets for support and attachment of the girders. Bolts and accessories for fixing the girders to the columns as well as alignment and erection of the girders is part of this Contract.

The complete track with rails, rail fixtures, backplates, end buffers, bolts and nuts shall be included in the supply. The design shall allow for future adjustment of the lateral position of each rail by using clamps for fixing the rails to the concrete beam as shown on drawings or by other approved means.

#### 1.4.7.8 Lighting and Power Points

Four mercury vapor lamps complete with reflectors shall be furnished for crane. These shall be conveniently located and be adjusted from the gangway. The lamp capacity shall be 400 Watts. A power supply with three sockets shall be provided in convenient places along the crane gangway for light, hand tools etc.

#### 1.4.7.9 Hooks and Wires Ropes

The hooks shall be made of forged annealed alloy or carbon steel in accordance with the General Mechanical Requirements. The hooks shall swivel freely on grease lubricated ball or roller bearings. The bearings shall be totally enclosed, dust-tight and constructed to prevent grease leakage.

The wire ropes shall have sufficient length to provide three turns of each end on the drums with the hook at the lowest position. The wire ropes shall be galvanized, permanently lubricated and of heavy duty, fiber core, twist-free design.

The main hook of the powerhouse crane shall have a perfect, vertical lift.

#### 1.4.7.10 Motors

The motors shall be of the slip-ring or squirrel cage type with sufficiently smooth start characteristics and with sufficient capacity to handle the maximum loads They shall be rated for at least 40% relative duty factor and shall have class B or better insulation. Motors of relatively low speed will be preferred. The motor protection shall correspond to IP 54, IEC 144.

The Proposer shall offer thyristor based variable speed motors for crane and trolley drive and/or hoisting machinery.

### 1.4.8 Power Supply and Electrical Wiring

The power supply is 400 V AC, 50 Hz. Connection boxes will be situated next to the crane rail. For the powerhouse this connection box will be located at the top floor of the service bay.

Power shall be supplied to the EOT and monorail cranes hoists through flexible suspended cables.

All wiring shall be furnished and shall be installed in galvanized steel conduits.

Separate conduit systems shall be provided for power and control circuits. All wiring, unless otherwise specified, shall be of the stranded conductor type and shall be brought to terminal



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blocks to facilitate external power connection. All wires shall be tagged or marked for permanent identification to facilitate erection and maintenance.

### 1.4.9 Control Equipment

All functions of the main and auxiliary crane hoists of the powerhouse crane shall be controlled from the operator's cabin specified above.

Additionally, the crane shall have a radio control panel for control from the machine hall.

The electrical equipment and installation shall be complete and comprise all control and protective devices, particularly:

i. Limit switches controlling the end travel of hoist hooks.
ii. Limit switches controlling the end travel of traveling carriages.
iii. Limit switches controlling the end travel of cranes and trolleys.
iv. Load switches that cut the power supply in the event of overloading the hoists.

Emergency stop switch shall be provided at the machine hall floor near the generating units.

The control cubicle for the crane/hoist shall include all necessary fuses, circuit breakers, relays, switches, etc., as required for the proper and safe operation of the equipment. The supply shall also include all necessary limit switches, motor protection devices, cables, cable racks, etc.

### 1.4.10 Spare Parts

#### 1.4.10.1 Recommended Spare Parts

The Proposer shall recommend additional spare parts required for five (5) years of plant operation.

Prices for recommended spare parts shall not be included in the Total Proposal Price.

#### 1.4.10.2 Mandatory Spare Parts

The Proposer shall provide the following Mandatory Spares given for Powerhouse machine hall EOT crane and include its cost in the Price Schedule:

**Table 1-9: Spare Parts**

| Sr. No. | Description | Qty |
|---|---|---|
| 1 | Motor of each type used for the crane to be supplied | 01 No. |
| 2 | Bearings, bearing bushes, wear pins, etc., of each type used | 01 set |
| 3 | Brake shoe liners for each brake used | 01 set |
| 4 | Set of gaskets and packing for each type used | 01 set |
| 5 | Set of limit switches of each type used | 02 sets |
| 6 | Set of flexible couplings of each type for main and auxiliary hoist drive motors | 01 set |
| 7 | Set of electric control coils, controllers, contractors of each type used | 01 set |
| 8 | Sets of lamps, fuses, etc. of each type used (A set consist of 50 Nos.) | 01 set |



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| Sr. No. | Description | Qty |
|---|---|---|
| 9 | Complete crane PLC along with modules | 01 No. |
| 10 | Electronic module of each type | 01 No. |

### 1.4.11 Tests

The Contractor shall submit detailed testing and commissioning plan / protocol including factory acceptance tests (FATs), site testing & commissioning in accordance with following requirement and latest applicable international standards for approval of the Employer. Testing shall be carried out as per the approved plan.

#### 1.4.11.1 Assembly and Tests in the Workshop

The Contractor shall prepare a table, listing all components to be tested and the tests to be performed. The Employer reserves the right to request additional tests necessary. Tests certificates for materials and equipment shall be provided in triplicate to the Employer.

This shall include the following:

- Material tests and chemical analysis of steel and other principal metals used.
- Welds shall be physically and radiographically or ultrasonically tested as specified.
- Routine tests on purchased equipment.
- Insulation tests, operating tests, heating tests, load tests, etc. on electric motors,
- starters, transformers, and other electrical and mechanical components.
- Load rope breaking tests
- Crane static rigidity
- Static test
- Dynamic test

The material test shall include the following:

- Plates or rolled sections of 2 tensile tests and 3 notched bar the main girders impact test on specimens from each kind of plate of each kind of rolled section.
- Shafts rope drum, gear wheels, traveling roller tests: 2 tensile tests and 3 notched bar impact tests of each component according to contractor's test list.
- Hooks: 2 tensile tests and 3 notched bar examinations, in accordance with DIN 15404.
- All plant shall be assembled for the inspection of functional tests. Exceptions may be permitted if approved by the Employer. All parts shall be correctly doweled and matchmarked to facilitate assembly at the Site. The Contractor shall intimate the Employer Requirements in writing of the date and place of inspection and testing not less than two weeks before the parts are ready, and give the Employer full facilities for conducting or witnessing the tests. Three copies of the test reports shall be provided to the Employer.

#### 1.4.11.2 Tests at Site

**a) No-load Test**

During the testing maneuvers, the following items shall be checked:

- Correct operation and efficiency of brakes and limit switches,



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- Vertical and horizontal traveling distances and approach measurement,
- Synchronization of pulley operation when several hoists are used,
- Operating speeds,
- Operation and characteristics of manual and emergency control,
- Examination of paintwork.

**b) Commissioning**

As far as possible, the Contractor shall carry out the load tests under the worst operating conditions under which the hoisting equipment will be operated. All measuring equipment, including test loads, test load carrying structures, ropes etc. shall be provided by the Contractor.

**i. Static test**

With the handling mechanism in a fixed position, the hoisting equipment shall be tested under an overload 40%: greater than its rated load. This load shall be maintained for one hour. The load shall then be relieved gradually. No defect or permanent deformation shall remain after complete removal of the load.

**ii. Dynamic test**

Overload tests: After satisfactory completion of the static test, the testing load shall be decreased to a value 20% greater than that of the rated load of the hoisting equipment. Under these conditions, all the lifting and lowering operations shall be carried out successively for a period of fifteen minutes of effective operation, without vibration, deformation or detrimental temperature rise. Transverse movements of the handling mechanism shall be tested under the same conditions as above. During these maneuvers the following shall be checked:

- Correct behavior of the handling mechanism along its rolling track: the framework shall remain perpendicular to the track and shall under no circumstances give evidence of any defect or deformation;
- Correct operation and efficiency of the brakes and limit switches;
- Adjustment of the starting equipment, adherence of rollers on starting and braking;
- Correct operation of the overload safety system for a load slightly exceeding 120% of the rated load.
- Rated load tests: The crane shall be loaded to its rated load and the following shall be checked:
- The deflection;
- The horizontal and vertical travel distances;
- Correct general operation of the safety mechanisms and accessories;
- The operating speeds;
- The lifting and lowering movements, which shall be made in a continuous smooth manner so that all maneuvers shall be possible with adequate accuracy;
- Brakes and stopping distance: The hoist brakes shall be capable of stopping the rated load operating at a normal slow speed with a maximum slip of 4 mm and maintaining this load in a stationary position without slipping.
- The bearings and other mechanical parts shall also be checked for temperature rise.

**Final inspection**



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After the dynamic test, suspect components shall be dismantled and cleaned. Bearing surfaces shall be inspected for wear and lack of lubrication. Defective components shall be replaced at the Contractor's expense.

### 1.4.12 Trial Operation

After successful completion of all commissioning tests, the bridge crane and the associated equipment shall be subject to a Trial Operation Period. The Trial Operation shall be carried out under supervision and responsibility of the Contractor.

## 1.5 MECHANICAL AUXILIARY SYSTEMS

Mechanical auxiliary systems to be provided shall include but not be limited to the following complete, integrated and fully functional systems:

- Cooling water system
- Dewatering and drainage systems
- Compressed air system,
- Oil purification systems.

### 1.5.1 Cooling Water System

#### 1.5.1.1 General

This specifies the requirements for the design, engineering, manufacture, works testing, packing, transport, storage at site, install, test and commission, acceptance testing, warranty and other services specified or required in these specifications for the supply of cooling water system for the turbine and generator units.

#### 1.5.1.2 Description

The cooling water system shall be provided for the following components:

- Generator air coolers.
- Oil coolers of turbine and generator bearings.
- Turbine shaft seal (if applicable).
- Governor oil cooler (if applicable).

The close loop cooling system shall be provided for each unit of the power plant; however, the EPC Contractor must carried out his own water, petrographic and sedimentation analysis where necessary for verification and confirmation of contractual guarantees. The EPC Contractor shall be required to take sedimentation into consideration in the design of the cooling water system. The Contractor shall determine the flow requirements for cooling water system of each unit and size all associated equipment accordingly

For safe and steady operation, standby arrangement for pump for redundancy shall be provided. The Contractor shall design the complete cooling water system for ease of cleaning and maintenance.

The cooling water systems shall be complete in all respects and include but not be limited to: heat exchangers, horizontal shaft centrifugal pumps with electric motors (1 working + 1 standby) for each unit, air and oil coolers, duplex filters motor operated control valves, flow meters, makeup water tanks, expansion vessels, checks valves, discharge valves, all interconnected piping, instrumentation with cabling, wiring, panels, etc.

The P&ID, system description, detailed arrangement and specifications of cooling water equipment shall be submitted by the Contractor for Employer's approval during design phase.

Based on the requirements, the Proposer shall develop and detail the cooling water system in his Proposal.

Cooling clean water connections shall be such that refilling can be provided through direct couplings to the water supply storage tank provided by the Contractor using fixed pipes.

To compensate for pressure fluctuations during operation of the unit, the closed-loop circulation system shall be equipped with an expansion steel tank. The tank capacity shall be finalized during the design stage. The material specifications for the tank shall be proposed by the Contractor based on the water chemistry report and water analysis, and shall be subject to the Employer's approval during the design phase.

#### 1.5.1.3 Tubular Heat Exchanger

The tubular heat exchangers shall be arranged in the tailrace pond. The heat exchanging elements, tubes and water boxes shall be of corrosion resistant metal

Provisions shall be made to allow easy cleaning of the primary circuit side of the heat exchanger. Drain sockets with valves and pipe connections through to the drainage gallery shall be foreseen.

A temperature indicator and remote temperature detector shall be provided. The heat exchangers shall be designed and tested according to an approved pressure vessel code.

Two sets of special cleaning brushes and of all other necessary equipment to carry out effective cleaning shall be included in the scope of supply.

#### 1.5.1.4 Pumps

The operating range of cooling water pump shall also cover the required cooling water demand in the case only one turbine is in operation. The delivery head of the pump shall be designed to allow for a safety margin to all cooling water consumers.
The pump shall be standard units of a reputable manufacturer and shall conform to the requirements of the standards as prescribed in these specifications. Pump performance curves shall be submitted during basic design.

#### 1.5.1.5 Expansion Vessel

In order to compensate for the pressure fluctuation during operation, the closed loop circuit shall be provided with a pressurized closed expansion vessel of bladder type or piston type with suitable capacity at the selected pressure. The vessel or the filling system shall be provided with automatic filling valve and safety valve, and a volume meter in the filling line for monitoring of the volume of water introduced in the closed loop circuits. Pressure gauge and pressure switch for remote alarm indication shall be provided at the expansion vessel.

#### 1.5.1.6 Piping and Valves

The design of the piping shall ensure that the water flow velocity under normal operating conditions does not exceed 2 m/s. Welding of pipe joints and painting of the pipes shall be done in the shop as far as practicable. A sufficient quantity of flanged connections and threaded unions shall be provided to allow dismantling and replacement of piping without welding work. The connecting pipes of each unit of equipment shall be equipped with shut-off valves. The pipes shall be so arranged that no excessive vibrations or forces can occur and provisions shall be made to prevent pulsations.



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### 1.5.1.7 Tests

The Contractor shall submit detailed testing and commissioning plan / protocol including factory acceptance tests (FATs), site testing & commissioning in accordance with following requirement and latest applicable international standards for approval of the Employer. Testing shall be carried out as per the approved plan.

**a) Assembly and Tests in the Workshop**

The Contractor shell prepare a table, listing all components to be tested and the tests to be performed. The Employer reserves the right to request additional tests if necessary. Test certificates for materials and equipment shall be provided in triplicate to the Employer.

Shop tests shall include the following:

- Hydraulic pressure tests on all components under internal pressure. The test pressure shall be 1.5 of the design pressures.
- Routine tests on purchased equipment.
- Insulation tests, operating tests, heating tests, load tests, etc. on electric motors, and other electrical and mechanical components.

All plant shall be assembled for the inspection of functional tests. Exceptions may be permitted if approved by the Employer. All parts shall be correctly doweled and matchmarked to facilitate assembly at the Site. The Contractor shall intimate the Employer Requirements in writing of the date and place of inspection and testing not less than two weeks before the parts are ready, and give the Employer full facilities for conducting or witnessing the tests. Three copies of the test reports shall be provided to the Employer.

At least the following components shall be assembled and presented to the Employer:

- Pump sets.
- Automatic strainers.
- Control valves.
- Non-return valves.
- Safety valves.
- Local control board.
- Heat exchangers.

The tests shall include the following:

- Check of conformity with approved documents.
- Operation of electric motors, limit switches, etc.
- Hydraulic pressure test.
- Setting and calibration of safety valves.
- Seal leakage check.

When the plant has passed the tests to the Employer satisfaction, he will confirm that it is satisfactory, and that it can be disassembled, painted and packed for shipment.



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**b) Tests at Site**

**i. Commissioning Tests**

The Contractor shall conduct the following commissioning tests to ensure that the equipment has been correctly installed, all necessary adjustments and settings been made, and that it is in sound condition to operate. The site tests are subdivided in preliminary tests, and operation and performance tests.

**ii. Preliminary Tests**

- Electrical check of correct wiring and cabling
- Testing and setting of pressure switches, pressure transmitters and limit switches
- Measuring of insulation level on electrical plant
- Functional tests of the valves
- Ultrasonic testing of cooling water pipelines

**iii. Operation and Performance Tests**

- Leakage test
- Final adjustment of pressure switches, indication instruments and interlocking devices.
- Pump performance tests

**1.5.1.8 Trial Operation**

After successful completion of all commissioning tests, the cooling water systems shall be subject to a Trial Run. Trial Run Operation shall be carried out under the supervision and responsibility of the Contractor.

**1.5.2 Drainage and Dewatering System**

**1.5.2.1 General**

This specifies the requirements for the design, engineering, manufacture, works testing, packing, transport, storage at site, installation, test and commission, acceptance testing, warranty and other services specified or required in these specifications for the powerhouse drainage and dewatering systems.

The P&ID, system description, detailed arrangement and specifications of drainage and dewatering equipment shall be submitted by the Contractor for Employer approval prior to commencement of manufacture.

**1.5.2.2 Description**

The powerhouse drainage system shall be designed to drain water leakages from turbine components, auxiliary equipment and power station floors, galleries and pits, and shall be designed for automatic operation with the provision of local manual control of individual pumps from the local control boards. Provision for oil-water separation shall be provided for the drainage system with means to safely collect separated oil in some suitable container for proper disposal in accordance with environmental regulations.

The dewatering system shall be designed to dewater water passages including tunnel, penstock, spiral case, draft tube tailrace pond etc., when these water passageways are under repair or maintenance.



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Based on the requirements, the Proposer shall develop and detail the drainage and dewatering system in his Proposal.

### 1.5.2.3 Tests

The Contractor shall submit detailed testing and commissioning plan / protocol including factory acceptance tests (FATs), site testing & commissioning in accordance with the following requirements and latest applicable international standards for approval of the Employer. Testing shall be carried out as per the approved plan.

**a) Assembly & Tests in the Workshop**

The Contractor shall prepare a table, listing all components to be tested and the tests to be performed. The Employer reserves the right to request additional tests, if necessary. Test certificates for materials and equipment shall be provided in triplicate to the Employer.

Shop tests shall include the following:

- Hydraulic pressure tests on all components under internal water pressure. The test pressure shall be 1.5 times the design pressure.
- Routine tests on purchased equipment.
- Insulation tests, operating tests, heating tests, load tests, etc. on electric motors and other electrical and mechanical components.

All equipment shall be assembled for the inspection of functional tests. Exceptions may be permitted if approved by the Employer. All parts shall be correctly doweled and matchmarked to facilitate assembly at the Site. The Contractor shall intimate the Employer Requirements in writing of the date and place of inspection and testing not less than two weeks before the parts are ready, and give the Employer full facilities for conducting or witnessing the tests. Three copies of the test reports shall be provided to the Employer.

At least the following components shall be assembled and presented to the Employer:

- Pump sets.
- Control valves.
- Non-return valves.
- Local control switchboards.

The tests shall include the following:

- Check of conformity with approved documents.
- Operation of electric motors, float switches, etc.
- Hydraulic pressure test.
- Seal leakage check.

When the equipment has passed the tests to the Employer satisfaction, he will confirm that it is satisfactory, and that it can be disassembled, painted and packed for shipment.

**b) Tests at Site**

**i. Commissioning Tests**

The Contractor shall conduct the following commissioning tests to ensure that the equipment has been correctly installed, all necessary adjustments and settings have been made, and



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that it is in sound condition to operate. The Site tests are subdivided into preliminary tests, and operation and performance tests.

**ii. Preliminary Tests (Dry Tests)**

The electrical check of correct wiring and cabling of all control, alarm and auxiliary power circuits. Testing and setting of all relays, float switches, etc. Measuring of insulation level on electrical equipment with megger. Functioning test of the valves.

**iii. Operation and Performance Tests**

- Tightness test of seals.
- Adjustment of float switches.
- Final adjustment of pressure switches, indication instruments and interlocking devices.
- Pump performance test.

#### 1.5.2.4 Trial Operation

After successful completion of all commissioning tests, the Drainage Systems and the associated equipment shall be subject to a Trial Run for a minimum period to be specified in the Contract. Trial Run operation shall be carried out under the supervision and responsibility of the Contractor.

### 1.5.3 Compressed Air System

#### 1.5.3.1 General

This specifies the requirements for the design, engineering, manufacture, works testing, packing, transport, storage at site, installation, test and commission, acceptance testing, warranty and other services specified or required in these specifications for the powerhouse compressed air systems.

The P&ID, system description, detailed arrangement and specifications of compressed air equipment shall be submitted by the Contractor for Employer approval.

#### 1.5.3.2 Description

Two compressed air systems shall be provided in the powerhouse:

a) A high-pressure system to charge the oil accumulators of the governors (the design pressure of the high-pressure system shall be at least 130% of the maximum operating oil pressure of the oil/air accumulators of the governors).

b) A low pressure compressed air system (10 bar) shall be provided in the powerhouse for air supply to the following:
   - to operate the mechanical generator brakes;
   - to provide service air to required points in the Powerhouse and Transformer Deck

In case the Proposer opts to use Nitrogen/oil accumulator for governor oil pressure system, then high pressure compressed air system will not be required.

Based on the requirements, the Proposer shall develop and detail the compressed air systems in his Proposal including compressor capacity, redundancy and air quality class.



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### 1.5.3.3 Tests

The Contractor shall submit detailed testing and commissioning plan / protocol including factory acceptance tests (FATs), site testing & commissioning in accordance with the following requirements and latest applicable international standards for approval of the Employer. Testing shall be carried out as per the approved plan.

**a) Assembly and Tests in the Workshop**

The Contractor shall prepare a table, listing all components to be tested and the tests to be performed. The Employer reserves the right to request additional tests if necessary. Test certificates for materials and equipment shall be provided in triplicate to the Employer.

Shop tests shall include the following:

- Hydraulic pressure tests on all components under internal pressure. The test pressure shall be 1.5 of the design pressures.
- Routine tests on purchased equipment.
- Insulation tests, operating tests, heating tests, load tests, etc. on electric motors, and other electrical and mechanical components.

All plant shall be assembled for the inspection of functional tests. Exceptions may be permitted if approved by the Employer. All parts shall be correctly doweled and matchmarked to facilitate assembly at the Site. The Contractor shall intimate the Employer Requirements in writing of the date and place of inspection and testing not less than two weeks before the parts are ready, and give the Employer full facilities for conducting or witnessing the tests. Three copies of the test reports shall be provided to the Employer.

At least the following components shall be assembled and presented to the Employer:

- Compressor sets.
- Control valves
- Non-return valves
- Safety valves
- Local control switchboard

The tests shall include the following:

- Proof of conformity with approved documents.
- Operation of electric motors, limit switches, etc.
- Hydraulic pressure test.
- Setting and calibration of safety valves.
- Seal leakage check.

When the plant has passed the tests to the Employer satisfaction, he will confirm that it is satisfactory and that it can be disassembled, painted and packed for shipment.

**b) Tests at Site**

**i. Commissioning Tests**

The Contractor shall conduct the following commissioning tests to ensure that the equipment has been correctly installed, all necessary adjustments and settings been made, and that it



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is in sound condition to operate. The site tests are subdivided in preliminary tests, operation and performance tests.

**ii. Preliminary Tests**

- Electrical check of correct wiring and cabling
- Testing and setting of pressure switches, and pressure transmitters
- Measuring of insulation level on electrical plant
- Functional tests of the valves

**iii. Operation and Performance Tests**

- Leakage test
- Final adjustment of pressure switches, indication instruments and interlocking devices.
- Compressor performance tests

#### 1.5.3.4 Trial Operation

After successful completion of all commissioning tests, the compressed air systems shall be subject to a Trial Run. Trial Run Operation shall be carried out under the supervision and responsibility of the Contractor.

### 1.5.4 Oil Purification Systems

#### 1.5.4.1 General

This specifies the requirements for the design, engineering, manufacture, works testing, packing, transport, storage at site, installation, test and commission, acceptance testing, warranty and other services specified or required in these specifications for the oil purification systems.

A. Transformer oil purification system

B. Governor and lubricating oil purification system.

The P&ID, system description, detailed arrangement and specifications of oil purification equipment for both the above systems shall be submitted by the Contractor for Employer approval.

#### 1.5.4.2 Description

Transformer oil purification system shall comprise but not be limited to the following:

- One (01) Oil Purifier (trolley mounted mobile type; capacity not less than 4,000 l/h)
- One (01) Vacuum Pump
- One (01) clean and One (01) dirty oil transfer pump (Mobile type)
- One (01) set of oil drums in enough quantities to drain One (01) transformer completely
- One (01) Oil testing device for BDV and moisture measurement
- Two (02) sets of rubber hose pipes with connectors at both ends for connecting the purification plant / transformer pump with the transformers.



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Governor and lubricating oil purification system shall comprise but not be limited to the following:

- One (01) Oil Purifier (trolley mounted mobile type; capacity not less than 4,000 l/h)
- Oil storage drums of sufficient capacity
- Two (02) sets of rubber hose pipes with connectors

Based on the requirements, the Proposer shall develop and detail the oil purification systems in his Proposal including oil quality limits to be achieved.

#### 1.5.4.3 Tests

The Contractor shall submit detailed testing and commissioning plan / protocol including factory acceptance tests (FATs), site testing & commissioning in accordance with the following requirements and latest applicable international standards for approval of the Employer. Testing shall be carried out as per the approved plan.

**a) Assembly and Tests in the Workshop**

The Contractor shall prepare a table, listing all components to be tested and the tests to be performed. The Employer reserves the right to request additional tests, if necessary. Test certificates for materials and equipment shall be provided in triplicate to the Employer.

Shop tests shall include the following:

- Hydraulic pressure tests on all components under internal pressure. The test pressure shall be two (2) times the design pressure.
- Routine tests on purchased equipment.
- Insulation tests, operating tests, heating tests, load tests, etc. on electric motors, starters, and other electrical and mechanical components.

All plant shall be assembled for the inspection of functional tests. Exceptions may be permitted if approved by the Employer. All parts shall be correctly doweled and match marked to facilitate assembly at the Site. The Contractor shall intimate the Employer in writing of the date and place of inspection and testing not less than two weeks before the parts are ready, and give the Employer full facilities for conducting or witnessing the tests. Three copies of the test reports shall be provided to the Employer.

At least the following components shall be assembled and presented to the Employer:

- Pump sets,
- Purifier
- Power and Control board

The tests shall include the following:

- Check of conformity with approved documents
- Operating of electric motors, starters, safety valves, etc.,
- Hydraulic pressure test,
- Operating test of purifier. This shall include the treatment of a minimum of 200 l oil. This test may be conducted as site test, subject to Employer approval, if the equipment is the standard product of a reputable, specialized manufacturer.

When the plant has passed the tests to the Employer satisfaction, he will confirm that it is satisfactory, and that it can be disassembled, painted and packed for shipment.

**b) Tests at Site**

**i. Commissioning Tests**

The Contractor shall conduct the following commissioning tests to ensure that the plant has been correctly installed, all necessary adjustments and settings have been made, and that it is in sound condition to operate.

- Electrical check of correct wiring and cabling.
- Testing and setting of all relays, pressure switches, etc.
- Measuring of insulation level on electrical equipment with Megger.
- Performance test of pump sets at rated operating conditions.

**1.5.4.4 Trial Operation**

After successful completion of all commissioning tests, the oil purification/handling system and the associated equipment shall be subjected to a Trial Run for the period specified in the Contract Conditions. Trial Operation shall be carried out under the supervision and responsibility of the Contractor.

## 1.6 MECHANICAL WORKSHOP EQUIPMENT

### 1.6.1 Location and Layout

The workshop will be located adjacent to machine hall at El. 2313.3 m. Layout of machine tools and other equipment in the workshop shall be submitted by the Contractor for Employer approval prior to installation.

### 1.6.2 Machine Tools and Equipment

The equipment shall be new, of latest design and shall be of standard commercial quality from reputable manufacturers. Individual motor drives shall be provided to all machine tools. Lathe, drilling machine, and grinder shall be provided with work-lights. Motors shall be squirrel cage, full voltage start for operation on 400 V, three-phase, 50 Hz or 230 V, single-phase supply.

All machine tools with electric drives shall be provided with individual control and protection panels including emergency stop facilities. The accuracy of machine tools shall be in accordance with relevant ISO Standards.

### 1.6.3 Subcontract Orders

Should some parts of the equipment be supplied by a subcontractor, the Contractor shall provide the Employer with references of the subcontractor on similar works for Employer approval.

### 1.6.4 Particular Requirements

In case of standard equipment not being available to the exact dimensions and characteristics specified, or if maintenance requirements lead to modified data and sizes, the next larger standard size will be acceptable subject to Employer approval, provided the specified performance data will be fulfilled.



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Equipment for mechanical workshop is mentioned in the succeeding clauses:

### 1.6.5 High Precision Bench Lathe

The precision bench lathe shall be quick-change gear-type, light duty, general purpose bench lathe. The accuracy of the lathe shall be in accordance with ISO Standard 1708. The dimensions and facilities of the lathe shall be approximately as follows:

**Table 1-10 : Bench Lathe Facilities**

| Description | Value |
|---|---|
| Swing over cross-slide | 190 mm |
| Swing over bed | 380 mm |
| Height of centers | 180 mm |
| Bed length between centers | 1000 mm |
| Spindle bore | 56 mm |
| Spindle speeds | 25-2000 rev/min. |
| Thread cutting facilities | Metric |

#### 1.6.5.1 Equipment to be provided with the Lathe:

a. 200 mm, 03 jaw, self-centring chuck.
b. Coolant equipment and splash guard.
c. Two (02) tapered centres No. 3 Morse or equivalent.
d. Emergency stop button.
e. One (1) square tool post, one pair of dead centres, one taper sleeve.
f. Set of spanners and keys, instructions and spares manual, accuracy chart.
g. 250 mm diameter, 04 jaw independent, direct or spindle mounting chuck.
h. Low voltage machine lighting for standard ac supply.
i. Chip guard.
j. Large faceplate, manufacturer's standard.
k. Ten (10) assorted cutting tools complete with a selection of cutting bits and tips.
l. Collet chuck with a set of collets, manufacturer's standard.

### 1.6.6 Drill Stand

The drill stand shall be of floor-standing type with pulley drive, adjustable depth stops, graduated in metric calibrations and fitted with safety foot switch. The dimensions and facilities shall be approximately as follows:

| | | |
|---|---|---|
| a. | Drilling capacity | 15 mm |
| b. | Spindle travel | 100 mm |
| c. | Worktable size | 350 x 290 mm |
| d. | Spindle speeds | 480-3800 rev/min. |
| e. | Spindle size | No. 2 Morse taper or equivalent |
| f. | Motor | 3-Phase, 400 V, 50 Hz |



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#### 1.6.6.1 Equipment to be provided with the Drill:

a. 15 mm drill chuck and Arbor.
b. One (01) set of high-speed straight shank twist drills from 5 mm diameter to 15 mm in 0.25 mm steps.

### 1.6.7 Bench Mounted Grinder

Bench grinder shall be heavy duty industrial type with pushbutton starter, shatter proof wheel guards and robust work-rests. The approximate sizes and dimensions shall be as follows:

| | | |
|---|---|---|
| a. | Wheel size | 200 x 25 x 20 mm |
| b. | Wheel centers | 350 mm |
| c. | Motor speed | 3000 rev/min. |
| d. | Motor | 3-phase, 400 V, 50 Hz |

#### 1.6.7.1 Equipment to be provided with Grinder:

Twelve (12) 200 x 25 x 20 mm grinding wheels, comprising 3 sets of 4 wheels, each set having different grit sizes.

### 1.6.8 Electric Welding Machines

Each portable arc welding machine shall be of multi process GTAW/GMAW/SMAW/TIG inverter type sets suitable for industrial maintenance use. At least one large for the workshop and one small portable one shall be supplied. Each unit shall be equipped with an overload protection. The entire assembly shall be attached to a steel platform and shall be mounted on four mould-on rubber wheels. The following standard accessories shall be furnished with each unit:

a. 10 m of extra flexible rubber covered electrode cable with electrode holder attached.
b. 10 m of extra flexible rubber covered ground cable, with ground clamp.
c. One (1) head shield with lens and cover glass
d. One (1) wire scratch brush
e. One (1) cone and chisel head hammer

Each welding unit shall be furnished complete with 12 m of four (04) conductor rubber covered power cable.

In addition, a triple panel, vinyl coated fibre glass, green colored screen having each panel 2m wide and 2m high shall be provided. The unit shall include three (03) connected steel frames, platform legs, a single curtain that covers all three (03) frames and ties.

#### 1.6.8.1 Electrode Ovens

Two (02) portable electrode ovens, of capacities approx. 7 kg and 25 kg, shall be provided. Ovens shall be suitably insulated capable to heat up to 135°C and to hold about 46 cm long electrodes. Units shall have handles for ease of handling for transportation, supplied with 3m length of cables and rated at 220 volts ac.

#### 1.6.8.2 Oxy-Acetylene Welding Equipment

The oxy-acetylene combination welding and cutting outfit shall consist of:

a. One (1) welding blow-pipe with 5 tips, lighter and wrench



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b. One (1) oxygen regulator with 0.7 to 21.0 MPa gauges and wrench

c. One (1) acetylene regulator with 2 to 2.5 MPa gauges

d. 8 m of 5 mm green oxygen hose.

e. 8 m of 5 mm red acetylene hose.

f. Four (4) 5 mm hose ferrules

g. One (1) cutting attachment with 2 nozzles

h. One (1) pair no. 16 goggles

i. One (1) instruction manual

### 1.6.9 Tool Cabinets

Tool storage cabinets shall be of steel construction and each shall be approximately 600 mm deep and 1,000 mm wide. Each shall be complete with shelves and drawers and lockable doors as required for most efficient storage.

#### 1.6.9.1 Tool Room Racks

The metallic racking and shelving for hand tools, air operated tools and precision instruments normally used in station workshops, shall be approximately 1.8 m high and 600 mm deep. The metallic racking shall consist of shelves vertically adjustable. The racks shall be supplied for assembly at Site.

#### 1.6.9.2 Lockers

Five (5) lockers shall be supplied, and each shall have approximate dimensions of 450 x 500 x 1,800 mm and shall have shelves, drawers and hanging space to accommodate the personal effects of workshop and maintenance personnel.

### 1.6.10 Metal Working Benches

Two (2) metal-working benches shall be approximately 800 mm wide by 4,000 mm long, each with a 1,000 mm diameter welder's bench. The legs of the benches shall be designed so that the benches can be attached to the floor by means of expansion bolts. Each workbench shall be complete with a strong clamping base for four 200 mm swivel bench vices furnished with the benches.

#### 1.6.10.1 Electrical-Working Bench

The wooden-topped bench for electrical work shall be supplied approximately 800 mm wide by 2,500 mm long. The legs shall be designed so that the bench can be attached to the floor by means of expansion bolts. The bench shall be complete with strong clamping bases for two 200 mm swivel bench vices furnished with the bench.

### 1.6.11 Hand Tools

#### a) General

The following basic hand tools and gauges shall be supplied of industrial grade quality:

a. One (01) cased set of metric hand taps and dies - range 6 to 24 mm.

b. One (01) boxed set of BSP taps and dies - range 1/8 inch to 1¼ inch.

c. One (01) boxed set of BSP high speed steel taps - range 1/8 inch to 1¼ inch.

d. One (01) LCD digital external micrometre to read 0-25 mm and one to read 0-1 inch, both shall be fitted with friction thimble.

e. One (01) external micrometre with extension rods and setting gauge to read 0 - 150 mm with accuracy of 0.01 mm.

f. One (01) external micrometre with range of anvils and setting gauge to read 150-300 mm.

g. One (01) cased set of internal micrometres reading 25-50 mm.

h. One (01) cased set of internal micrometres reading 50-300 mm.

i. Two (02) sets of socket wrenches 6 mm to 60 mm.

j. Two (02) sets of end wrenches from 6 mm to 42 mm.

k. One (01) pipe wrench.

l. Pliers

m. One (01) set of screw drivers

n. One (01) set of small files

o. Hammers

p. One (01) set of medium size files

q. Two (02) standard dial gauges with magnetic bases and cross bar assembly to suit reading 0.01 mm over a total travel of 12 mm.

r. 300 mm engineer's level with main, cross and plumb facilities and sensitive to 0.1 mm over 300 mm.

s. One (01) micrometre depth gauge, range 0-150 mm, with six measuring rods.

t. Three (03) inside callipers, sizes 100, 150 and 200 mm.

u. Three (03) outside callipers, sizes 100, 150 and 200 mm

v. One (01) dial calliper, range 0-150 mm, accuracy 0.01 mm.

w. Two (02) electric drilling machines, suitable for 230 V, 50 Hz electric supply, different size from 08 mm to 16mm. One (01) Drill machine shall be supplied suitable for concrete and One (01) suitable for steel.

**b) Air operated tools**

The following air operated tools and appliances shall be supplied:

a. One (01) worm drive nut-runner suitable for bolts up to 12 mm dia.

b. One (01) ratchet wrench for nuts in the range 10-15 mm across flats.

c. Two (02) straight grinders suitable for 75 x 25 mm wheel.

d. One (01) surface grinder with 15 mm spindle with metric thread.

e. One (01) spray gun suitable for low and medium viscosity fluids, e.g., water, solvents, paints etc.

f. Three (03) 10 m lengths of hose suitable for use with above items along with couplings and fittings.



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#### 1.6.11.1 Standard of Accuracy

All machine tools supplied under this section shall conform to the standards of straightness, flatness, parallelism, squareness and rotation laid down in the latest edition of ISO 230-1: Acceptance Code for Machine Tools.

### 1.6.12 Motors Control Panels, Motors and Starters

The motor control panels supplied by the Contractor shall have all the necessary contactors for starting the motors and be complete with motor protection. Motor duty switching shall be integral within the Contractor's supply. Local panels as indicated herein shall be supplied complete with terminal strips for connection by others as indicated in the attached Control and Indication Schedule. All electrical equipment supplied shall be in accordance with the relevant clauses of Electrical requirements of these Specifications.

Motors and starters shall conform to the Electrical requirements of these Specifications. Full load operation of the motor shall not, under any circumstances, exceed its nameplate kW rating.

Wherever possible, three-phase, 400 V, 50 Hz motors shall be supplied with the machine tools specified.

Loose starters complying with the requirements of Electrical requirements shall be supplied under this section for those machine tools which do not embody starters in their structure. Loose starters shall be to the approval of the Employer and shall be equipped with a suitable starter stand.

### 1.6.13 Painting

Painting shall be the manufacturer's standard system.

### 1.6.14 Tests

The Contractor shall submit detailed testing and commissioning plan including factory acceptance tests (FATs) and site testing and commissioning and trial operation in accordance with latest applicable international standards for approval of the Employer. Testing shall be carried out as per the approved plan.

#### 1.6.14.1 Tests in the Workshop

The Contractor shall prepare a table, listing all components to be tested and the tests to be performed. The Employer reserves the right to request additional tests, if necessary.

The accuracy of the machine tools shall be checked in accordance with the "Reference Book for Machine Tools" by G. Schlesinger, published by G.W. den Boer, Middelburg, Germany, or equivalent reference information. Test certificates for materials and equipment shall be provided in triplicate to the Employer.

Shop tests shall include the following:

- Check of conformity with approved documents
- Operating of electric motors, starters, etc.
- Accuracy checks and functional test of machine tools
- Functional test of air compressor



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When the equipment has passed the tests to the Employer satisfaction, he will confirm that it is satisfactory, and can be packed for shipment.

### 1.6.14.2 Tests at Site

The Contractor shall conduct the following commissioning tests to ensure that the equipment has been correctly installed, all necessary adjustments and settings been made and that it is in sound condition to operate:

- Electrical check of correct wiring and cabling.
- Measuring of insulation level on electrical equipment.
- Performance check of air compressor.
- Load tests of chain blocks.
- Repetition of accuracy check and functional test of machine tools in conjunction with the training of the Employer's personnel.
- Functional check of welding equipment

After successful completion of all commissioning tests, the equipment shall be subject to a Trial operation Period as defined in the Contract Conditions. Trial Operation shall be carried out under supervision and responsibility of the Contractor.



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# SECTION 2 HYDRAULIC STEEL STRUCTURES

## 2.1 GENERAL

This section specifies the requirements for design, engineering, manufacture, inspection, paint, shop test, transport, storage, erection, spare parts, testing and commissioning of the hydraulic steel structures works (comprising gates, stoplogs, trash racks & trash rake, hoisting equipment etc.) to be furnished. General arrangement and location of the hydraulic steel structures are shown in the attached drawings and shall be read in conjunction with these specifications.

### 2.1.1 Applicable Standards

Gates, Stoplogs, Trash racks:

- DIN Standard 19704, "Recommendations for the Design, Construction and Installation of Hydraulic Steel Structure Equipment" (or other equivalent standards, subject to approval by the Employer).
- USACE Manuals.

Gantry Crane:

- DIN Standards
- FEM Standards
- ASME Standards
- CMAA Standards
- ASTM Standards

Trash rack Cleaning Machine:

- DIN Standards
- FEM Standards
- ASME Standards
- ASTM Standards

In case of conflict between standards, the more stringent requirement shall govern, subject to Employer approval.

### 2.1.2 Mandatory Spare Parts

The Proposer shall provide the following Mandatory Spares given for Power intake Gantry crane and Hydraulic hoisting equipment of power and flushing tunnels intake gates and include its cost in the Price Schedule:

#### 2.1.2.1 Power Intake Gantry Crane

**Table 2-1*: Spare Parts***

| Sr. No. | Description of the Item | Qty |
|---|---|---|
| 1 | Motor of each type used for the crane to be supplied | 01 No. |



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| Sr. No. | Description of the Item | Qty |
|---|---|---|
| 2 | Bearings, bearing bushes, wear pins, etc., of each type used | 01 set |
| 3 | Brake shoe liners for each brake used | 01 set |
| 4 | Set of gaskets and packing for each type used | 01 set |
| 5 | Set of limit switches of each type used | 01 set |
| 6 | PLC with all modules | 01 set |
| 7 | Electronic card/module of each type | 01 set |

#### 2.1.2.2 Hydraulic Hoisting Equipment of Power and Flushing Tunnels Intake Gates

**Table 2-2: Spare Parts**

| Sr. No. | Description | Qty. |
|---|---|---|
| 1 | Complete pressure oil pump with motor | 01 No. |
| 2 | Seals / Packing (all types) | 02 sets |
| 3 | Twin filter for oil | 01 no. |
| 4 | Limit switches | 01 set |
| 5 | Pressure switches | 01 set |
| 6 | Ball bearings (all types) | 01 sets |

### 2.1.3 Testing

For all the hydraulic steel structures mentioned in these specifications, the Contractor shall submit detailed testing and commissioning plan including factory acceptance tests (FATs) and site testing and commissioning and trial operation, in accordance with latest applicable international standards for approval of the Employer. Testing shall be carried out as per the approved plan.

## 2.2 POWER TUNNEL INTAKE

Equipment to be furnished at the power intake:

- Two (02) emergency intake gates (vertical lift fixed wheel type)
- One (01) set of stoplogs
- Four (04) sets of trash racks
- One (01) moving electric gantry crane
- One (01) moving, electrically operated trash rack cleaning machine

### 2.2.1 Power Tunnel Intake Emergency Gates

#### 2.2.1.1 Gate Equipment

The intakes of power tunnel shall be equipped with two intake emergency gates of vertical fixed wheel type to protect the turbine in an emergency situation. One hydraulic power unit for the operation of both gates shall be provided and located at the intake deck.



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The fixed wheel gate equipment shall be complete with all parts and components required for installation and operation in accordance with these specifications:

The fixed wheel gate equipment shall include but not to be limited to the following major items:

- Two (02) fixed wheel gates complete with wheels, self-lubricating spherical bearings, guide rollers & seals etc.;
- Two (02) set of embedded parts (first and second stage) for side, bottom & top sealing, guidance and support;
- Two (02) hydraulic hoisting systems comprising of hydraulic servomotors with connecting rods, hydraulic power unit, gate dogging mechanism necessary for maintenance and service, interconnecting pipes, control panels etc.;
- Any other equipment not mentioned above, but necessary to make it fully functional for safe & proper operation and maintenance.

#### 2.2.1.2 Gate Arrangement

Each intake gate shall be designed by the Contractor to close against unbalanced head conditions in emergency with maximum specified discharge through the tunnel at maximum reservoir water level, and also to withstand the maximum reservoir water level with the tunnel empty without permanent deformation.

The gate shall be required to open under balanced head conditions with no flow through the tunnels. The tunnel shall be flooded and heads balanced before opening the gate. The gate shall also be closed under balanced head conditions for routine inspection and maintenance of the tunnel.

The gate will normally remain either fully open or fully closed and will not be used to control the discharge of water into the tunnel. When fully open the gate will normally remain on the intake blocks just above the gate opening.

The gate shall be raised and its rate of closure shall be controlled by a separate oil hydraulic double-acting servomotor. The length of each gate connecting rods shall be sufficient for making gate connection with the servomotor to be installed at intake deck level. The servomotor shall be energized from a single central pumping unit installed in the gate control building located at operating platform level. The servomotor shall have both local and remote controls and the gate shall have both local and remote position indicator. The servomotors shall be amply sized to ensure that gate opening / closure can be obtained at the minimum operating pressure. The piston rods shall be foraged steel having chrome plated surface.

The servomotors and their mountings, pressure piping and control valves shall be adequate for the pressure produced in the servomotor with the most adverse conditions of unbalanced closure against maximum flow.

The oil commonly used in the hydraulic systems is mineral oil, which should have good resistance to the formation of rust, oxidation and foam and shall be suitable for ambient temperature conditions at site. Oils having a viscosity of 150 SSU at 38$^{o}$C and a minimum viscosity index equal to 90 are used.

Pipes used in the hydraulic systems are usually black seamless steel pipe conforming to ASTM A53 or A106 standards. Pipe sizing is determined according to the maximum oil speed. Generally, the following speed limitations are observed in pipe design according to the DIN 19704:



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| | |
|---|---|
| – in suction and filling lines, | 0.6 m/s |
| – in pilot line return and leakage lines, | DN≤40: 1.0 m/s |
| | DN≥40: 1.5 m/s |
| – in pressure lines, | DN≤40: 3.0 m/s |
| | DN≥40: 5.0 m/s. |

The gate shall close under its own weight but the servomotor shall be reversible so that in the event of an obstruction being lodged on the gate tracks or in the guides, a positive downward thrust may be exerted on the gate to ensure complete closure.

#### 2.2.1.3 Shop Painting

The non-stainless-steel parts of the supply shall be shop-primed and painted before being transported from works to site as per the painting schedule provided in these specifications.

**Main Data**

| | | |
|---|---|---|
| i) | Type of Gate | Fixed wheel type |
| ii) | No. of Bays | Two (2) |
| iii) | No. of gate | Two (2) |
| iv) | Embedded metal works | Two (2) |
| v) | Clear width of opening | 4 m |
| vi) | Clear height of opening | 5 m |
| vii) | Sill level | El. 2402.5 m.a.s.l |
| viii) | Max. Operation level | El. 2412.0 m.a.s.l |
| ix) | Max. Flood Water level | El. 2421.0 m.a.s.l |
| x) | Design head at sill | ~21 m (Contract will confirm) |
| xi) | Type of side & top seals | Music note / double stem EPDM |
| xii) | Type of bottom seal | EPDM, wedge |
| xii) | Operation | Lowering / raising under un-balanced head conditions by hydraulic servomotor. |

### 2.2.2 Stoplogs

#### 2.2.2.1 Stoplog Equipment

The Stoplog equipment shall include but not to be limited to the following major items:

- One (1) set of Stoplogs with guide shoe and seals
- Two (2) sets of embedded parts (first and second stage) for side, bottom & top sealing
- One (1) semi-automatic lifting / grappling beam



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- Any other equipment not mentioned above, but necessary to make it fully functional for safe & proper operation and maintenance

#### 2.2.2.2 Arrangement

The stoplogs will be comprised of suitable number of sections to be installed one above the other to form a set of stoplogs for closing the waterway for maintenance of power intake gate and other civil works.

The stoplogs will be of vertical-lift type with skin plate and seals on downstream side as shown in the layout drawings. The structure shall be of welded steel construction. The skin-plate shall be reinforced by vertical and horizontal members welded to the skin-plate.

The stoplogs shall be provided with J-type side and wedge-type bottom rubber seals. The seals shall be fastened to the stoplogs by steel clamp bars. The top most section of the stoplogs shall be provided with J-type top seal to completely seal the opening.

Pair of guide shoes on each side of each stoplogs shall be arranged to engage with embedded guides bars. Moreover, each set of embedded metalwork for stoplogs shall consist of two side-seal and one top seal and one sill beam bearing and guide plates. All seal bearing plates shall be of corrosion-resisting steel. The guide plates shall be provided from the bottom to the deck level. The embedded metalwork shall be installed in the block outs and adjusted by means of alignment screws attached to welding pads embedded in the first stage concrete. After the alignment of the embedded metalwork, the block outs shall be filled with second stage concrete.

**Main Data**

| | | |
|---|---|---|
| i) | Type of Stoplogs | Vertical lift, slide type with guide rollers/shoe |
| ii) | No. of Bays | Two (2) No. |
| iii) | No. of stoplogs | One (1) set |
| iv) | Embedded metalworks | Two (2) sets |
| v) | Clear width of opening | 4 m |
| vi) | Clear Height of stoplog | 5 m |
| vii) | Sill level | 2402.5 m.a.s.l |
| viii) | Max. Flood Level | 2421.0 m |
| ix) | Max. Operation Level | 2412.0 m.a.s.l |
| x) | Design head | ~21 m (Contractor will confirm) |
| xi) | Type of side seals | EPDM, Music Note Type |
| xii) | Type of bottom seal | EPDM, wedge Type |
| xiii) | Operation | Lowering / rising under balanced had conditions by gantry crane with Lifting Beam of adequate capacity |

#### 2.2.2.3 Grappling / Lifting Beam

One lifting beam for lowering/lifting of the stoplogs shall be provided. The lifting beam shall be of welded construction. The beam shall be equipped with two semi-automatic engaging and disengaging hooks. Two guide rollers on each side of the lifting beam shall use the same guide bars/rails provided for the stoplogs. The semi-automatic hooks and guide rollers shall be mounted on corrosion-resisting steel pins with self-lubricating bushings.



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#### 2.2.2.4 Shop Painting

The non-stainless-steel parts of the supply shall be shop-primed and painted before being transported from works to site as per the painting schedule provided in these specifications.

### 2.2.3 Trash racks

#### 2.2.3.1 Trash rack Equipment

Trash racks will be provided to protect the power tunnel from entry of trash / floating debris. The trash rack equipment shall include but not to be limited to the following major items:

- Four (04) sets of Trash racks
- Four (04) sets of side and bottom embedded parts for the trash racks
- One (01) semi-automatic lifting / grappling beam;
- Any other equipment not mentioned above, but necessary to make it fully functional for safe & proper operation and maintenance

#### 2.2.3.2 Arrangement

The trash rack shall be of welded steel construction and of rectangular sections as shown on the specification drawings for power intake structure. Each set of trash rack shall consist of dismantlable sections. Trash rack sections shall be slide into inclined channel with the help of guide rollers and shoe and removable for inspection and maintenance.

The rack bars spacings shall be set in consultation with turbine manufacturer. Trash racks shall be designed to safely avoid resonant vibration under normal operating conditions of maximum operation flow through each trash rack. However, the fundamental frequency of the rack-bars and the lateral plates / beams shall not be less than 2.5 times the frequency of flow induced vibration of the trash rack at normal flow velocity. The trash racks shall be structurally designed for a differential head of 6 m acting on surface area of the trash racks.

The rack bars of power intake trash rack shall facilitate an active cleaning of all parts of the rack area by the trash rack cleaner. There shall be no openings or gaps of any kind which may obstruct the wire ropes or the rake itself. The horizontal bars shall allow the teeth of the rack cleaner to enter at least 25 mm in between the vertical bars of the trash racks.

Each set of trash racks embedded parts shall consist of integral side guide and side bearing plates, and sill bearing plates. The embedded parts shall be installed in block-outs and shall be adjusted by means of erection studs attached to the welding pads embedded in the first stage concrete.

Trash racks integral side guide and side bearing plates shall extend from the sill to deck elevation above top water level and the guide bearing plates to the top of the trash racks. The trash rack embedded parts shall be installed in block-outs and adjusted by means of erection studs attached to welding pads embedded in the concrete.

Trash racks shall be equipped with differential pressure gauge for detection of trash rack clogging. The cleaning of trash racks shall be done with the help of trash rack cleaning machine provided at deck elevation of 2425.0m.

**Main Data**

| | | | |
|---|---|---|---|
| i) | Clear width of opening | : | 4.0 m |
| ii) | Clear height of opening | : | 5 m |
| iii) | No. of trash racks | : | Four (04) sets |



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| | | | |
|---|---|---|---|
| iv) | Sill level | : | El. 2404.0 m.a.s.l |
| v) | Max. operation Level | : | El. 2412.0 m.a.s.l |
| vi) | Operating deck level | : | El. 2425.0 m |
| vii) | Clear spacing between trash rack bars | : | Set in agreement with turbine manufacturer |
| viii) | Differential head for design | : | 6 m $W_c$ |
| ix) | Flow velocity through the trash rack: | | Less than 1m/s. |
| x) | Vertical Inclination | : | Approx. 15º |

#### 2.2.3.3 Grappling / Lifting Beam

One lifting beam for lowering/lifting of the trash racks shall be provided. The lifting beam shall be of welded construction. The beam shall be equipped with two semi-automatic engaging and disengaging hooks. Two guide rollers on each side of the lifting beam shall use the same guide bars/rails provided for the trash racks. The semi-automatic hooks and guide rollers shall be mounted on corrosion-resisting steel pins with self-lubricating bushings.

#### 2.2.3.4 Shop Painting

The non-stainless-steel parts of the supply shall be galvanized before being transported from works to site as per the painting schedule provided in these specifications.

### 2.2.4 Moving Gantry Cranes

#### 2.2.4.1 General

i. As hoist equipment for both the power and flushing intakes hydraulic steel structures one rail mounted gantry crane will be provided.
ii. One rail mounted gantry crane will be provided for handling of the draft tube gates.

#### 2.2.4.2 Extent of Supply for Gantry Crane of Power and Flushing Intakes HSS

The supply shall include but not to be limited to the following major items:

- One (1) gantry crane complete with electrical equipment;
- One (1) set of rails for movement of gantry crane (from power intake to flushing intake complete);
- All components, devices, items and equipment not mentioned above, but necessary for the safe and proper manufacture, transport, testing, operation and maintenance of the supply.

**Main Data**

- Span (centre to centre of runway rails) approx. 11 m
- Length of crane runway approx. 90 m
- Maximum lift approx. 52 m

Crane required capacity shall be determined considering the final lifting load of the heaviest gate assembly including grappling beam and adding 30% safety margin.

#### 2.2.4.3 Extent of Supply for Gantry Crane Draft Tube Gates

The supply shall include but not to be limited to the following major items:

- One (1) gantry crane complete with electrical equipment;



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- One (1) set of rails for movement of gantry crane;
- All components, devices, items and equipment not mentioned above, but necessary for the safe and proper manufacture, transport, testing, operation and maintenance of the supply.

**Main Data**

- Span (centre to centre of runway rails) approx. 3 m
- Length of crane runway approx. 45 m
- Maximum lift approx. 20 m

Crane required capacity shall be determined considering the final lifting load of the heaviest gate assembly including grappling beam and adding 30% safety margin.

### 2.2.4.4 Operating Conditions

The crane shall be an electrically driven platform controlled, outdoor travelling gantry type.

The crane will be used to for erection, handling and maintenance of hydraulic steel structures provided at both the power and flushing tunnels. The gantry crane will move between both the intakes runway using curved rails.

Regarding the outward appearance, the crane shall be pleasant from an aesthetic point of view, and the mechanical and electrical equipment shall be fully protected from the influence of dust and high air humidity at the Site.

The crane shall be designed to require a minimum of space while optimizing the accessible working area. Furthermore, the design shall provide easy accessibility to all important parts which require regular maintenance and inspection.

#### 2.2.4.4.1 Crane Runway

The runway rails with supporting and fixing elements shall be installed within the allowable erection tolerances as stipulated in the applicable standards. Four (4) bumper stops at the ends of the runway shall be provided.

#### 2.2.4.4.2 Gantry

The gantry shall consist of structural steel box sections of welded construction. Special care shall be taken in the design in order to achieve an aesthetic appearance of the crane. The design for fastening the hoist elements to the portal shall allow adjustment of the lateral distance between the runway rails.

Suitable means shall be provided to fix the lifted gate/stoplog in both longitudinal directions in order to prevent unallowable longitudinal oscillations of the bulkhead gate, caused by starting or stopping the crane.

#### 2.2.4.4.3 Gantry Drive

The casings for the wheels and drive mechanism shall have a box type construction. The design of the casings shall permit easy removal of the wheels, bearings, etc.

The portal shall be provided with suitable track sweeps on both sides. Furthermore, safety cams shall be attached to limit the maximum sag of the crane to 20 (twenty) millimetres if any shaft or wheel breaks. Additional safety grips shall be attached to the sides of the wheel casings and shall reach down below the top edge of the rail to prevent the crane from leaving the rails in case of derailment.



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The wheel frames shall be fitted with rubber bumpers to absorb the impact arising at stoppage of the gantry travel under nominal load and at rated speed with the current switched-off.

The gantry shall be supported by at least four wheels. Gantry travel shall be affected by driving one wheel on each track. The driving wheels on each track shall be synchronized electrically.

#### 2.2.4.4.4 Hoist

The hoist shall preferably be of standard design with weather-proof cover, selected under consideration of the requirements specified hereunder.

#### 2.2.4.4.5 Ropes

The wire rope shall have sufficient length to provide three extra turns of each part on the drums with the hook at the lowest position. The wire rope shall be galvanised, permanently lubricated and of heavy duty, fibre core, twist-free design. They shall be dispatched to the site wound on reels which are adequately protected against damage and shall be identified with metal tags firmly fixed to each end. The ends shall be wire bound.

The ropes shall be fixed to the drum in such way, that for their adjustment and replacement only a minimum number of parts need to be removed.

#### 2.2.4.4.6 Drums

The hoisting drums of all hoists shall be made of cast or welded steel of sufficient strength to sustain the combined crushing and bending loads of the rope pulls. Allowance shall be made for fabrication and machining tolerances to ensure that the drum shell thickness under the machined groove shall be at least equal to one diameter of rope. All drums shall be arranged to carry the hooks on the middle of the cranes. All drums shall comply with the requirements of FEM Section 1. Grooves shall be smooth and well-rounded and shall have a minimum depth of 0.35 times the rope diameter. The minimum groove pitch shall be the rope diameter plus 3 mm. Double layer of rope winding shall not be allowed when the hook is at highest position.

#### 2.2.4.4.7 Sheaves and Blocks

The rope sheaves shall be of cast steel or welded structural steel, with machined grooves to minimize wear on the rope.

The sheave pins shall be fabricated of annealed carbon steel or steel alloy, having an ample bearing surface. All moving sheaves shall be equipped with roller bearings, suitable for force feed lubrication.

#### 2.2.4.4.8 Hooks

The load hooks shall be of forged steel of Ramshorn type, subject to the approval of the Employer. The yield point shall be approximately two thirds of the tensile strength. The hooks shall be load tested with 150% of rated load and x-rayed after testing in accordance with applicable standards.

The hooks shall be ground finish and rotate freely on anti-friction bearings. The bearings shall be dust tight and properly sealed to avoid grease leakage.

#### 2.2.4.4.9 Brakes

The hoist shall be equipped with two independent brakes, one each for holding the load and control of lowering speed.

The holding brake shall be of the automatic spring set type, respectively, electrically or electro-hydraulically released double-shoe type. The brake capacity shall not be less than 200% of



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the torque caused by rated load including dynamic effects. The brake shall prevent the load from descending.

The control brake shall be preferably an electrical brake of the frequency transformer-controlled type. An electrical brake of the eddy-current type or a combination of electrical and mechanical brakes can be tendered alternatively. Friction load braking will not be accepted.

#### 2.2.4.4.10 Cabin

Each enclosed operator's cabin shall be mounted on one of the gantry legs and shall be positioned for good visibility of all crane operations. The cabin shall be designed and located to provide maximum visibility of the loaded hook during all operations of the crane. The cab shall be fully enclosed for outdoor service. Provision shall be made in the cab for mounting the manually operated master switches, main line disconnecting breakers, and all necessary wiring and fittings together with a tool box or cabinet containing maintenance tools and equipment to be supplied by the Supplier. The cabin shall be provided with a seat and a ventilation fan.

The cabin shall be located to afford a minimum of 75 mm clearance from all fixed structures and its height shall not be less than 2.2 m.

The cabin shall be constructed of structural steel and rigidly attached to the crane to avoid excessive swaying or vibration. The cab construction shall offer protection from falling objects. Each cabin shall be enclosed with safety type glass windows that can be opened for cleaning and to provide cross ventilation. All hatches, doors, and windows shall be water tight against windblown rain. Sufficient lighting shall be provided in the cabin to enable the operator to see clearly enough to perform his work.

A carbon-dioxide, dry-chemical or equivalent hand fire extinguisher shall be provided in the cabin.

#### 2.2.4.4.11 Platform and Ladders

The gantry cranes shall be provided with walkways, stairways, and ladders from the boarding area to the bridge walkways, the cab and to permit access for lubrication, inspection and maintenance, as necessary. A walkway with guard railing shall be provided around the top of the gantry structure for the crab maintenance.

#### 2.2.4.4.12 Motors

The motors to be provided shall be induction motors with adequate rating to cope with the load involved.

The motors shall have at least class F insulation and be rated for operating against maximum ambient temperature at site. Low speed motors shall be given preference.

#### 2.2.4.4.13 Control Equipment

The crane control shall be of Siemens, ABB or equivalent subject to the approval of Employer and shall be of proven industrial application. All functions of the gantry crane shall be controlled from a lockable cabinet, protection class IP 65. The cabinet shall maintain protection class IP 65 when the crane is in use. The main and auxiliary hoist drives of the gantry cranes shall have stepless speed control between the maximum and minimum specified speeds for the loaded hook condition.

The main hoist drives of the gantry cranes shall also be capable of the fast unloaded speeds as provided in Design and Technical Requirements. The controls shall be arranged such that



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in the unloaded condition it shall be possible to switch from the unloaded speeds to the loaded speeds, but it shall not be possible to switch to the unloaded speeds when loaded.

The electrical equipment and installations shall be complete and comprise all control and protective devices particularly:

a. Limit switches controlling the upper and lower position of the hook
b. Limit switches controlling the end travel of crane and trolley
c. Dual load switches that cut the power supply in the event of overloading the hoist, designed for the different load situations, the trolley operating in between the crane rails, or outside the crane rails.
d. Slack rope switch
e. Hook position display
f. Hoist load display for the power intake crane

All electrical equipment supplied shall be in accordance with the standards and requirements specified in the General Specifications and IEC standards where applicable.

The control unit for the crane/hoist shall include the necessary ammeters, fuses, circuit breakers, relays, switches, etc., as required for the proper and safe operation of the equipment. The supply shall also include all necessary limit switches, motor protection devices, cables, cable racks, etc.

#### 2.2.4.4.14 Power Supply and Electrical Wiring

The power supply is 400 V AC, 50 Hz. The power shall mainly be supplied through a heavy-duty, corrosion-resistant insulated conductor, protection class IP 23. The terminal box, protection class IP 65, shall have an emergency switch in front and shall be provided with a socket for the flexible electrical cable.

Suspension brackets for the conductor shall be a part of the supply. The connectors shall be "low" above the concrete deck, and where the connectors pass the piers, steps or similar should be provided to allow passing by foot. Power shall be supplied to the trolley through flexible suspended cables.

All wiring shall be furnished and shall be installed in galvanised steel conduits. Separate conduit systems shall be provided for power and control circuits. All wiring, unless otherwise specified, shall be of the stranded conductor type and brought to terminal blocks to facilitate external power connection. All wires shall be tagged or marked for permanent identification to facilitate erection and maintenance.

#### 2.2.4.4.15 Shop Painting

The non-stainless-steel parts of the supply shall be shop-primed and painted before being transported from works to site as per the painting schedule provided in these specifications and shall be suitable for aggressive outdoor and humid environmental conditions.

### 2.2.5 Trash rack Cleaning Machine

#### 2.2.5.1 General

Trash collected on the power intake trash racks during operation of the power plant shall be removed by an electrically operated trash rack cleaner of outdoor travelling type. The cleaner shall travel along the trash racks on top of the intake structure. A trolley shall remove the trash



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from the top of the intake deck.

The rake shall serve every intake trash rack, and shall be used without interrupting the power generation.

A hoisting boom with grab bucket hoist mounted on the trash rack cleaner frame, shall also be provided for the removal of heavy logs and floating debris.

#### 2.2.5.2 Extent of Supply

The supply shall include but not to be limited to the following major items:

- One (01) Trash rack cleaner, complete with rake, rake hoist and controllers
- One (01) Hoist boom with electrical wire hoist
- One (01) Grab bucket, to be used with the hoist boom
- One (01) Control cabinet
- One (01) Trolley for the transportation of trash
- One (01) set of rails for movement of trash cleaning machine

All components, devices, items and equipment not mentioned above, but necessary for the safe and proper manufacture, transport, testing, operation and maintenance shall be part of the supply.

**Main Data**

| | |
|---|---|
| Operating deck | 2425 m |
| Raking width, approximately | 4000 mm |
| Lowest rake position (El.) | 2404 m |
| Trash racks, inclination | 15° |

#### 2.2.5.3 Equipment Description

##### 2.2.5.3.1 Trash rack Cleaner

The supply shall include a complete trash rack cleaning machine including hoist, rake and controllers etc.

The rake shall travel along the total height from top of the intake structure to the bottom sill of the intake trash racks on rails by steel operating ropes. No part of the structure shall interfere with the trash rack itself.

The rake shall have an effective rake width of about 4 m and shall travel along the whole width of the trash racks. For movement of the trash rack cleaning machine, rails shall be provided. Hoist and travelling mechanism shall be electrically operated, lateral positioning of the rake and the operation of the cleaner shall be manually controlled. The collected trash shall be dumped into a trolley running under the cleaner.

The cleaner design shall be rigidly dimensioned to carry the load of the hoist machinery and the maximum rake load. If the cleaner frame is subdivided during transportation, major joints shall be doweled and bolted with high-strength bolts.

The rake teeth shall protrude about 25 mm at least in between two bars and shall be so aligned to avoid any damage caused to the trash rack structure.

The rake shall have a clearance of approximately 25 mm to the concrete or steel face.



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The wheels shall have double flanges and the wheel carriages shall have buffers at the outer side as well as sturdy retainers to prevent the cleaner from tilting at adverse conditions, i.e., both maximum rake and hoist boom load.

The rake forming a bucket shall close automatically towards the trash rack when the rake reaches the lowest point of each run. Collected trash shall be firmly held by the rake bucket when the rake is running upwards. Special guide plates or bars shall be bolted to the front

wall of the intake structure, above the top of the trash racks. These shall be part of the supply. All hinged joints, wheel spindles, gears etc. shall be equipped with self-lubricating bushings/bearings. All spindles shall be made from stainless steel. The rake teeth shall be replaceable and made of hardened or abrasion resistant steel.

The main hoist of the cleaner shall be protected by a steel sheet cabinet and well ventilated. The cabinet shall contain all parts of the operating machinery, electrical components and ample room for inspection and maintenance. Electric light shall be included, as well as door locks.

The trash rack cleaner shall be operated from a platform with rails and a light roof at one side, giving a good view for the operator. The control cabinet, protection class IP 65, shall have easy operated controllers and an accurate and reliable indicator of the trash cleaning machine position. The tripping of the overload protection for the rake or auxiliary hoist, as well as at slack rake hoisting wire, shall be clearly indicated. The cabinet shall have a switch for automatic rake stopping at the bottom of the intake trash racks.

Electric power for the trash rack cleaner shall be supplied, which shall include a control cabinet with a terminal block with internal connections to all electrical contacts of the equipment, as well as to the limit switches. All signal outputs in the terminal block shall potential free type.

The control cabinet shall include all necessary fuses, circuit breakers, relays, switches, etc., as required for the proper and safe operation of the equipment. The supply shall also include motor protection devices, cables, cable racks, etc. All wires shall be tagged or marked for permanent identification to facilitate erection and maintenance.

#### 2.2.5.3.2 Hoist and Hoisting Boom

A hosting boom shall be supported on the trash rack cleaner frame, being able to swivel nearly a full circle by an electrical motor.

The hoist shall have a hook, and shall be used for the following purposes:

a. With a sufficient capacity to handle a single trash panel and with an attachment of hydraulic operated grab, to remove larger logs and floating debris and similar in front of the intake.

b. For handling of trash rack panels with the help of grappling beam.

c. With the hook and slings assist the trash rack cleaner rake when required.

d. General maintenance purpose within the hoist boom capacity and operating area.

e. The hoist boom might also be used in assisting the erection of some of the other items at the intake structure

The hoist and the hoist boom shall be operated from the trash rack cleaner operating platform. The supply includes a suitable grab with operating mechanism. The hoist boom shall be provided with a flood light at the outer end.



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#### 2.2.5.3.3 Trolley

The supply includes a trolley, designed for running between the gantry crane frame legs, below the trash rack cleaner raking board. The trolley shall have rubber tires with ball bearings, and shall have standard connections for pulling or pushing by a tractor, the latter not being a part of the supply. The trolley shall be designed to allow easy, manual emptying to both sides and one rear side.

#### 2.2.5.3.4 Shop Painting

The supply shall as far as possible be shop primed and painted before being transported from works to site as per the painting schedule provided in these specifications.

## 2.3 FLUSHING TUNNEL INTAKE

Equipment to be furnished at the flushing intake:

- One flushing intake service gate (vertical lift fixed wheel type)
- One guard gate (fixed wheel type)
- One set of stoplogs required for removal of rock plug (optional)

### 2.3.1 Flushing Tunnel Intake Service Gate

#### 2.3.1.1 Gate Equipment

The intake of flushing tunnel shall be provided with one (01) service gate of vertical lift fixed wheel type to flush out the sediments deposited in vicinity of the power intake. One hydraulic power unit for the operation of gate shall be provided and located at the intake deck level of 2425.0m.

The fixed wheel gate equipment shall be complete with all parts and components required for installation and operation in accordance with these specifications.

The fixed wheel gate equipment shall include but not to be limited to the following major items:

- One (01) fixed wheel gate complete with wheels, self-lubricating spherical bearings, guide rollers & seals etc.;
- One (01) set of embedded parts (first and second stage) for side, bottom & top sealing, guidance and support;
- One (01) hydraulic hoisting system comprising of hydraulic servomotors with connecting rods, hydraulic power unit, gate dogging mechanism necessary for maintenance and service, interconnecting pipes, control panels etc.;
- Any other equipment not mentioned above, but necessary to make it fully functional for safe & proper operation and maintenance.

#### 2.3.1.2 Gate Arrangement

The flushing tunnel intake gate shall be designed by the Contractor to close against unbalanced head conditions in emergency with maximum specified discharge through the tunnel at maximum reservoir water level, and also to withstand the maximum reservoir water level with the tunnel empty.

The gate shall be required to open and close under un-balanced head conditions. The gate will normally remain closed and will be opened when deposited sediments are to be flushed



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out through the flushing tunnel in to Hunza river. When fully open the gate will normally remain on the intake blocks just above the gate opening.

The gate shall be raised and its rate of closure shall be controlled by a separate oil hydraulic double-acting servomotor. The length of each gate connecting rods shall be sufficient for making gate connection with the servomotor to be installed at intake deck level. The servomotor shall be energized from a single central pumping unit installed in the gate control building located at operating platform level. The servomotor shall have both local and remote controls and the gate shall have both local and remote position indicator. The servomotors shall be amply sized to ensure that gate opening / closure can be obtained at the minimum operating pressure. The piston rods shall be foraged steel having chrome plated surface.

The servomotors and their mountings, pressure piping and control valves shall be adequate for the pressure produced in the servomotor with the most adverse conditions of unbalanced closure against maximum flow.

The oil commonly used in the hydraulic systems is mineral oil, which should have good resistance to the formation of rust, oxidation and foam. Oils having a viscosity of 150 SSU at 38$^{o}$C and a minimum viscosity index equal to 90 are used.

Pipes used in the hydraulic systems are usually black seamless steel pipe conforming to ASTM A53 or A106 standards. Pipe sizing is determined according to the maximum oil speed. Speed limitations observed in pipe design according to the DIN 19704:

- in suction and filling lines, 0.6 m/s
- in pilot line return and leakage lines, DN$\leqslant$40: 1.0 m/s
  DN$\geqslant$40: 1.5 m/s
- in pressure lines, DN$\leqslant$40: 3.0 m/s
  DN≥40: 5.0 m/s.

The gate shall close under its own weight but the servomotor shall be reversible so that in the event of an obstruction being lodged on the gate tracks or in the guides, a positive downward thrust may be exerted on the gate.

### 2.3.1.3 Shop Painting

The non-stainless steel parts of the supply shall be shop-primed and painted before being transported from works to site as per the painting schedule provided in these specifications.

**Main Data**

| | | |
|---|---|---|
| i) | Type of Gate | Vertical Fixed wheel |
| ii) | Embedded metal works | One (01) set |
| iii) | Clear width of opening | 5.5 m |
| iv) | Clear height of opening | 5.5 m |
| v) | Sill level | El. 2380.0 m.a.s.l |
| vi) | Max. Flood Water level | El. 2421.0 m.a.s.l |
| vii) | Design head at sill | ~43.5 m (Contractor will confirm) |
| viii) | Type of side & top seals | Music Note / Double Stem EPDM |
| ix) | Type of bottom seal | EPDM, wedge |



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| | | |
|---|---|---|
| x) | Operation | Lowering / raising under un-balanced head conditions by hydraulic servomotor. |

### 2.3.2 Flushing Tunnel Guard Gate

#### 2.3.2.1 Gate Equipment

The intake of flushing tunnel shall be provided with one (01) guard gate at upstream of service gate for maintenance. The gate shall also be capable to close under unbalanced water condition under its own weight in case service gate stuck due to some problem. However, the gate will be raised under balanced head conditions.

The fixed wheel gate equipment shall be complete with all parts and components required for installation and operation in accordance with these specifications.

The fixed wheel gate equipment shall include but not to be limited to the following major items:

- One (01) fixed wheel gate complete with wheels, self-lubricating spherical bearings, guide rollers & seals etc.;
- Gate dogging mechanism;
- One (01) set of embedded parts (first and second stage) for side, bottom & top sealing, guidance and support;
- One (01) semi-automatic lifting beam;
- Any other equipment not mentioned above, but necessary to make it fully functional for safe & proper operation and maintenance.

#### 2.3.2.2 Gate Arrangement

The Flushing tunnel guard gate shall be designed by the Contractor to close against unbalanced head conditions to restrict / block the water way in flushing tunnel for maintenance of service gate.

The guard gate will be of vertical lift fixed wheel type and will be operated through same gantry crane provided at power tunnel intake located at deck level of 2425.0 m.a.s.l. The gate, when not in use, shall be stored / Dogged in its slot in such a way that the top edge of gate will be flush with top surface of flushing intake tower deck. Top openings & grooves of the gate shall be provided with removeable protection steel gratings.

The gates will be of fixed wheel type having fabricated steel construction designed against maximum applicable loads. Gate shall have downstream skin plate and seals. Side seals shall be of EPDM rubber music note type and bottom seal of EPDM rubber wedge type. The seals shall be fastened to the gate using stainless steel fasteners. The guard gate will be handled using gantry crane (single gantry crane will be shared to serve at both power and flushing tunnels intake areas) and a semi-automatic grappling / lifting beam of adequate capacity. The grappling / lifting beam shall be attached to the gantry crane hook at single point.

**Main Data**

| | | |
|---|---|---|
| i) | Type of Gate | Vertical Fixed wheel |
| ii) | Embedded metal works | One (01) set |
| iii) | Clear width of opening | 5.5 m |
| iv) | Clear height of opening | 5.5 m |
| v) | Sill level | El. 2380.0 m.a.s.l |



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| | | |
|---|---|---|
| vi) | Max. Flood Water level | El. 2421.0 m.a.s.l |
| vii) | Design head at sill | ~43.5 m (Contractor will confirm) |
| viii) | Type of side & top seals | Music Note / Double Stem EPDM |
| ix) | Type of bottom seal | EPDM, Wedge |
| x) | Operation | Lowering/raising under un-balanced head conditions by gantry crane. |

#### 2.3.2.3 Grappling / Lifting Beam

One lifting beam for lowering/lifting of the guard gate shall be provided. The lifting beam shall be of welded construction. The beam shall be equipped with two semi-automatic engaging and disengaging hooks. Two guide rollers on each side of the lifting beam shall use the same guide bars/rails provided for the guard gate. The semi-automatic hooks and guide rollers shall be mounted on corrosion-resisting steel pins with self-lubricating bushings.

#### 2.3.2.4 Shop Painting

The non stainless steel parts of the supply shall be shop-primed and painted before being transported from works to site as per the painting schedule provided in these specifications.

### 2.3.3 Flushing Tunnel Stoplogs (OPTIONAL)

#### 2.3.3.1 Stoplogs Equipment

The Stoplogs equipment shall include but not to be limited to the following major items:

- One (01) set of Stoplogs with guide rollers and seals;
- One (01) set of embedded parts (first and second stage) for side, bottom & top sealing;
- One (01) semi-automatic lifting / grappling beam;
- Any other equipment not mentioned above, but necessary to make it fully functional for safe & proper operation and maintenance.

#### 2.3.3.2 Arrangement

The stoplogs will be comprised of suitable number of sections to be installed one above the other to form a set of stoplogs for closing the waterway for removal of rock plug and other civil works.

The stoplogs will be of vertical-lift type with skin plate and seals on downstream side as mentioned in the layout drawings. The structure shall be of welded steel construction. The skin-plate shall be reinforced by vertical and horizontal members welded to the skin-plate.

The stoplogs shall be provided with J-type side and wedge-type bottom rubber seals. The seals shall be fastened to the stoplogs by steel clamp bars. The top most section of the stoplogs shall be provided with J-type top seal to completely seal the opening.

Pair of guide shoes on each side of each stoplogs shall be arranged to engage with embedded guides bars. Moreover, each set of embedded metalwork for stoplogs shall consist of two side-seal and one top seal and one sill beam bearing and guide plates. All seal bearing plates shall be of corrosion-resisting steel. The guide plates shall be provided from the bottom to the deck level. The embedded metalwork shall be installed in the block outs and adjusted by means of alignment screws attached to welding pads embedded in the first stage concrete. After the alignment of the embedded metalwork, the block outs shall be filled with second stage concrete.



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**Main Data**

| | | |
|---|---|---|
| i) | Type of Stoplogs | Vertical lift, slide type with guide rollers |
| ii) | No. of stoplogs | One (01) set |
| iii) | Embedded metalworks | One (01) set |
| iv) | Clear width of opening | 5.5 m |
| v) | Clear Height of stoplog | 5.5 m |
| vi) | Sill level | El. 2380.0 m.a.s.l |
| vii) | Max. Flood Water level | El. 2421.0 m.a.s.l |
| viii) | Design head at sill | ~43.5 m (Contractor will confirm) |
| ix) | Type of side & top seals | Music Note / Double Stem EPDM |
| x) | Type of bottom seal | EPDM, Wedge |

#### 2.3.3.3 Grappling / Lifting Beam

One lifting beam for lowering/lifting of the stoplogs shall be provided. The lifting beam shall be of welded construction. The beam shall be equipped with two semi-automatic engaging and disengaging hooks. Two guide rollers on each side of the lifting beam shall use the same guide bars/rails provided for the stoplogs. The semi-automatic hooks and guide rollers shall be mounted on corrosion-resisting steel pins with self-lubricating bushings.

#### 2.3.3.4 Shop Painting

The non stainless steel parts of the supply shall be shop-primed and painted before being transported from works to site as per the painting schedule provided in these specifications.

### 2.4 POWERHOUSE DRAFT TUBE OUTLET AREA

Equipment to be Furnished at the Draft Tube Outlet:

- Three draft tube bulkhead gates (vertical lift fixed wheel type)
- One moving electric gantry crane

### 2.4.1 Draft Tube Bulkhead Gates

#### 2.4.1.1 Gate Equipment

Each draft tube outlet shall be provided with one vertical lift bulkhead gate to be used during inspection and maintenance work of the main turbine and the draft tube.

The gate equipment shall be complete with all parts and components required for installation and operation in accordance with these specifications.

The bulkhead gate equipment shall include but not to be limited to the following major items:

- Three (3) bulkhead gates complete with wheels, self-lubricating spherical bearings, guide rollers & seals etc.;
- Three (3) sets of embedded parts (first and second stage) for side, bottom & top sealing, guidance and support;
- Gate dogging mechanism;



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- One (1) semi-automatic lifting beam;
- Any other equipment not mentioned above, but necessary to make it fully functional for safe & proper operation and maintenance.

#### 2.4.1.2 Gate Arrangement

The bulkhead gate shall be operated under balanced head conditions. The bulkhead gate will be of vertical lift fixed wheel type and will be operated through a moving gantry crane provided at powerhouse downstream deck at a level of 2313.3m. The gate, when not in use, shall be stored / Dogged in their slot in such a way that the top edge of gate will be flush with finish surface of deck. Top openings & grooves of the gate shall be provided with removeable protection steel gratings.

The gates will be having fabricated steel construction designed against maximum applicable loads. Gate shall have upstream skin plate and seals. Side seals shall be of EPDM rubber music note type and bottom seal of EPDM rubber wedge type. The seals shall be fastened to the gate using stainless steel fasteners. The gate will be handled using gantry crane and a semi-automatic grappling / lifting beam of adequate capacity. The grappling / lifting beam shall be attached to the gantry crane hook at single point.

**Main Data**

| | | |
|---|---|---|
| i) | Type of Gate | Vertical fixed wheel |
| ii) | No. of gates | Three no. |
| iv) | Embedded metal works | Three sets |
| v) | Clear width of opening | 5 m |
| vi) | Clear height of opening | 3 m |
| vii) | Sill level | El. 2294.25 m.a.s.l |
| ix) | Max. Flood Water level | El. 2301.86 m.a.s.l |
| x) | Design head at sill | ~7.61 m (Contractor will confirm) |
| xi) | Type of side & top seals | Music note / double stem EPDM |
| xii) | Type of bottom seal | EPDM, wedge |
| xii) | Operation | Lowering / raising under balanced head conditions by gantry crane. |

#### 2.4.1.3 Grappling / Lifting Beam

One lifting beam for lowering/lifting of the bulkhead gate shall be provided. The lifting beam shall be of welded construction. The beam shall be equipped with two semi-automatic engaging and disengaging hooks. Two guide rollers on each side of the lifting beam shall use the same guide bars/rails provided for the gate. The semi-automatic hooks and guide rollers shall be mounted on corrosion-resisting steel pins with self-lubricating bushings.

#### 2.4.1.4 Shop Painting

The non stainless-steel parts of the supply shall be shop-primed and painted before being transported from works to site as per the painting schedule provided in these specifications.

#### 2.4.1.5 Gantry Crane for Draft Tube Gates

(Covered under “Moving Gantry Cranes” section above)



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## 2.5 PAINTING SCHEDULE FOR HSS WORKS

**Table 2-3 Paint Schedule**

| Type | Item / Part | Surface Preparation | Paint System | Dry Film Thickness µm |
|---|---|---|---|---|
| A | Steel Structures which are constantly in contact with water and not exposed to UV-rays; e.g., Gates incl. Armatures, Interior Surfaces of Steel Lining, Valves and Trash Racks | Sa 2.5 | **Prime Coat:**<br>1x Zinc-Rich Epoxy Primer<br>**Intermediate and Finish Coat:**<br>3x High Build-Epoxy Paint | min. 60, max. 120 **µm**<br>3 x 150 = 450 **µm**<br>**Total Min. 510 µm** |
| B | Exterior Surfaces of Equipment exposed to UV-rays including:<br>Gates, Stoplogs, Hoisting Equipment, Valves, Cranes, Piping, Electric Motors and all other Steel Structures | Sa 2.5 | **Prime Coat:**<br>1x Zinc-Rich Epoxy Primer<br>**Intermediate Coat:**<br>2x Epoxy Micaceous Iron Oxide Paint<br>**Finish Coat:**<br>1x Epoxy Micaceous Iron Oxide Paint of different color | min. 60, max. 120 **µm**<br>2 x 80 = 160 **µm**<br>80 **µm**<br>**Total Min. 300 µm** |
| C | Indoor Steel Structures like Exterior Surfaces of Valves and Piping, Cranes and Electric Motors etc. | Sa 2.5 | **Prime Coat:**<br>1x Zinc-Rich Epoxy Primer<br>**Intermediate Coat:**<br>1x Epoxy Micaceous Iron Oxide Paint<br>**Finish Coat:**<br>1x 2-Pack Polyurethane or Epoxy Paint | Min. 60 **µm**, Max. 120 **µm**<br>80 **µm**<br>80 **µm**<br>**Total Min. 220 µm** |
| D | Control Boards, Panels, Cubicles | Sa 3 | **Prime Coat:**<br>2x Epoxy Zinc-Phosphate Primer<br>**Finish Coat:**<br>2x Epoxy Paint | 2 x 40 = 80 **µm** |



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| Type | Item / Part | Surface Preparation | Paint System | Dry Film Thickness µm |
|---|---|---|---|---|
| | | | | 2 x 60 = 120<br><br>**Total Min. 200 µm** |
| E | Surfaces of Steel Structures to be Embedded in Concrete | Degreasing | **Primer Coat:**<br>1x Zinc-Rich Epoxy Primer | Min. 60 **µm** |

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# SECTION 3 ELECTRICAL PLANT EQUIPMENT

## 3.1 GENERATORS

The generators shall include the following components/systems:

- Synchronous generators
- Excitation Compartment with Carbon Brushes and Slip Rings
- Neutral grounding Cubicle
- Piping, fitting, valves, pressure gauges, thermometer, instruments for oil, water, air, and cooling water system as separately specified in these specifications.
- Bearings
- All necessary foundation plates and bolts.
- Braking equipment.
- Heaters for stand still.
- Control equipment and connections to the generator control cubicles.
- Fire Protection system
- Fire detection and alarm system

In addition, the following shall be supplied.

- Spare parts
- Maintenance equipment and Tools

Generator Inertia value shall be calculated and finalized by the Contractor, during detailed design phase, subject to review and approval by the Employer.

The generators shall be synchronous vertical shaft type, coupled to the turbine through shaft, provided with guide and thrust bearings.

Generator output shall be matched with the maximum output of the turbine. Generating voltage shall be 11 kV with power factor operating range of 0.8 lagging to 0.9 leading. The Rated Voltage of Generator shall be 11 kV$\pm$10 and Rated Frequency 50$\pm$6%.

### 3.1.1 Scope of Work

The scope of work covers the design, manufacture, delivery to site, storage, erection, testing and commissioning of three (3) Nos. alternating current vertical shaft synchronous generators complete with ancillary equipment including reliability and guaranteed performance tests.

### 3.1.2 Service Conditions

See Section “General Electrical Requirements”.

### 3.1.3 Standards and Codes

All equipment under these Technical Specifications shall be manufactured and tested in accordance with the latest revision of the following international standards.

In case there is contradiction between the contents of relevant clauses of any two standards, Contractor will proceed with the most applicable one with prior approval of the Employer.



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**Table 3-1:Standards and Codes**

| Subject | Standard |
|---|---|
| Rotating electrical machines | IEC 60034 |
| Dimensions and output series for rotating electrical machines | IEC 60072 |
| Electrical insulation thermal classification | IEC 60085 |
| Electrical strength of insulating materials - Test methods | IEC 60243 |
| Specification for insulating materials based on mica | IEC 60371 |
| Magnetic Materials | IEC 60404 |
| Dielectric and resistive properties of solid insulating materials | IEC 62631 |
| Insulation co-ordination. | IEC 60071 |
| Dimensions of brushes and brush holders for electrical machinery. | IEC 60136 |
| Insulating bushing for alternating voltages above 1000 V. | IEC 60137 |
| Industrial platinum resistance thermometer sensors. | IEC 60751 |
| Short circuit current calculation of effects, Part 1: Definition and calculation methods. | IEC 60865-1 |
| Techniques for High Voltage Testing. | IEEE 4 |
| Recommended Practice for Testing Insulation Resistance of Rotating Machinery. | IEEE 43 |
| Test Procedures for Synchronous Machines. | IEEE 115 |
| Short circuit calculation in three phase AC systems. | IEC 60909 |
| Rotating Electrical Machinery Synchronous Machines. | ANSI C50.10 |
| Requirements for Salient - Pole Synchronous Generators and Generator / Motors for Hydraulic Turbine Applications. | ANSI C50.12 |
| Guide for Installation of vertical generators and Generator / Motors for Hydroelectric Applications. | IEEE 1095 |
| Code for Field Acceptance Tests. | IEC 60041 |
| Specifications for particular types of windings wires. | IEC 60317 |
| Methods of Tests for Winding wires. | IEC 60851 |
| High voltage test techniques - Partial discharge measurement. | IEC 60270 |
| Requirements of rotating Electrical machine without limitation of output or voltage. | BS: 5000 |

The commissioning and field acceptance tests of the generator equipment shall be carried out according to the IEC and ANSI Standards.

### 3.1.4 Key Technical Parameter

**Table 3-2: Key Technical Parameters**

| | |
|---|---|
| Guaranteed rated capacity (MVA) | 23.20 MVA with temperature rise less than $80^0$C (operation at class B temperature rise) |
| Real Power (MW) at 0.8 pf lagging | 18.56 MW |



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| | |
|---|---|
| Rated Voltage (kV) | 11 |
| Rated Frequency (Hz) | 50 |
| Rated Speed (rpm) | 375 |
| Power Factor | 0.8 lagging to 0.9 leading |
| Stator/Rotor Winding Insulation | Class F/F |
| Duty Type | S1, Continuous |
| Efficiency (% Minimum) | 98 |
| Short Circuit Ratio | ≥ 1.10 |
| Telephone Hormonic Factor (THF) | ≤1.5% |
| Cooling of stator and rotor | Air-cooled, self-ventilated with air/water heat exchangers with air leaving the coolers at not more than 40°C. |

### 3.1.5 Generator Design Particular

The generators shall be designed in accordance with best modern practice & factors of safety and shall be suitable for operation under abnormal conditions. The generators shall be suitable and their appurtenances shall be designed for fully automatic start-stop, unattended supervisory-controlled operation.

The generator and its associated excitation system shall be designed to withstand multiple full load rejection over speeds, with a maximum speed rise of 150%. After runaway, the generator shall be returned to normal operation.

The rotating parts of the generators shall be able to withstand the stresses at runaway speed for a minimum duration of thirty (30) minutes. The maximum unit stresses for any rotating part of generator or other shaft driven auxiliary machine at runaway speed shall not exceed two-third (2/3) of the respective material yield strength.

The first critical speed of the combined turbine generator unit will be at least 25% higher than runaway speed. A “worst case” calculation shall be performed, considering unbalanced magnetic pull resulting from eccentricity between stator and rotor equal to 10% of the air gap.

Design calculations showing that technical requirements mentioned herein are satisfied shall be submitted to Employer for approval before manufacturing commences.

Following limits of temperature rise shall be applied to the generator, when the generator delivers the rated output continuously at the rated voltage, rated power factor and rated frequency, conforming that air temperature entering the generator through the air coolers does not exceed 40 °C.

**Table 3-3: Temperature Rise Limits**

| Part of Generator | Method of Measurement | Temperature Rise Limit |
|---|---|---|
| Stator Winding | Embedded Temperature Detector | 85 K |
| Field Winding | Resistance | 80 K |



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The generator windings shall be insulated with Class F insulation using Vacuum Pressure Impregnation (VPI) technology.

All parts of the generators and the connections thereto shall be designed to withstand the mechanical and electrical forces due to a rated voltage 3-phase short circuit at the generator terminals, without incurring any damage.

The design of equipment shall include an allowance for earthquake loading in accordance with the seismic values of Project area as provided elsewhere in the Employer Requirement.

The generator shall be suitable for withstanding any un-balanced fault conditions without mechanical or electrical failure or permanent deformations.

The voltage withstand levels for the generator shall be in accordance with IEC 60071. Whereas, stator winding impulse voltage withstand level shall be as per IEC 60034-15 and following shall apply:

**Table 3-4: Insulation Voltage withstand Levels**

| Factor | Value | Unit |
|---|---|---|
| System Maximum Voltage | 12 | kV |
| Rated Power Frequency Withstand Voltage (2xUn+1) | 25 | kV |
| Rated Lightning Impulse Withstand Voltage (4xUn+5) | 55 | kV |

### 3.1.6 Efficiency and Losses

The generator efficiency when operating at the rated output, 0.8 pf lagging to 0.9 leading, 11 kV, 50 Hz, shall not be less than 98%.

Generator load and no-load losses at rated output shall be stated in the Technical Schedules as guarantee figures.

### 3.1.7 Line Charging Capability

Each generator shall provide a maximum continuous line charging capability of –16.55 MVAr, when connected to open-ended transmission lines, without becoming self-excited or unstable.

### 3.1.8 Stator Frame & Housing

The housing shall be furnished complete with all base supports, frames, foundation bolts, nuts etc.

The stator housing shall transfer all loads and torque to the generator foundations. Thrust forces, if any shall be transferred to the machine floor.

The stator frame shall be designed to keep the core in an isotropic cylindrical shape; to decrease the thermal stress under all generator operating conditions; and to provide adequate rigidity and strength against forces caused by out-of-phase synchronizing and short circuits, including short circuits of one-half of the field windings.

### 3.1.9 Stator Core

The stator core shall be designed in a manner to ensure smooth air flow to cool the core and other parts of stator evenly, efficiently and thoroughly, and to minimize air friction losses. The stator core shall be built with non-oriented grain, non-aging silicon steel lamination, and each



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lamination shall be coated on both sides with an insulating varnish. The design of the core clamping system shall ensure a regular and uniformly tight core which can be maintained throughout the service life of the generator.

### 3.1.10 Stator Winding

The stator winding shall be wye connected, multi-turn or bar type, suitable for both grounded and ungrounded neutral operation.

The windings shall be insulated with Class “F” insulation.

The coil shall be protected against surface partial discharges (corona) inside the stator core by applying a semi conductive tape or varnish.

The end portions of the winding shall be rigidly supported to prevent movement and distortion under short-circuit conditions.

### 3.1.11 Rotor

The rotor shall be designed to withstand all overloads and other stresses encountered during normal operating or runaway speed condition.

Design shall take into account the correct distribution of ventilation air to minimize air friction losses.

### 3.1.12 Field and Damper Winding

The field winding shall be insulated with Class F insulation.

The field winding and their insulation shall be capable of withstanding vibration, thermal displacement and stresses at maximum runaway speed, and shall also be capable of withstanding short-circuit and unbalanced current without mechanical or electrical damage or permanent deformation.

The damper winding shall be adequately dimensioned such that the Generator can operate continuously on an unbalanced system in accordance with IEC 60034-1.

### 3.1.13 Generator Brakes

Each generator shall be provided with pneumatically operated mechanical brake with air to be supplied from station compressed air system.

The air receiver shall be of sufficient capacity for at least five (5) complete braking operations without make-up air.

Pneumatical brake shall be applied at 15% of rated speed. The brakes shall remain applied when the machine is stationary.

The braking system shall be electrically interlocked with the turbine guide-vane locks and the generator main circuit breaker so that the brakes cannot be applied either automatically or from the manual control switch, unless the guide-vanes are closed and the generator circuit breakers are open. Each brake pad shall be provided with at least two interlock and alarm position switches.

The brake linings shall be asbestos-free and suitable for not less than 25,000 braking operations before they require to be renewed.



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### 3.1.14 Fire Protection System

Generators shall be provided with a fire extinguishing system comprising $CO_2$ inert gas and water spray type.

The water for the water spray system shall be taken from the powerhouse fire fighting water main supply.

The Contractor shall supply all equipment for the water fire extinguishing system inclusive of pipes, spray heads, valves, locks, key cabinet etc.

The fire protection system shall comply with NFPA 851 National Fire Protection Association (and additional NFPA regulations).

The Generators shall also be provided with fire detection and alarm system.

### 3.1.15 Cooling System

The generators shall be air-cooled, self-ventilated with air/water heat exchangers. All equipment and materials related to the cooling system of each generator such as valves, fittings, strainers, pipe-work etc. shall be provided by the Contractor.

With one complete heat exchanger out of service, the maximum continuous output shall be maintained without the stator and rotor winding temperatures exceeding Class B permissible temperature rise.

### 3.1.16 Condensation Prevention

Electric heaters shall be provided in each generator frame. Heaters shall be of sufficient capacity to prevent condensation when the generator is not working. Heaters shall be automatically controlled from the unit start/stop in conjunction with a thermostat. Heaters shall be arranged from the auxiliary 400/230V ac supply connected to form a balanced three phase load. A control switch, with "ON/OFF" indicating lamps for manual operation, shall be provided.

### 3.1.17 Bearings

Guide bearings shall be of the segmented multiple pad design, oil lubricated self-pumping type. Their design shall permit vertical movement of the shaft system for adjustment and removal of the thrust bearing shoes. Bearing pads shall be individually adjustable and shall be lined with high grade white metal, no less than 5mm thick, securely bonded to the pads. The bond shall be ultrasonically examined. Bearing pads shall be easily removable without the removal of any other major component. A portion of the bearing shall be continually immersed in oil to provide initial lubrication during a unit start.

All bearings shall be equipped with water-in-oil sensors with alarms. Each generator bearing housing shall be sealed and ventilated to ensure that oil vapor does not enter the generator, slip-ring housing or turbine pit. Vapor pipe work from each bearing housing shall be terminated in a convenient location in the turbine gallery, by condensate containers equipped with drain and level indicator. If necessary to completely eliminate vapor release from the bearing housings, an external vapor extraction and condensation system shall be provided for each unit.

#### 3.1.17.1 Upper Guide Bearings

The bearing shall be of self-pumping design mounted in the upper bracket. Coolers shall be consistent with those on the lower guide. It shall be possible to remove the upper guide bearing pads without dismantling the brush gear or its enclosure.



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### 3.1.17.2 Thrust Bearings

The thrust bearing shall be self-pumping by rotation of the shaft. It shall be mounted in a lower bracket designed to transmit axial loads into the concrete foundations. The design shall be such as to limit thermal expansion forces whilst maintaining the bearing concentricity with the shaft. The thrust pads shall be supported so as to ensure uniform load distribution between pads and provide ease of adjustment for maintenance. The bearing shall be designed to accommodate repetitive restarts immediately after hot shut down. Removal of the pads shall be possible sideways by jacking the generator rotor. The Contractor shall supply all special tools and devices for this purpose.

The thrust bearing runner shall be a one-piece forging. Weld repair of the runner surface will not be accepted. The bond of the white metal to the bearing pads shall be inspected ultrasonically.

The thrust bearing shall be equipped with a high-pressure oil lift system which shall normally be operative during start up and shut down. However, it shall be possible (and demonstrated during commissioning) that the unit can be stopped without the pumps in operation without any appreciable temperature rise and any damage to thrust bearing pads. The results of this demonstration shall be visually verified by inspecting two thrust bearing pads at random. Each pad shall be equipped with non-return valve integral with the pad. The high-pressure system shall comprise two pumps (normal and standby) with all necessary starters and associated controls for automatic switching. The standby pump shall be dc motor driven which shall start automatically upon failure of ac motor driven main pump. The required oil film thickness shall be established in about five (5) seconds. Remote indication and local visual indication shall be provided for excess inlet and outlet filter pressure drop.

The high-pressure lift system shall be located external to the unit so that it can be easily inspected and maintained without entering the unit. Automatic drainage of any leakage oil shall be provided. Bearing oil coolers shall be mounted outside the bearing housings with isolating valves so that they can be removed for cleaning. There shall be indicating devices or visual aids to observe foaming of oil in the bearing.

### 3.1.17.3 Lower Guide Bearings

The lower guide bearing may share an oil reservoir with the thrust bearing. In this case oil supply to the lower guide bearing may be by the pumping action of the thrust bearing. Otherwise, the guide bearing shall be self-pumping.

If a separate oil reservoir is used, the coolers of the lower generator guide bearing shall be external to the guide bearing housing and shall be easily isolated and removable for cleaning and maintenance.

Alternatively, if self-pumping is proven to be impractical with external coolers, then coolers may be installed in flanged recesses in the bearing houses such that they can be removed without the necessity of dismantling any major component.

### 3.1.18 Control & Instrumentation

The Contractor shall supply and install all the necessary auxiliary transformers, pipework, tubing, fittings, orifice plates, flanges, pockets and other items to provide the complete control and instrumentation for each unit.

Generator shall be equipped with following monitoring systems;

i. Air-gap monitoring system

ii. Online Vibration detection system

iii. Online partial discharge monitoring system

iv. Cooling water pressure sensing and monitoring at different parts

v. Oil pressure sensing and monitoring at different parts

The vibration measuring system is designed to give alarm (1st stage) and unit trip (2nd stage) signals in the event of excessive vibration.

The bearings shall be equipped with necessary instrumentation i.e., flowmeters, oil level indicators, water level indicator, etc.

Temperature detectors shall be located in the area of maximum predicted temperature, in each component or part. Where limitations imposed by electrical safety or mechanical integrity at the measuring point dictate otherwise, measuring point locations shall be to the Employer approval.

Temperature detectors other than those in the windings and core shall be housed in suitable pockets, and in all cases a second pocket with a screwed protection cap shall be provided alongside to accommodate a liquid-in-glass thermometer for temperature detector calibration.

Resistance-type temperature detectors (PT-100) shall have a resistance of 100 ohms at 0°C and shall be permanently wired to a marshalling box outside the generator housing. The detector and bridge circuits shall be wholly insulated. Common point connections may be used in the detector circuit wiring for any one resistance thermometer, but there shall be no common point between separate resistance thermometers. The spare embedded temperature detectors in the core and windings shall be permanently wired to the above marshalling box.

### 3.1.19 Generator Connections and Neutral Earthing

Segregated phase bus shall be used for generator connections. The Contractor shall supply a separate phase and neutral enclosure, each complete with all conductors, resistor, insulators, current transformers and all ancillary equipment as required.

The neutral ends of the generator windings shall be star-connected and the neutral shall be earthed via a high resistance grounding method as described in standard IEEE C37.102. The Contractor shall provide the neutral grounding calculations for Employer review.

### 3.1.20 Testing and Commissioning

Testing and commissioning shall comprise type, routine/factory and site testing designed to verify the performance of the generator. Except as otherwise specified, all tests shall be performed in accordance with relevant standards from IEEE, IEC, ASME, ASTM, ANSI/NETA and ISO. Detailed Inspection Test protocols, Factory Tests Procedure and Site Acceptance Test Procedures following requirement of above quoted standards shall be prepared and submitted for review/approval.

#### 3.1.20.1 Routine tests on all Generators in Workshop

Routine tests shall be carried out on rotor & stator windings, magnetic material, core laminations, winding insulation before assembly as per applicable IEC and IEEE standard.

#### 3.1.20.2 Routine tests on all Generators at Site after Erection

All site tests as per IEC, IEEE, ANSI/NETA shall be carried out on the generators in assembled condition at site.

### 3.1.20.3 Site test for each generator

After installation of the generator at site, following tests as a minimum but not limited to it shall be carried out during commissioning:

- Phase sequence and direction of rotation
- H.V dielectric test
- Measurement of stator and rotor winding insulation resistance test before and after dielectric test
- Stator and rotor winding resistance measurement
- Thermal Test
- Measurement of vibration and noise level
- Load acceptance and rejection tests at selected load from “no load” to “full load & maximum load”
- Synchronizing test
- Black start test
- Checking and commissioning test of all auxiliary equipment

### 3.1.20.4 Unit Reliability Run Test

- Stable and reliable operation for at least 24 hours at varying outputs between maximum possible and minimum possible allowable capacity of the unit without any failure or interruption and with no more than 2 start/stop cycles.
- Stable and reliable operation within a continuous 72 hours period, at least 10 successive cycles of starting (i.e., including synchronizing and loading to the dispatch level) and stopping (i.e., including unloading from the dispatch level down to no load and stopping to standstill).

### 3.1.20.5 Multiple Units Test

Following tests but not limited to these shall be performed on multiple units.

- Parallel operations, power (MW) and MVar sharing
- Multiple Units active power load rejection test (100% load)
- Plant capacity, efficiency and performance tests, to demonstrate compliance with the plant performances and guarantees.

### 3.1.20.6 Test Equipment

The Contractor shall provide all necessary labour, equipment and instruments to perform the tests on Plant. The test instruments shall be of the latest model and type available with the precision required to conduct the specified tests and their calibration shall be checked prior to use.

In the event repeated testing becomes necessary, the entire expenditure on such tests shall be borne by the Contractor.

### 3.1.20.7 Characteristics Curves

The generator characteristics values for determination of performance shall be arrived either through circle diagram method or equivalent circuit method after conducting all required tests on the generator even though they have not been specifically mentioned above.



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After testing the machine, the equivalent of circuit of the generator, phase diagram and performance characteristics like load versus efficiency; load versus power factor or load versus magnetizing kVAR, kVA and kW output and load current shall be determined and furnished to the Employer by the Contractor.

Tests on other equipment like auxiliaries, CTs, PTs, LAs shall comply with the routine tests etc. as per applicable international standards.

### 3.1.21 Spare Parts, Maintenance Equipment and Tools

Spare Parts, Maintenance Equipment and Tools mentioned herein are the minimum required. Any other necessary spare parts, maintenance equipment and tools required for maintenance of the equipment shall be provided by the Contractor.

**Table 3-5: Spare Parts and Tools**

| Sr. No. | Description | Unit | Qty |
|---|---|---|---|
| **Mandatory Spare Parts for Generators** | | | |
| 1 | Spare Stator Windings, with required mounting material | Lot | 1/3rd for stator and rotor winding |
| 2 | Poles, one of each polarity | complete | 2 |
| 3 | Linings for the guide bearings | Set | 1 |
| 4 | Pads for the thrust bearing | Set | 1 |
| 5 | Brake linings | Set | 1 |
| 6 | Brush holders | Set | 2 |
| 7 | Brushes | Set | 10 |
| 8 | Air heat exchanger element | No. | 4 |
| 9 | Bearing oil heat exchanger | No. | 2 |
| 10 | High pressure oil pump and motor of each type (AC and DC) | Set | 1 |
| 11 | Gaskets, screws, bolts and nuts of all types used | Lot | 1 |
| 12 | Maintenance tools with cabinet | Lot | 1 |
| **Mandatory Spare Parts for Generator Control and Instrumentation** | | | |
| 1 | Temperature detectors and thermometers | Lot | 1 |
| 2 | Flow indicators | Lot | 1 |
| 3 | Relays, limit switches etc. | Lot | 1 |
| 4 | I/O modules of each type | Set | 1 |
| 5 | Relays, limit switches etc. | Lot | 1 |
| 6 | Pressure sensors | Lot | 1 |
| 7 | Pressure Switches | Lot | 1 |
| 8 | Pressure Indicators | Lot | 1 |
| **Maintenance Equipment** | | | |



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| Sr. No. | Description | Unit | Qty |
|---|---|---|---|
| 1 | Insulation test set to cover the range of equipment | Sets | 1 |
| 2 | Resistance measurement test set to cover the range of equipment | Sets | 1 |
| **Tools** | | | |
| 1 | All necessary tools required for complete maintenance | Lot | 1 |
| 2 | Laptop for testing, commissioning and setting of parameters | No. | 1 |

### 3.2 EXCITATION SYSTEM

#### 3.2.1 Scope of Work

Three (03) static excitation systems along with complete protection and three phase dry type transformers shall be supplied. The forced air-cooled thyristor bridge rectifier, shall be controlled by stabilized firing circuits fed from the excitation transformer output. A solid-state microprocessor based dual channel digital excitation controller with redundant controls shall be provided to maintain maximum reliability.

The excitation controller shall incorporate an Automatic Voltage Regulator (AVR) with backup Field Current Regulation mode and a Power System Stabilizer (PSS).

Local automatic, remote automatic and manual standby controls shall be provided along with indications and alarms. The excitation output shall be connected by cable to the generator slip rings through a field circuit breaker. The equipment shall be designed as an integrated suite.

#### 3.2.2 Service Conditions

See Section “General Electrical Requirements”.

#### 3.2.3 Standards and Codes

All equipment under these Technical Specifications shall be manufactured and tested in accordance with the latest revision of the following international standards.

In case there is contradiction between the contents of relevant clauses of any two standards, Contractor will proceed with the most applicable one with prior approval of the Employer.

**Table 3-6: Standards and Codes**

| Subject | Standard |
|---|---|
| Rotating electrical machines | IEC 60034 |
| Rotating electrical machines - Part 16: Excitation systems for synchronous machines | IEC 60034-16 |
| Insulation Co-ordination. | IEC 60071 |
| Power Transformers | IEC 60076 |
| Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um = 1.2 kV) up to 30 kV (Um = 36 kV) - ALL PARTS | IEC 60502 |
| Degrees of protection provided by enclosures (IP Code) | IEC 60529 |
| Practices and Requirements for Semi-Conductor Power Rectifiers. | ANSI C34.2 |



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| Subject | Standard |
|---|---|
| General Requirements for Dry-type Distribution and Power Transformers. | ANSI/IEEE C34.12.01 |
| Requirements for Field Discharge Circuit Breakers for Rotating Electric Machinery. | ANSI C37.18 |
| Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear. | ANSI C37.20 |
| Metal-Enclosed Interrupter Switchgear. | ANSI C37.20.3 |
| Guide for Surge Withstand Capability (SWC) Tests. | ANSI C37.9.1 |
| Requirements for Electrical Analog Indicating Instruments. | ANSI C39.1 |
| Guide for Loading Dry Type Distribution and Power Transformers. | ANSI C57.96 |
| Test for dry type and distribution transformers. | ANSI C57.12.91 |
| Criteria and Definitions. | IEEE 421.1 |
| Guide for Identification of Dynamic Performance. | IEEE 421.2 |
| High-Potential-Test Requirements. | IEEE 421.3 |
| Guide - Preparation of Excitation System Specification. | IEEE 421.4 |
| Excitation System Models for PSS-Studies. | IEEE 421.5 |
| Instrument transformers. | IEC 60044-1, 2, 6. |
| Semiconductor convertors - General requirements and line commutated. | IEC 60146-1-1, 1-3. |
| Insulation co-ordination for equipment with low voltage system- Part 1: Principal requirements and tests. | IEC 60664-1. |
| Low voltage switchgear and control gear assemblies. | IEC 60439 |
| Environmental Testing. | IEC 60068 |
| Electrical relays- Part 21: Vibration, shock and seismic tests. | IEC 60255-21-1 |
| Seismic qualification. | IEEE 344 |
| Emission | EMC Standards |
| Electromagnetic compatibility (EMC). | IEC 61000-4-4, 4-5 |

### 3.2.4 Structure of Excitation System

The excitation control system shall be of fully static type and shall include:

A) Excitation Control Equipment, incorporating
   i. Automatic Voltage Regulator
   ii. Manual Field Current Regulation
   iii. Power System Stabiliser
   iv. Thyristor firing circuit output



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v. Monitoring of Excitation Control System
vi. Interface with DCS
vii. Limiters and Protection System

B) Excitation Power Transformers
C) Full wave (Force Air cooled) Thyristor Convertor with Controller
D) Field Suppression Circuit and rotor overvoltage protection
E) Field Circuit Breaker

### 3.2.5 Excitation Design Particular

The excitation equipment shall meet the requirements of IEC 60034 based on 40°C ambient air temperature.

The equipment shall meet the following requirements:

- The equipment shall be continuously rated at 110% of the excitation required for rated generator output at 105% rated voltage.
- The ceiling excitation voltage shall be not less than 160% of the rated field voltage at Class B rotor temperature rise.
- The excitation equipment shall produce ceiling excitation output coupled to the rotor, for 5 seconds, following continuous operation at rated output, without exceeding component design temperatures.
- The nominal excitation response, as defined in IEC 60034-3, shall not be less than 2 per unit per second.
- The equipment shall be designed and protected so as to withstand a short circuit across the direct current output terminals without permanent damage.
- The equipment shall maintain generator voltage at set point value under load rejection conditions up to a nominal overspeed trip setting of 130%.
- The excitation system shall include parallel droop or parallel differential compensation such that the reactive load is shared between all units on the line.
- Provide field flashing from 220V dc unit auxiliary board for excitation initiation under “Black Start Conditions”.
- Suppress the generator field under fault conditions using thyristor inversion under automatic or manual control. The maximum induced rotor voltage shall be limited to prevent rotor inter turn damage.
- Suppress the field by circuit breaker operation whenever the 11kV breaker is tripped under fault conditions.
- Limit harmonic voltage distortion on the 11kV bus to less than 5%.
- Maintain voltage control at 70% of rated voltage during close-up faults on the 132kV side of the generator transformer.

### 3.2.6 Excitation Control Equipment

#### 3.2.6.1 General

The excitation control equipment shall maintain stable generator voltage under all conditions of generator operation. The equipment shall consist of a proven AVR as specified below, with a Field Current Regulation system for manual follow-up in case of an AVR fault and for manual operation.



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The AVR shall be fitted with a PSS based on proven feed-back circuits to improve the machine stability under system fault conditions. A PSS based on an angular acceleration signal is preferred.

An under excited reactive power limiter, field current limiter, voltage setting control and generator transformer over-fluxing control device shall also be provided.

An annunciator shall be provided to indicate faulty conditions and to sound an alarm in the event of a fault.

#### 3.2.6.2 Type

The excitation control equipment shall be a solid-state microprocessor based digital system suitable for operation over the full range of ambient conditions specified for the powerhouse. It shall be made to the highest equipment and manufacturing specifications and shall be of proven industrial application.

#### 3.2.6.3 Automatic Voltage Regulator

A continuously acting, no "dead band", static dual channel type of AVR of proven design shall be provided.

AVR shall include Local auto, remote auto (through the PCS) and local manual switching inside the enclosure. During normal operation the AVR shall be automatically controlled by the PCS (Remote Auto). Additional controls shall be provided for Local Auto and Local Manual control of the AVR. AVR control modes shall be selected at the Excitation Control Panel.

Response to changes in voltage shall be characterized by adjustable proportional gain and integral and derivative time constants.

Parallel operation shall be afforded by adjustable parallel droop or cross compounding compensation and connections to ensure stable operation and sharing of reactive power with other generators in the station.

Voltage drop compensation for the generator main step-up transformer shall be incorporated into the AVR. The voltage drop shall be adjustable over the range 0 to 120% of the transformer impedance, the estimated value of which will be given to the Contractor.

Line drop compensation shall be provided to ensure satisfactory operation of the AVR for large voltage dips on the system.

The AVR shall include dual voltage transformer with a continuous voltage comparator to detect failure of either set of voltage transformers. In the event of failure of any voltage transformer, the AVR shall automatically transfer the sensing voltage to the secondary channel.

In the event of failure of both voltage transformers, the AVR fault control shall be automatically transferred to the manual FCR mode without interruption of excitation.

The AVR shall utilize automatic tracking between channels and between control modes so that no significant change of excitation shall occur when switching between channels or from AVR to FCR modes.

#### 3.2.6.4 Performance Requirements

The AVR shall be capable of working over the complete load, voltage, and frequency range of the generator within the limits defined below:

Under steady-state load conditions at rated power factor and frequency, and over the whole of the operating range of the excitation system, the generator voltage shall be maintained within ± 0.2% of the setting value without hunting.

Under steady-state open-circuit conditions, the generator terminal voltage rise shall be not more than ± 1% of the setting value for all speeds between rated speed and 150% of rated speed.

Under AVR control, the generator open-circuit voltage response shall be such that for a - 10% step-change, the time for the machine terminal voltage to return to within ± 0.5% of rated value shall not exceed 0.5 seconds.

For voltage variations exceeding ± 0.1% of the rated value, the AVR response time shall be less than 0.02 seconds.

### 3.2.6.5 Field Current Regulation

FCR mode shall be provided for manual operation of the excitation system and as a follow-up manual mode in case of failure of both voltage sensing channels or in case of an AVR faults.

The FCR field current set point shall automatically track the AVR set point such that for a manual changeover or failover changeover to FCR mode no significant variation in reactive power load or voltage output shall occur.

While operating in FCR mode the field current set point shall be adjustable from the ULCP or DCS or from local controls at the Excitation Control Panel. The control source for the field current set point shall be selectable at the Excitation Control Panel.

Manual control shall also be provided whereby the generator voltage shall be capable of being varied continuously from 80% to 115% of rated voltage under normal operation, but down to 10% voltage for commissioning and line charging.

A manual excitation range of 0 to 115% shall be allowed for commissioning.

### 3.2.6.6 Power System Stabiliser

A PSS circuit shall be provided to damp out voltage fluctuations following faults on the power system. The PSS shall be capable of damping out local mode, inter area and inter unit oscillations occurring in the frequency range of 0.1 to 5 Hz by adjustment of the excitation output to control rotor oscillations.

The PSS shall continuously operate and shall operate in conjunction with the AVR during transient oscillations. Parameters utilized in the PSS algorithm shall be adjustable at the Excitation Control Panel.

It is preferred that the PSS circuit algorithm is based on the integral of angular acceleration.

For the purpose of setting PSS system parameters, if power system simulation results are required the Contractor shall provide written notice outlining the required information at least six months prior to the required date.

### 3.2.6.7 Limiters

The excitation control equipment shall incorporate limiters to prevent unsafe operation of the generator. Limiters shall be set to avoid operation of protective devices. As a minimum the following limiters shall be provided:



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i) An under-excitation (VAR) limiter with a setting dependent on MW loading. The limiter shall prevent the excitation being reduced to such a level that the machine becomes unstable. The limiter shall be adjustable so that the range of stability margin can be selected. The stiffness of the VAR-limiter control shall be independent of the rate of change of MVAR. When the limiter is in operation, the overshoot shall not exceed 5% of the VAR setting.

ii) A field current limiter. This control shall stop the follow-up from reducing the manual setting below safe limits, at any output load.

iii) An adjustable over fluxing control, to ensure the generator and generator transformer is not over fluxed.

All limiters shall be fully adjustable at the Excitation Control Panel.

#### 3.2.6.8 Monitoring and Self Diagnostic Systems

At all times the Excitation Controller shall provide self-diagnostic facilities that monitor its internal systems and supplies to ensure that they are healthy. In the event of a voltage sensing failure or AVR fault the Excitation Controller shall provide an "Excitation Fault" alarm to the DCS and ULCP and shall automatically failover to the FCR mode.

Permanent monitoring devices shall be supplied or incorporated to provide comparative readings of component performance. Fault diagnostic and fault location equipment shall also be included for fault location and maintenance.

The following shall be included:

i. Voltage reference and reset circuits
ii. Limiters in accordance with section ‘limiters’
iii. AVR stabilising circuits
iv. Manual follow-up and restrictive circuits
v. Power output stage
vi. Over-excitation and under-excitation protection circuits
vii. Fuse failure protection
viii. Stator over current
ix. Generator under and over voltage
x. Transformer over-fluxing control circuit

### 3.2.7 Control and Indication

#### 3.2.7.1 PCS Interface

During on-line operation, remote commands to the Excitation Control Equipment will be from the station PCS.

Therefore, start/stop command and set-point adjustments will either be from the ULCP (local manual/auto) or from the PCS (remote auto) depending on which mode has been selected at the ULCP or at the Excitation Control Panel.

The connection details and signals between the Excitation Control Equipment, ULCP and PCS will be subject to approval by the Employer.



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### 3.2.7.2 Normal Control and Indication Signals

For day-to-day operation of the Excitation Control System the following minimum Control and Indication facilities shall be available to the PCS and at the operator interface. The operator interface may either by a separate HMI or via the front fascia of an integrated Excitation Controller. The signals shall be supplemented as necessary by the Contractor to reflect the actual equipment supplied.

**Control**

1. Start/Stop Excitation
2. Local/remote operation select
3. AVR/FCR mode select
4. ACR set point raise/lower
5. FCR set point raise/lower
6. Voltage sensing channel select

**Indication**

1. Network frequency
2. Generator frequency
3. Network voltage
4. Generator terminal voltage
5. AVR/FCR mode selected
6. AVR Set point
7. FCR Set point
8. Voltage sensing channel selected
9. Excitation at under excitation limit
10. Excitation at over excitation limit
11. Excitation at field current limit
12. Loss of potential channel 1
13. Loss of potential channel 2
14. Voltage matching enabled
15. Generator under/overvoltage detected
16. Loss of field
17. Excitation at over fluxing limit
18. AVR fault
19. Field over temperature
20. Thyristor over current
21. Thyristor over temperature alarm
22. Thyristor failed alarm
23. Second thyristor failed in the same bridge arm alarm
24. Multiple thyristors failed trip
25. Rotor temperature
26. Rotor temperature alarm
27. Rotor earth fault alarm

### 3.2.7.3 Maintenance Control and Indication Signals

For maintenance operation of the Excitation Control System the following minimum necessary Control and Indication facilities shall be available at the operator interface via password protection. The operator interface may either by a separate HMI or via the front fascia of an integrated Excitation Controller. The signals shall be supplemented as necessary by the Contractor to reflect the actual equipment supplied.

1. Generator and system parameter input
2. P, I and D settings for AVR and FCR modes
3. Under and over-excitation limiter settings
4. Field current limiter settings
5. Over fluxing limiter settings
6. PSS algorithm parameters



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7. Parallel droop/parallel differential droop compensation settings
8. Line drops compensation settings
9. Protective function settings

#### 3.2.7.4 Software

It shall be possible to adjust all variable parameters via the operator interface.

Where proprietary programs are available for adjustment of the excitation controller settings the Contractor shall provide all necessary software including perpetual licenses, with ongoing support and updates that shall allow installation of software on multiple computers.

#### 3.2.7.5 Power Supplies

Electrical supplies shall be in accordance with Section General Electrical Requirements. DC control supplies shall be redundant and where alternative power supplies are required redundant converters shall be used. Switch over between alternate power supplies shall be without interruption to the excitation function. In the event of failure and switch over an "Excitation System Fault" alarm shall be raised.

#### 3.2.7.6 Excitation Reference Signals

Current and voltage transformers for AVR operation shall be supplied by the Contractor.

Each of the two AVR channels shall be provided with a set of three single-phase voltage transformers, fed from the generator terminals.

An additional three-phase isolating transformer shall be provided between the voltage transformer and the voltage comparator (voltage error detector) of the AVR. The reference voltage shall be unaffected by changes in the ambient temperature or fluctuations in supply voltage or frequency, including full load rejection or close-up faults on the 132kV system.

Unless otherwise agreed, the three-phase auxiliary power supplies for the AVR shall be taken from the low voltage winding of the excitation transformer via suitable interposing transformers.

Current transformers required for each automatic voltage control channel shall be supplied and installed in the generator neutral cubicle.

### 3.2.8 Excitation Transformers

Three-phase excitation transformers suitable for connection to segregated phase bus bars shall be supplied for each unit. The transformers shall be of the dry type, naturally cooled, and shall meet Class B temperature rise limits when carrying the design rating with the worst harmonic losses associated with the thyristor unit. The transformer shall meet the requirements of IEC 60076-11 and IEC 60726 with non-hydroscopic Class F insulation and insulation levels in accordance with Table 1 list 2 of IEC 60071-1 and thermal Class 200 to IEC 60085.

The flux density shall not exceed 1.65 Tesla at rated output condition. Noise levels shall not exceed 90 dB (A) at 1 meter from the cubicle.

#### 3.2.8.1 Rating

The transformer shall be sufficiently rated to achieve the excitation system requirements. The Contractor shall conduct an insulation coordination study to ensure that the excitation transformers are suitable for continuous operation when subjected to the operating conditions



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defined in these specifications.

### 3.2.8.2 Terminals

High voltage terminal bushings shall be supplied and spaced for bus duct connection. Low voltage connections to the thyristor equipment shall be either bus bar or cable provided by the Contractor. An earth connection, rated in accordance with the short circuit capability in IEC 60076, shall be provided near the base of the frame.

Current transformers for each excitation transformer shall be provided in the HV connections for overcurrent protection and the Contractor shall ensure that the relays and current transformers are compatible.

### 3.2.8.3 Protection

Current transformers for each excitation transformer shall be provided in the HV connections for instantaneous overcurrent protection (50) and Inverse time overcurrent protection (51). Each Excitation Transformer shall also to be provided with complete thermal overload protection (49), restricted earth fault protection (64REF) and other necessary protection and the Contractor shall ensure that the relays and current transformers are compatible.

### 3.2.8.4 Mechanical construction

The cores, framework, clamping arrangements and general structure of the transformers shall be of a design capable of withstanding any shocks to which they may be subjected during transportation, installation, service and under any severe fault condition.

Approved lifting arrangements shall be provided and arranged so that the core structures are not subjected to unacceptable stresses during lifting and handling operations.

Each transformer shall be fitted with omni-directional rollers which shall be capable of being locked in the direction of either of the two principal dimensions of the transformer.

All structural members of the assembled cores shall be steel except when conventional core-bolt clamping is replaced by an approved taping or banded-clamping technique.

Clamping of the core and coil assemblies shall be of approved material and be arranged to prevent deterioration of the core characteristics.

### 3.2.8.5 Enclosures

Each enclosure shall consist of a rigidly constructed steel framework which shall be completely clad in sheet steel and, if necessary, with screened openings to provide natural cooling.

The degree of enclosure protection shall be IP 54 and IEC 60529.

Internal access shall be by means of lockable hinged doors at the front of the enclosure and the arrangement shall ensure that the transformer can be withdrawn easily.

Termination chambers with bushings shall be provided on enclosure to interface the isolated phase bus bars supplied under this Contract.

Each enclosure shall be provided with anti-condensation heaters and rating plates.

Each transformer shall be fitted with indicators, alarm and trip facilities which shall be terminated at a junction box in the transformer enclosure.

### 3.2.9 Forced Air Cooled Thyristor Converter

The converter shall comprise 3-phase bridge-connected, fully controlled, thyristors. The unit shall be made up of several sections connected in parallel and so rated as to provide an excess capacity of not less than 100% of that required for maximum continuous excitation. The equipment shall be designed to withstand the maximum voltage rise on load rejection on the ac side of the equipment (allowing for the fact that the field current could be reduced to zero under this condition by an overvoltage trip).

Thyristors shall be forced air cooled. Filtered air shall be circulated by fans and if necessary, shall be cooled using air/water heat exchangers. The cooling system shall be provided with 100% duplicate coolers and circulating fans, with automatic change-over and all necessary alarms and indications.

#### 3.2.9.1 Converter Protection

The minimum protection for each converter shall be as follows:

- **Thyristor overcurrent.**

Approved overcurrent protection in the form of specially designed HRC fuses for each parallel circuit of all arms of the bridge shall be provided. The overcurrent protection shall protect each thyristor in the event of an internal thyristor short circuit and a short circuit at the dc load. Fuse failure indication shall be provided in the cubicle. The Contractor shall provide information regarding the operation of the fuses in the event of a short circuit on the output side of the transformer.

- Thyristor over temperature alarm.
- First thyristor failure (alarm)
- Second thyristor failure in the same bridge arm (alarm)
- Multiple thyristor failure trip.
- Voltage and current suppression.

Voltage and current surge suppressors shall be provided. The suppressors shall be designed and connected into the rectifier circuits in such a way that the highest values of rate of change of voltage and current with time, to which the thyristors may be subjected, will not endanger either the thyristors or any other components of the rectifier. The maximum voltage surge to which any thyristor may be subjected under any operating or fault condition shall not exceed 80% of the peak transient inverse rating of the thyristor.

- **Transient pole slip voltage protection**

The equipment shall withstand the maximum transient voltage pole slip conditions or be fitted with suitable equipment to provide protection in the form of a "crowbar" circuit which is self-resetting. In the event of extended slip operation, trip protection shall be initiated.

- **Thyristor replacement**

Thyristor replacement shall not affect current sharing, and shall not require more than 15 minutes to complete.

Normal field suppression shall be achieved by thyristor control.

- **Firing circuit controls**

Thyristor firing circuits shall be arranged so that, in the event of a component failure, a standby system comes into operation.

The thyristor firing circuits shall be taken from the excitation supply terminals. They shall be so designed that stable voltage control is maintained under all normal and fault operation.

- **Converter bus-bars**

Bus-bars with phase isolating barriers shall be designed to avoid the possibility of short circuits. They shall have clearances and creepage distances to earth between phases of not less than 50 mm, be insulated for an operating voltage of at least 1.5 kV and withstand a 50 Hz 1 min use pressure test to earth of 5.5 kV. Phases not under test shall be connected to earth. All the insulating material shall be non-hygroscopic and the insulation surfaces shall be treated to minimize the risk of tracking.

### 3.2.9.2 Field Suppression Equipment

A field suppression device incorporating a non-inductive de-energizing resistor, with a field suppression switch shall be provided. This field suppression equipment shall be mounted in a sheet steel cubicle with a lockable door forming part of the excitation suite. The field switch shall be a double-pole air circuit breaker with arc chutes and shall interrupt the maximum field current of the generator under all conditions of service, including short-circuit conditions, without incurring damage which would require component maintenance. The field switch shall be capable of operation by hand at the field switch cubicle. Approved arrangements for locking-off shall also be supplied. The nominal closing and tripping voltage shall be 220 V dc, but the trip coil shall operate between 50 and 120% of nominal voltage.

In the event of a generator fault the master trip relay shall trip the field circuit breaker. Operation of the field circuit breaker over-current tripping device shall operate the generator protection. A non-inductive resistor shall be connected across the generator rotor before the main contacts break the rotor current. This resistor shall be not more than the hot rotor winding resistance.

Alternative proposals to supply a ‘crow bar’ circuit consisting of anti-parallel thyristors in series with the discharge resistor in place of the field switch may be considered. For these proposals a high-speed surge suppression device shall be installed in parallel for very short voltage transients. An ac circuit breaker shall be installed on the power supply side to the rectifier bridge.

Normally the field switch will remain closed, but remote trip and close operation shall be provided, for automatic restart after a fault.

Contacts shall be provided for remote status indication and interlock, and shall be connected to a terminal box in the cubicle by the Contractor.

### 3.2.9.3 Main Excitation Connections

The Contractor shall supply and install all heavy current connections between the excitation transformer, the converter, the field breaker and the generator slip rings.

Heavy power circuit connections shall consist of cables with XLPE insulation for, stranded copper conductors and protected overall with a chlorosulphonated polyethylene sheath. They shall be constructed in accordance with IEC 60502 and shall have a voltage designation of not less than 1000 V. All cables shall be armored.

Cable sizes shall be selected according to the maximum current in the circuit, without any allowance for diversity, load factor or cyclic loading. No cable shall be less than 2.5 $mm^2$ cross sectional area. The ambient temperature shall be taken as 40°C except for cables run within the generator enclosure.



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### 3.2.10 Excitation Auxiliary Equipment

#### 3.2.10.1 Rotor Earth Fault Protection Equipment

Rotor earth fault protection equipment of an approved type shall be included in the excitation equipment. The protection relay shall provide continuous digital insulation resistance indication and alarm in the event of a single earth fault on the generator rotor winding whilst the machine is running or at rest. The device shall be of the type which continuously monitors the insulation resistance of the whole of the rotor winding. The level of insulation resistance at which operation occurs shall be as high as possible, preferably above 10,000 ohms. Operation of the relay shall be time delayed by 1 to 10 seconds.

The monitoring voltage injected into the generator rotor may be ac or dc. Any voltage produced by the excitation circuit, appearing across the relay circuit shall not cause operation. The protection equipment shall be designed to withstand continuously any voltage development by the excitation circuit in the event of a rotor earth fault. A second rotor earth fault device shall be arranged to trip the machine. Provision for testing the alarm and trip settings shall be incorporated without disconnecting the protection circuit.

#### 3.2.10.2 Rotor Temperature Indicator

A rotor temperature indicator shall be supplied and installed in the excitation suite. The instrument shall be provided with remote indication and alarm facilities and be suitably damped to provide stable indication under normal operation and alarm suppression under field forcing conditions. The rotor earth fault equipment and temperature indicating instruments shall be indirectly connected to the main excitation circuits, through isolating transformers or transducers to avoid polarity reversing equipment. Their primaries shall be designed to be tested with the voltage appropriate to the main circuit, and their secondaries at not less than 2 kV.

#### 3.2.10.3 Spare Parts, Maintenance Equipment and Tools

Spare Parts, Maintenance Equipment and Tools mentioned herein are the minimum required. Any other necessary spare parts, maintenance equipment and tools required for maintenance of the equipment shall be provided by the Contractor.

**Table 3-7: Spare Parts and Tools**

| Sr. No. | Description | Unit | Qty |
|---|---|---|---|
| **Mandatory Spare Parts for Excitation System** | | | |
| 1 | Pole dismantling device, if required | No. | 1 |
| 2 | Electronic prints corresponding to a complete AVR | Set | 2 |
| 3 | Thyristors and thyristor fuses | Set | 2 |
| 4 | One complete excitation transformer plus two spare legs of coils | Set | 1 |
| 5 | Cubicle ventilation fan unit | No. | 1 |
| 6 | Spares for Excitation Circuit Breaker | Lot | 1 |
| 7 | Spares for measuring and protection circuits | Lot | 1 |
| **Maintenance Equipment** | | | |
| 1 | Insulation test set to cover the range of equipment | Sets | 1 |
| 2 | Resistance measurement test set to cover the range of equipment | Sets | 1 |



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| Tools | | | |
|---|---|---|---|
| 1 | All necessary tools required for complete maintenance | Lot | 1 |
| 2 | Laptop for testing, commissioning and setting of parameters | No. | 1 |

### 3.3 SEGREGATED PHASE BUS (SPB)

The Contractor shall perform the detailed design of the segregated phase bus duct in accordance with the requirements of these specifications.

The connections shall withstand without injury the mechanical and electrical forces arising from maximum possible fault currents and from seismic forces.

The connections shall be capable of carrying continuously the maximum three-phase current rating of the generator without the temperature exceeding 105°C on the surface of the conductors and 65°C on the surface of the enclosures at a design ambient temperature of 40°C.

The housings and conductors shall be proportioned to avoid natural frequencies near to any natural frequencies of the turbine and generator.

The extreme climatic and other external conditions shall be taken as the basis for the design of the main connection system.

#### 3.3.1 Basic Construction

The bus duct shall be of the Segregated Phase type with adequate air space between each phase and from phase to ground. An aluminum ground barrier shall be secured between the phases. Bus duct designed for outdoor installations shall be totally enclosed, non-ventilated, and weather resistant, with peaked top cover. Bus duct designed for indoor installations shall be totally enclosed, non-ventilated and drip proof.

#### 3.3.2 Standards and Codes

The assemblies shall be constructed, wired and tested in accordance with all applicable sections of the following latest listed standards and codes.

- American National Standards Institute (IEEE-C37.23- 2015)
- National Electric Code (NEC) (NFPA No. 70)
- National Electrical Manufacturers Association (NEMA)
- It shall be the manufacturer’s responsibility to be knowledgeable of the requirements of the above Standards and Codes. Where standards or codes conflict, IEEE-C37.23-2015, shall be the governing document.

#### 3.3.3 Service Conditions

See Section “General Electrical Requirements”.

#### 3.3.4 Ratings

- Maximum voltage up to 15.5 kV
- Basic impulse insulation level up to 110 kV
- Rated frequency withstands up to 50 kV (1 min. dry) 50HZ
- Rated continuous current up to 1600 Amperes
- Rated short circuit withstand current 40 kA (3 sec.)



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- Conductor total temperature limit 105ºC for silver-plated surfaces, or equivalent bolted bus joints.
- Maximum voltage drops on entire length not exceeding 3%
- Enclosure total temperature limit 65ºC

### 3.3.5 Conductors

- Copper-ETP 110 ASTM Designation B187, or Aluminum 6101-T61 ASTM Designation 8236.
- Conductors shall not exceed specified temperature limit when operated at the rated current.
- Conductor supports shall be provided to withstand short circuit currents and remain functional after short circuit has been experienced.

### 3.3.6 Bus Joints

- Temperature rise of bus bar joint shall not exceed 65ºC above a maximum 40ºC ambient, or a total of 105ºC operating temperature.
- Hardware shall be high strength 304 stainless steel, including bolts, flat washers. Belleville spring washers are used for copper, aluminum bus bar and flexible link connections. Nuts shall be silicone bronze hardware.
- Conductor splices to be an overlap single row bolted joint. Joints with splice plates and filler putty are not acceptable.
- Contact surfaces of bolted copper joints shall be silver plated, to maintain low contact resistance without the use of joint compounds.

### 3.3.7 Bus Bar Insulation

- 15kV application shall have fully insulated conductors and conductor joints. Insulating materials shall be fluidized bed epoxy coating. The materials shall be non-hygroscopic and flame retardant, rated for continuous operation at 105ºC (Class 105). The insulation level of the combined system shall meet or exceed the requirements in Table 2 of IEEE Standard C37.23-2015.
- Insulation at bus joints shall be molded vinyl boots.
- All bolted joints to be taped shall be wrapped with a conductive mesh prior to insulation. This mesh serves as a corona suppressant.

### 3.3.8 Grounding

- The bus enclosure shall be designed to carry the system ground fault current without excessive temperature rise. As an option, a separate ground bus can be provided on the inside or outside of the bus enclosure. Separate ground bus may terminate to equipment, or a ground pad, for connection to the station ground.
- Flexible jumpers shall be provided at all expansion joints to ensure ground continuity.
- The housing ground continuity shall be maintained at the shipping splits by the use of housing ground splice plates.

### 3.3.9 Conductor Support System

- Bus conductors shall be rigidly supported within the enclosure and shall be braced to withstand the short circuit currents specified.
- 15kV systems shall be supported on insulators, which are non-hygroscopic, track



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resistant and flame retardant. Insulators will be molded Cycloalephatic epoxy mounted on glass reinforced polyester blocks or wet process porcelain post type insulators.

### 3.3.10 Enclosure

- Enclosures shall be constructed of one-piece aluminum for the sides and bottoms to limit reduced current losses and circulating currents, which prevents magnetic heating.
- All exposed surfaces are to be finished as described below:
  - All surfaces shall be cleaned to prepare them for paint adhesion.
  - All surfaces shall have a primer coat applied to 0.2 mil minimum dry film thickness
  - Outside surfaces shall have a final finish coat of 1.5 mil minimum dry film thickness
- Enclosure shall be designed for a maximum temperature rise of 40°C when carrying rated current in a 40°C ambient.
- Removable covers shall be provided throughout the bus duct run, on the top, for access to bus joints and supports without the need for disassembling the bus duct. The bottom shall have removable parts at the splice joints only.

### 3.3.11 Outdoor weatherproof construction

- Top covers shall be peaked and have drip lips to shed and prevent entry of wind-blown rain.
- Outdoor exposed enclosure assembly hardware shall be 304 stainless steel.
- Top cover joints, and joints with end flanges, are to be flanged, gasketed, and protected with a metallic sealing strip.
- Screened breather/drains are required along bottom covers and at all low points of the installation

### 3.3.12 Indoor non-ventilated drip-proof construction

- Housing will include gasketed solid top and bottom splice covers, and solid sides to prevent entry of falling liquid or solid particles.
- Enclosure assembly hardware shall be stainless steel.
- Screened breather/drains are required along bottom covers and at all low points along the installation.
- Enclosure joints will provide adjustment to accommodate site variances and linear expansion of up to ¼ inch per joint.
- Enclosures are to be shipped in longest practical lengths to minimize field assembly labor.

### 3.3.13 Space Heaters

- Space heaters shall be completely factory wired inside the bus enclosure. Wiring shall be in a separate grounded metal shielding. Heaters shall be thermostatically controlled. Each phase shall have a separate heater circuit individually wired to operate independently. Each circuit shall be thermostatically controlled, total of three (3) circuits per bus run.
- Space heaters shall be rated 240 volts/1000 watts.
- Space heaters shall be operated at 120 volts/125 watts to maintain low heater surface temperature and prolong their life.



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### 3.3.14 Wall, Floor or Roof Entrances

- Bus duct will include an internal vapor/fire barrier for one half hour to three-hour fire rating, where specified, at all wall, floor and roof penetrations when required.
- A dress up plate shall be provided to seal between the outside of the bus enclosure, and the building opening. The fire rating material between the wall and outside of the bus duct enclosure to be supplied by the installing contractor.

### 3.3.15 Testing

- All equipment will be subjected to IEEE-C37.23 standard production tests.
- Manufacturer may be requested to submit test reports showing compliance with the following IEEE-C37.23 design tests, or may submit design tests performed on similar ratings along with technical data to substantiate compliance of the equipment being furnished:
  - Temperature Rise
  - Insulation Withstand
  - Impulse
  - Wet and Dry Withstand
  - Insulation Flame Retardance
  - Water Tightness

### 3.3.16 Equipment Connections

- All transition parts for connection to mating equipment terminals shall be provided by the bus manufacturer. The Purchaser will provide the Manufacturer with the necessary interfacing details from other equipment manufacturers, to allow the bus duct manufacturer to design the connections.
- Equipment connections will include bolting hardware, bus adapters (where required), insulating materials and assembly drawings.
- Where connection to porcelain bushing of transformers, generators, or reactors is required, flexible connectors having a continuous current rating equal to or greater than the main conductors will be furnished.

### 3.3.17 Expansion Joints (For enclosures and conductors)

- Expansion joints are required for straight runs exceeding 60 feet on copper or aluminum conductors. This applies to indoor or outdoor bus duct construction.
- Expansion joints may be factory or field assembled. Full assembly instructions shall be furnished when field installation is required.
- Only outdoor expansion joints shall be used in seismic zones 3 or 4, or equivalent, as earthquake joints, indoors or outdoors, and when equipment being connected are on different pads or foundations.

## 3.4 GENERATOR STEP-UP TRANSFORMERS

### 3.4.1 Scope of Work

The scope of work covers design, engineering, manufacture, factory (works) testing, delivery, erection, installation, site tests and commissioning of four (4) number of three-phase generator step up transformers including one (1) spare transformer complete with their accessories. The



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LV Side of transformers shall be connected to generator circuit breakers through segregated phase bus duct system.

These shall be three-phase units, each rated 20/26 MVA, with 132/11kV voltage ratio, and with on-load tap changers complete with transformer purpose made supports and anti-vibration pads. The cooling type shall be ONAN/ONAF and the transformers shall be provided with fire detection and alarm system and SERGI transformer explosion protection system.

### 3.4.2 Service Conditions

See Section “General Electrical Requirements”.

### 3.4.3 Standards

The transformers shall conform to the applicable requirements of the latest edition of the following international standards:

- IEC Publication 60076
- IEEE C57.12.00
- IEEE C57.12.10
- IEEE C57.12.70
- IEEE C57.12.80
- IEEE C57.12.90
- IEEE C57.13
- IEC Publication 60076-10
- IEC 60060
- IEC 60085
- IEC 60354
- IEC 60529
- IEC 60567
- IEC 60814
- IEC Publication 60076-7
- IEC Publication 60137 (Bushing)
- IEC Publication 61869
- IEC Publication 60811, 60230, 60502, 60228
- IEC TC37, WG-4
- IEC Publication 60214
- IEC Publication 60071
- IEC 61181
- IEC 61198
- IEC 60296-2003
- IEEE 62
- IEEE 637
- IEEE 1538

### 3.4.4 Functional Specifications

All generator step-up transformers shall be oil-immersed, (ONAN/ONAF), with the oil preservation system of the constant pressure conservator type, with a flexible diaphragm to preclude direct contact of oil with air, complete with accessories, and spare parts, suitable for outdoor operation. The star points of the 132 kV windings shall be solidly earthed.

The core of each transformer shall be of high grade, non-ageing electrical silicon steel of low hysteresis loss and high permeability. The Low Voltage side bushings on the generator transformer shall be suitable for connection to generators bus.

The high voltage bushings shall be condenser type, and shall be free from partial discharges up to the test voltage.

All bushings shall comply with IEC 60137. The HV bushings shall be inside an oil box adequate for HV connection. The LV bushings shall be air insulated. The neutral terminals shall be provided with outdoor type bushing insulator.

Each transformer case shall be capable of withstanding, without leakage or distortion, an internal gas pressure of 0.7 bar and essentially a full vacuum and shall be designed and constructed for vacuum filling in the field.



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Each transformer oil tank shall be provided with an approved self-resetting pressure relief device for the release of any pressure that may be generated in the tank to save it from damage. It shall operate at a static pressure lower than the hydraulic test pressure and outlets shall be arranged to face away from the bushings. The device shall be provided with two sets of normally open signaling contacts. These contacts shall be used to operate alarms/trips.

The transformer shall be equipped with bushing type current transformers for the high voltage and neutral terminals. The transformer shall be protected by a water deluge system with all the accessories i.e., piping, deluge valve, sensors, nozzles etc.

The transformers shall be equipped with a motor-operated 17 position on-load tap changer (OLTC) on the HV side, with a regulating range of ± 8 x 1.25%. The OLTC shall be manually controlled by the operator, not having an automatic voltage regulator so that when interacting with the excitation voltage regulator they do not oscillate against each other.

### 3.4.5 Key Technical Parameters

#### 3.4.5.1 Transformers

| | |
|---|---|
| Nominal capacity per 3-phase unit | 20/26 MVA |
| Rated Voltage | 132 / 11 kV |
| Maximum System Voltage | 145 kV |
| Rated Frequency | 50 Hz |
| Vector Group | YNd11 |
| Voltage Impedance | Ud ≥ 12% |
| Tap Changer | On-load |
| Voltage Regulation | ± 8 × 1.25% |
| Cooling Type | ONAN / ONAF |
| Neutral Point Earthing Mode | Solid earthing |
| Rated short-time power frequency withstand voltage (HV) | 275 kV |
| Rated lightning impulse withstand voltage (HV) | 650 kV |
| Rated Short Circuit Level | 50 kA |
| Rated short-time power frequency withstand voltage (LV) | 28 kV |
| Rated lightning impulse withstand voltage (LV) | 75 kV |
| Noise Level | < NEMA TR-1 |
| Efficiency (minimum) | ≥ 99 % |
| Temperature rise at 40°C ambient (Coil) | 65 K |
| Temperature rise at 40°C ambient (Oil) | 60 K |
| Insulating Liquid | Mineral oil, IEC 60296 |



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#### 3.4.5.2 H.V Surge Arresters

- Material type — Zinc Oxide
- MCOV (maximum continuous operating voltage) — not less than 145 kV
- Standard Nominal Discharge Current rating — 10 kA (IEC 60099)
- Insulation impulse withstand voltage — 650 kV
- Insulation wet power frequency Withstand voltage — 275 kV

### 3.4.6 Overload Requirements

The overload rating and operation shall be in accordance with IEC 60076-7. The overload capability of any ancillary equipment such as bushings, CTs, oil expansion tanks, leads etc. shall not be less than the transformer overloads rating. The transformers shall also be capable of withstanding momentarily, without injury, a voltage of 20% greater than the rated generator voltage, when the generator full load is rejected.

### 3.4.7 Short Circuit Capability

The transformer and its accessories shall be capable of withstanding mechanical and thermal stresses caused by short circuit fault currents without mechanical deformation or impairing electrical capabilities. The sudden pressure relay and other alarm initiating devices will not respond to the effect of the through fault short circuit currents.

### 3.4.8 SERGI Transformer Fire Protection System

Transformers shall be equipped with transformer explosion prevention system of SERGI type complete with sensors, control unit, and interfaces.

### 3.4.9 Tests

#### 3.4.9.1 General

Each transformer shall be subjected to the routine shop and quality control tests and all applicable tests required by IEEE C57.12.90, in addition to any special test required in accordance with this Specification. Test procedures shall be submitted to the Employer prior to any tests being performed. The Contractor shall submit test procedures and notify the Employer sufficiently in advance of tests, giving the date and place where such tests shall be made. The Contractor shall furnish to the Employer certified copies of all test results in electronic PDF format. The results of each test shall be recorded in the form of test certificates or reports as specified.

#### 3.4.9.2 Type Tests

Type tests shall be made on one unit of each type of different equipment at the Contractor's expense in presence of the Employer and the Employer and the actual type test report shall be submitted to the Employer for approval. Instead of carrying out the type tests, the Contractor may submit duly certified and complete type test reports for tests carried out by an independent, accredited authority on similar equipment of the same type. However, the Employer reserves the right of accepting these certificates or to reject them partially or totally.

The generator step-up transformers shall be subject to the following type tests:

- Noise level test in accordance with IEC 60076-10,
- Zero phase sequence impedance measurement in accordance with IEC 60076-1
- Short-circuit test in accordance with IEC 60076-5.
- A temperature rise test, in accordance with IEC 60076-2. The test shall be conducted



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on the tapping corresponding to the maximum losses.

- Dielectric Type Tests in accordance with IEC 60076-3.
- Type tests shall be carried out on bushings in accordance with IEC 60137.
- Type test shall be carried out on one tap changer of each type in accordance with IEC 60214.

#### 3.4.9.3 Transformer Routine Tests

Usual non-destructive tests shall be performed on the tank welds. The tank welds shall be given a pressure test by filling the tank with dry nitrogen, dry carbon dioxide, or dry air to the highest pressure for which the tank is designed and exploring all welded seams with a suitable leak detector. There shall be no perceptible leaks and the transformer shall hold the test pressure for four hours without leakage. Any alternative pressure test shall be submitted to the Employer for approval.

The transformer tank shall be vacuum tested to a negative pressure of 25 mm Hg absolute or less prior to filling the tank with oil. The pressure rise shall not exceed 25 mm Hg in 30 minutes while the vacuum pump is not operating. This test may be performed as part of the filling procedure.

All test equipment shall be supplied for the specified shop tests in accordance with the latest issue of the applicable international standards. Calibration of all test equipment shall be traceable to the National Institute of Standards and Technology (NIST), and calibration certificates shall be submitted for approval. Certificates shall be renewed in accordance with the Quality Control Plan. For the loss tests, the instrumentation shall be calibrated for power factor.

Insulation resistance shall be measured at 1000 V and shall indicate a minimum resistance of 50 MΩ to ground.

The following tests shall be made at the completion of winding, at the conclusion of all other tests, and prior to shipment.

- Resistance of high voltage and low voltage windings, including all taps.
- Applied and induced voltage tests.
- Exciting current and no-load loss curves on rated voltage connections at 90%, 100% and 110% of rated voltage.
- Impedance and load loss test at rated current on the rated voltage connection and on the tap extremes of the transformer.
- Heat run on the transformer at lowest and highest MVA ratings.

Pressure tests at 25% above maximum nameplate rating shall be performed for the duration of 6 hours and shall be made immediately following the temperature rise test while the oil is hot.

On completion of all other tests and prior to shipment, the transformer shall be subjected to a one hour excitation loss run at 110% voltage. The current and power recorded at the conclusion of this test shall compare favorably with previous test results.

The following tests, described in cited sections of IEEE C57.12.90, unless otherwise indicated, shall be included:

- Resistance Measurement, Section 5.
- Polarity and Phase Relation, Section 6.



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- Ratio, Section 7.
- No-Load Losses and Excitation Current, Section 8.
- Impedance Voltage and Load Losses, Section 9.
- Dielectric Tests, Section 10.
- Temperature Rise, Section 11.
- Audible Sound Emission, Section 13.
- Measurement of zero-sequence impedance.
- 1 minute power frequency separate source AC withstand voltage test on auxiliary wiring and function tests on auxiliary equipment/devices. The functional tests of all auxiliaries including tap changer shall be performed.

#### 3.4.9.4 Additional Transformer Tests per IEEE C57.12.90

The following additional transformer tests shall be performed per IEEE C57.12.90:

- Insulation Power Factor, IEEE C57.12.90, Section 10.
- Bushing Power Factor, IEEE C57.19.00.
- Impulse Tests, IEEE C57.12.90, Section 10.3 (Full and Chopped Wave Test).
- Switching Impulse Voltage Tests, IEEE C57.12.90, Section 10.6.
- Bushing Capacitance, IEEE C57.19.00.
- Short-Circuit Tests

#### 3.4.9.5 Site Tests

Following tests shall be performed on generator step-up transformers at site:

- Visual inspection,
- Insulation resistance,
- Winding resistance and continuity on all taps,
- Polarity,
- Dielectric test of oil, and
- Functional test of all control and protection apparatus.
- Transformer turn ratio test.
- Load tests.
- Sweep Frequency Response Analysis (SFRA) Test

### 3.4.10 Spare Parts, Maintenance Equipment and Tools

Spare Parts and Tools mentioned herein are the minimum required. Any other necessary spare parts and tools required for maintenance of the equipment shall be provided by the Contractor at no extra cost.

**Table 3-8: Spare Parts and Tools**

| Sr. No. | Description | Unit | Qty. |
|---|---|---|---|
| | **Mandatory Spare Parts** | | |
| 1 | 132 kV bushings, complete with gasket, terminal connector and oil. | Set | 3 |
| 2 | 11 kV bushings, complete with gaskets and terminal connectors. | Set | 3 |



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| Sr. No. | Description | Unit | Qty. |
|---|---|---|---|
| 3 | Neutral bushings, complete with gaskets and terminal connectors. | Set | 3 |
| 4 | Complete set of gaskets for 132 kV GSU transformers. Each set to consist of one of each size and type of gaskets furnished and one liter can of lubricating grease. | Set | 3 |
| 5 | Contacts and coils for each type and size of relay and contactor. | Set | 2 |
| 6 | Replacement parts for pressure relief devices. | Set | 2 |
| 7 | Pressure gauge of each type and size for the heat exchanger. | Set | 2 |
| 8 | Gas and oil actuated relay of each type, complete. | Set | 2 |
| 9 | Oil thermometer of each type, complete. | Set | 2 |
| 10 | Oil gauge of each type, complete. | Set | 2 |
| 11 | Air breather for conservator tank, complete. | Set | 2 |
| 12 | Thermal relay of each type, complete. | Set | 3 |
| 13 | Tapping switch assembly for 132 kV transformer. | Lot | 2 |
| 14 | Complete spares for oil preservation system for 132/11 kV GSU transformers. | Set | 1 |
| 15 | Winding temperature indicating device, each type. | Set | 2 |
| 16 | Current transformer, associated with temperature indicating device, each type. | Set | 2 |
| | **Maintenance Equipment** | | |
| 1 | 10% transformer oil in addition to net quantity required for filling the transformer. | Set | 1 |
| 2 | Consumable items such as filters, oils, etc. for 3-years of operation | Set | 1 |
| 3 | Dissipation test (Tan Delta) set to cover the range of equipment | Set | 1 |
| 4 | Insulation test set | Set | 1 |
| 5 | Winding resistance measurement test set | Set | 1 |
| 6 | AVR test set | Set | 1 |
| 7 | Special tools for dismantling and maintenance | Set | 1 |
| 8 | Hydraulic Jacks | Nos | 4 |
| 9 | Lifting apparatus | Set | 1 |

## 3.5 MEDIUM VOLTAGE SWITCHGEAR

### 3.5.1 Scope

This section describes the technical requirements for the design, manufacture, factory testing,



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delivery, erection, testing and commissioning of the three (03) medium voltage switchgears complete in all respects and all ancillary equipment for successful safe, reliable and continuous operation. Three (03) GCBs shall be part of medium voltage switchgear along with compartments provided for connection with segregated phase bus (SPB).

The 11 kV Switchgear for all the generating units shall be SF6 gas-insulated Generator Circuit Breakers (GCBs) or Vacuum Circuit Breakers (VCBs). The 11 kV switchgear for all other applications shall be vacuum type using vacuum as the insulating and interrupting medium and shall comply with IEC 62271-100 Standard and IEC 62271-200 Standard.

The Generator Circuit Breakers (GCBs) shall be suitable for generator switching and synchronizing duties and shall be provided with the necessary Mechanical and Electrical interlocks to prevent incorrect operation of the associated Disconnectors and Earthing Switches.

The equipment offered shall be of high quality, sturdy, robust and of good design and workmanship complete in all respects and capable of performing continuous and satisfactory operations in the actual service conditions at site and shall have sufficiently long life in service as per statutory requirements.

The equipment offered shall be complete with all parts necessary for their effective and trouble-free operation. Such parts shall be deemed to be within the scope of the supply irrespective of whether they are specifically indicated or not.

### 3.5.2 System Conditions

The switchgear shall be metal enclosed, floor mounting, single front self-supporting cubical type suitable for indoor. The switchgear shall be easily extendable in future.

The switchgear assembly shall be designed for the power system having the following parameters.

| | | |
|---|---|---|
| a) | Nominal system voltage: | 11KV |
| b) | Highest system voltage: | 12KV |
| c) | Number of phases: | 3 |
| d) | Frequency: | 50 Hz |
| e) | System earthing: | Solidly earthed neutral |
| f) | Short Current Rating: | 40kA |
| g) | Continuous current rating: | 1600A |

### 3.5.3 Standards

The circuit Breaker shall confirm to the latest revision with amendment available of relevant standards, rules, and code. Some of which are listed herein for ready reference.

- IEC 62271-100 “Common specifications for high voltage switchgear, high voltage alternating current circuit breaker”
- IEC 62271-200 “AC metal enclosed switchgear and control gear for rated voltages above 1 kV and up to including 52 kV”
- IEC 62271-102 “Common specifications for high voltage switchgear, alternating current disconnector and earthing switches”
- IEC 61869-1 “Instrument transformers, part 1 general requirements”



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- IEC 61869-2 “Instrument transformers, part 2 additional requirements for current transformers”
- IEC 61869-3 Instrument transformers, part 2 additional requirements for inductive voltage transformers”
- IEC 60099 “Surge Arrestors”

### 3.5.4 Service Conditions

See Section “General Electrical Requirements”.

### 3.5.5 General Technical Requirement

a) The switchgear shall be of CRCA steel / corrosion proof aluminum-zinc construction with sheet not less than 3 mm thickness for load bearing section and not less than 2mm thickness for non-load bearing and shall totally dust and vermin proof. However, if vendor has standardized the thickness of enclosure other than above mentioned and it meets the performance requirements and the design has been established through type test, the same shall be accepted. The panels shall be rigid without using any external bracings. The switchboard panels should comply with relevant IEC and revision thereof and shall be designed for easy operation maintenance and further extension. Each circuit shall have a separate vertical panel with distinct compartments. Bus bar, metering, circuit breaker chamber, cables and cable box chamber should have proper access for maintenance and proper interlocks should be provided. All instruments (Except the Relays) shall be non-draw out type and safe guard in every respect from damages and provided with mechanical indicator of connection and disconnection position. The switchgear shall be completed with all necessary wiring, fuses, auxiliary contacts, terminal boards etc.

b) The switchgear boards shall have a single front, single tier, fully compartmentalized, metal enclosed construction, comprising of row of freestanding floor mounted panels. The adjacent panels shall be completely separated by steel sheets except in busbar compartments where insulated barriers shall be provided to segregate adjacent panels. The switchgear assembly shall be dust, moisture, rodent and vermin proof, with the truck in any position SERVICE, ISOLATED, TEST or removed, and all doors and covers closed. All doors, removable covers and glass windows shall be gasketed all round with synthetic rubber or neoprene gaskets.

c) The arcing contacts and bus bar should be rated for 40 KA faults for 3 seconds for 11kV system. Bus bars shall be capable of connecting one switchgear panel to other through proper insulated arrangement. The panels shall be modular in design.

d) The switchgear will be installed in a separate switchgear room, but the controls under normal conditions will be from the 11 kV remote supervisory control desk installed in the main control room.

e) The breakers should be able to be drawn out in horizontal position at ground level [with vertical/horizontal isolation]. When breaker is drawn out in horizontal position none of the live components inside the 11KV switchgear panel should be accessible. The safety shutters shall be robust and shall automatically cover the live components when the breaker is drawn out. The switchgear shall have complete interlocking arrangements at the fully inserted and fully drawn out and test positions. Withdrawal of the breaker should not be possible in ON position, it should not be possible to close the circuit breaker in service unless the entire auxiliary and control circuit are



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connected.

f) Circuit breaker shall be vacuum; draw out type housed in a separate cubicle of the switchboard and shall be enclosed from all sides. A sheet steel hinged lockable door shall be at the front. It shall be possible to withdraw the circuit breaker to 'Test' and "Isolated' position with the door closed. Door interlock shall be provided such that the door can only be opened after withdrawing the breaker to 'Isolated' position and the breaker cannot be racked into the 'Service' position unless the door is closed. A visual indication as to show when the breaker is in 'Service', 'Test' or 'Isolated' position shall be provided in front of the door.

g) Switchgear construction shall have a bushing or other sealing arrangement between the circuit breaker compartment and the busbar / cable compartments, so that there is no air communication around the isolating contacts in the shutter area with the truck in service position.

h) The breaker and the auxiliary compartments provided on the front side shall have strong hinged doors, busbar and cabling compartments provided on the rear side have bolted compartment covers with self-retaining bolts. Breaker compartment doors shall have locked facility.

i) Built-in / separate trolley mounted earth switches for incomer (busbar earth) and outgoing (feeder cable earth) shall be provided.

j) Two separate earthing terminals shall be provided in each panel and shall be connected to the earth bus within the panel. The earth bus shall be of copper and shall have adequate cross-sectional area.

k) Total height of the switchgear panels shall not exceed 2600 mm. The height of switches, pushbuttons and other hand-operated devices shall not exceed 1800 mm and shall not be less than 700mm.

l) Suitable base frames made out of steel channels shall be supplied along with necessary anchor bolts and other hardware, for mounting of the switchgear panels. These shall be dispatched in advance so that they may be installed and levelled when the flooring is being done, welding of base frame to the insert plates shall be as per approved installation drawings.

### 3.5.6 Busbar and Connections

a) Bus bars and all other electrical connection between various components shall be made of electrolytic copper of rectangular / tubular cross sections, as per the type tested and ratified design. The bus bars section should have ample capacity to carry the rated current of minimum 1600 Amps in panel current rating at an ambient temperature of 40 deg C, continuously without excessive heating and for adequately meeting the thermal and dynamic stresses in the case of short circuit in the system up to full STC rating of 40kA for 3 sec.

b) All bus bars connections shall be firmly and rigidly mounted on suitable insulators to withstand short circuit stresses and vibrations. 'Self-supported busbar' design will be acceptable if the same is ratified by type tests for the specified rating and busbar support drawings approved during type tests shall be furnished with the offer.

c) All fasteners (Nuts Bolts) used for bus bar connections shall be of non-magnetic stainless steel. Only Belleville type washers shall be provided for each nut bolt. If the fasteners used are not of stainless steel the Proposer shall state in their offer the material used and confirm that the same is non-magnetic and is superior to stainless



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steel.

d) Adequate clearance between 11 kV point and earth and between phase shall be provided to ensure safety in accordance with the relevant IEC standard specification and the same shall be capable of withstanding the specified high voltage tests as per IEC 62271-200 and amendment thereof.

e) Sharp edges and bends either in the bus bars or bus bar connections shall be avoided as far as possible. Wherever such bends or edges are un-avoidable, suitable compound or any other insulation shall be supplied to prevent local ionization and consequent flashover.

f) The bus bars along with their supporting insulators etc. shall have a short time current rating of 40 kA for 3 sec. Test certificate of bus bar for rated STC rating shall be submitted, along with the Proposal. This shall be confirmed by the tenderers in their technical offer. These insulators shall be of solid core porcelain or epoxy resin cast, with suitable petticoat design. Insulators shall have a cantilever strength of not less than 1200 kgf.

g) The Bus Bar should be color coded.

**3.5.7 Circuit Breaker**

a) The vacuum circuit breaker shall be draw out type suitable for installation in the switchgear cubicles (indoor). The breaker shall comply with IEC 62271-100 for circuit breaker and IEC 62271-200 for the switch gear and latest amendment thereof. Construction of breaker shall be such that the points, which require frequent maintenance, shall be easily accessible.

b) The circuit breakers shall be spring operated, motor/manually charging of the spring feature, manually released. VCB shall have spring closing mechanism for 3 pole simultaneous operation. The speed of closing operation shall be independent of the speed of hand operating level. The indication device shall show the OPEN and CLOSE position of breaker visible from the front of cubical.

c) The circuit breakers shall be type tested as per IEC 62271 for compliance with the following requirements:

d) E2 class: The circuit breakers shall not require maintenance of the interrupting part of the main circuit during its expected operating life;

e) C2 class: The circuit breakers shall have very low probability of restrike during capacitive current breaking.

f) M2 class: The circuit breaker should require very limited maintenance and should be tested for endurance for 10,000 close – open operations.

g) The breakers shall be capable of making and breaking the short time current in accordance with the requirement of IEC 62271-100 and latest amendment thereof and shall have three phase rupturing capacity of 40KA for 3 second at 11 KV. The continuous current rating of all current carrying parts of breaker shall be 1600 Amps for all items. The total break / make time shall be not more than 4 cycles for break and 6 cycles for make time for all breakers.

h) Circuit breaker shall be suitable for reclosing cycle i.e., O-0.3 sec.-CO-30 sec.- CO.

i) The spring release coil for VCB close and VCB trip coil shall both be rated for continuous energization at the rated close / trip voltage. Trip and close coil shall be



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suitable for 220 V DC.

j) The vacuum circuit breakers shall ensure high speed extinction and adequate control of pressure during breaking of current and also designed to limit excessive over voltages.

k) Comprehensive interlocking system to prevent any dangerous or inadvertent operation shall be provided. Isolation of circuit breaker from bus bar or insertion into bus bar shall only be possible when the breaker is in the open position.

l) Vacuum Circuit Breaker shall have completely sealed interrupting units for interruption of arc inside the vacuum. The vacuum interrupter sealed for life.

m) Vacuum interrupter should have an expected life of 30000 operations at rated current and should be capable of operating at least 100 times at rated short circuit current.

n) Vacuum interrupter technical data sheets & outline drawing particularly provided by the manufacturer should also be provided with Proposal.

o) The circuit breaker shall be provided with motor for spring charging operation. Spring charging motor shall be suitable for 240V, 50 Hz, single phase AC and 220 V DC Supply. Suitable rating starter/fuse shall be provided for Motor protection. Provision shall be available for charging the springs manually as well, and to close CB mechanically.

p) All circuit breakers should have mechanical ON/OFF indicator and spring charge indicator. These shall be visible from the front without opening the panel door. Also, there shall be provision for mechanical (manual) tripping and also for manual charging of the springs.

**3.5.8 Current Transformers**

a) The requirement of ratio, VA capacity, class or accuracy, limit factor etc. for resin cast CTs installed in different types of units are as specified in other section of Specifications.

b) Primaries shall be wound or bar or window type, rigid, high conductivity grade copper conductor. Unavoidable joints on the primary conductor shall be welded type, preferably lap type. The current density at any point shall not exceed 1.6 A/sq. mm.

c) The Insulation level of all the CTs shall be as per IEC requirement for 11 kV primary voltage.

d) Short time current rating of CTs shall correspond to 40KA faults for 3 seconds of 11kV system. CTs shall be triple / double core and dual ratio. Instrument safety factor for metering core shall not exceed 2.5.

e) The designed accuracy should be available even at the lowest ratios.

f) The secondary terminal of the current transformers shall be such that effective and firm wire terminations are possible. Shorting links of adequate capacity shall be provided at the terminal blocks for sorting of the leads from secondary terminals of current transformers. The secondary terminal of the CTs shall be earthed at one point.

g) The CTs shall be resin/epoxy cast. Contact tips on primary terminals shall be silver plated. Correct polarity shall be invariably marked on each primary and secondary terminal.

h) Secondary terminal studs shall be provided with at least three nuts, two plain and two spring washers for fixing leads. The stud, nut and washer shall be of brass, duly nickel



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plated. The minimum outside diameter of the studs shall be 6 mm. The length of at least 15 mm shall be available on the studs for inserting the leads. The space clearance between nuts on adjacent studs when fitted shall be at least 10 mm.

### 3.5.9 Potential Transformers

a) Potential transformer, ratio, accuracy class, as specified in other sections of Specifications shall be provided. Potential transformers shall be provided along with HT HRC fuse and Triple Pole & Neutral MCB, rated 1 Amp, with monitoring contacts on PT LV circuit. Primary and secondary neutrals of the PT shall be brought out and earthed. If required, the busbar connected P.T. may be housed in a separate cubicle. PT mounted on top of the panel shall not be acceptable.

b) PT may be provided in a separate compartment. The primary and secondary contacts (moving & fixed type) shall have firm grip while in service. Service position locking mechanism shall be provided and indicated by Proposer in relevant drawing. Rigidity of primary stud point with earth bus in service position shall be confirmed.

c) Contact tips of primary/secondary contacts shall be silver plated. Correct polarity shall be distinctly marked on primary and secondary terminal.

d) Secondary terminal studs shall be provided with at least three nuts, two plain and two spring washers for fixing leads. The stud, nut and washer shall be of brass, duly nickel plated. The minimum outside diameter of the studs shall be 6 mm. The length of at least 15 mm shall be available on the studs for inserting the leads. The space clearance between nuts on adjacent studs when fitted shall be at least 10 mm.

### 3.5.10 Protection Relays

All relays shall conform to the requirements of IEC-60255/ IEC 61850. Relays shall be suitable for flush or semi-flush mounting on the front with connections from the rear. The relay for entire Project shall be of same type. The relays shall be numerical protective & communicable type. Composite relay unit having O/C, E/F & directional element etc. shall be preferred. Relays should have USB / ethernet communication port and RS485 / RS232 serial communication port for communication through IEC 61850 Ed II (with high-speed GOOSE communication and certified by KEMA/CPRI certificate level A for IEC 61850 compliance). Licensed version of the relay software should be provided as per user's requirement.

### 3.5.11 Measuring Instruments

a) All instruments shall be switchboard type, back connected, suitable for flush mounting and shall comply with the requirements of latent issues of relevant Indian Standards. The instrument cases shall be dust proof, water tight, vermin proof and specially constructed to adequately protect the instruments against damage or deterioration due to high ambient temperature and humidity.

b) All instruments shall be access adjustable and calibrated before dispatch and shall have means for calibration check and adjustment at site.

c) All ammeters shall be digital type with direct reading scales. The scale value of ammeters shall be as per the primary current ratings of the associated current transformers.

d) All voltmeters shall be of digital type with direct reading scales. The maximum scale



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value of voltmeters shall be 50% in excess of the primary voltage of associated PT.

e) Indicating Wattmeters shall be of digital type of accuracy class 1.

### 3.5.12 Circuit Breaker Control Switch

a) Circuit Breakers Control Switches should have finger touch proof terminals. For the convenience of maintenance, screw driver guide should be from top/bottom of the switch and not from the side. Terminal wire should be inserted from the side of the switch terminal.

b) Terminal screws shall be captive to avoid misplace during maintenance.

c) Switch shall be with 48 mm x 48 mm escutcheon plate marked with Trip & Close.

d) Circuit Breakers control switch shall be non- discrepancy type.

e) Trip-neutral-close, with pistol grip handle shall be pushed in to spring return to either trip or close position from Neutral position for safety and not just turn to trip.

f) One contact to close in each position of Trip and Close. Contact not required in Neutral position.

### 3.5.13 Cubicle

a) The switchgear cubicle (panel) shall be free standing floor mounting indoor type. There shall be sufficient reinforcement to have level surfaces resistance to vibration and rigidity during transportation & installation.

b) Design & construction of the switchgear panel shall be of the highest order. All sheet steel work shall be treated as per the seven tank process before applying primary coating. The panels after final painting shall present an aesthetically pleasing appearance, free of any dent or uneven surface.

c) Power compartments shall be provided at the top of the switchgear panels and shall be suitable for segregated phase bus entry from the top. After connection with SPB the compartment shall be properly sealed.

d) Power compartments shall be suitable for connection with segregated phase bus. Power compartments shall be robust enough & self-supporting.

### 3.5.14 Testing and Commissioning GCB

The equipment offered should have been successfully type tested in line with the relevant standard and technical specification. The design of circuit breaker shall be proven through all the routine and in accordance with IEC 62271-100 / 200 and any amendment thereof. Photocopy of all the test reports shall be enclosed with the tender. The Proposer shall be required to submit complete set of the following type test reports along with the offer.

#### 3.5.14.1 Type Tests

a) Lightning Impulse Voltage withstand Test.

b) H.V. dry 1 min power frequency withstand test.

c) Short time and peak withstand current test.

d) Short circuit test with basic duties.

e) Single phase breaking capacity test.

f) Temperature Rise test.



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g) Seismic Level Test

**Circuit Breaker**

Each circuit breaker shall be fully type tested as per IEC 62271 - 100/200, including the following tests:

a) short time and peak withstand current test.

b) short circuit breaking capacity and making capacity.

c) Capacitive current switching test: Cable charging current breaking test (Ur less than or equal to 52 kV).

d) Dielectric test i.e., power frequency withstand and impulse withstand test.

e) Temperature rise test.

f) Mechanical Endurance Test at ambient temperature.

g) Measurement of resistance of the main circuit.

h) Internal arc test (IAC AFLR).

**Current Transformer**

a) Short Time Current Test.
b) Impulse Voltage Withstand Test.
c) Temperature Rise Test

**Potential Transformer**

a) Impulse Voltage Withstand Test
b) Temperature Rise Test

**Switchgear Panel**

a) IP 4X Test

### 3.5.14.2 Routine Tests

Each Switchgear shall be completely assembled in manufacturer's workshop and following routine tests but are not limited to shall be conducted in accordance with IEC 62271-100/ 200/ 102. The Employer shall witness all tests.

- Visual inspection
- Operation test of the switching devices
- 1 minute power frequency withstands voltage test
- Measurement of the resistance of main circuit
- Insulation and functional test on auxiliary and control circuits
- All Tests on generator circuit breakers in accordance with IEC

### 3.5.14.3 Commissioning Tests

After installation of panels, power and Control wiring and connect Contractor shall perform commissioning checks. As listed below to proper operation of switchgear/panels and correctness of all respects.

In addition, the Contractor shall carry out all other checks and tests recommended by the manufacturers.

### 3.5.14.4 General

I. Check name plate details according to specification.

II. Check for physical damage.

III. Check tightness of all bolts, clamps and connecting terminal.

IV. Check earth connections.

V. Check cleanliness of insulators and bushings.

VI. Check heaters are provided.

VII. H.V. test on complete switchboard with CT & breaker/ contractor lubricated in position.

VIII. Check all moving Parts are properly lubricated.

IX. Check for alignment of busbars with the insulators to ensure alignment and fitness of insulators.

X. Check for inter changeability of breakers.

XI. Check continuity and IR value of space heater.

XII. Check earth continuity of the complete switchgear board.

**3.5.14.5 Circuit Breaker**

I. Check alignment of trucks for free movement.

II. Check correct operation of shutters.

III. Check slow closing operation (if provided).

IV. Check control wiring for correctness of connections, continuity and IR values.

V. Manual operation of breakers completely assembled.

VI. Power closing/opening operation, manually and electrically at extreme condition of control supply voltage.

VII. Closing and tripping time.

VIII. Trip free and anti-pumping operation.

IX. IR values, resistance and minimum pick up voltage of coils.

X. Simultaneous closing of all the three phases.

XI. Check electrical and mechanical inter locks provided.

XII. Checks on spring charging motor, correct operation of limit switches and time of charging.

XIII. Check vacuum (as applicable).

XIV. All functional checks.

**3.5.14.6 Current Transformers**

I. Megger between windings and winding terminals to body.

II. Polarity tests:

a. Ratio identification checking of all ratios on all cores by primary injection of current.

b. Magnetization characteristics & secondary winding resistance.

III. Spare CT cores, if any to be shorted and earthed.



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### 3.5.14.7 Voltage transformers

I. Insulation resistance

II. Ratio test on all cores.

III. Polarity test

IV. Line connections as per connection diagram.

### 3.5.14.8 Cubicle Wiring

I. Check all switch developments.

II. It should be ensured that the wiring is as per relevant drawings. All interconnections between panels shall similarly be checked.

III. All the wires shall be meagered to earth.

IV. Functional checking of all control circuit e.g., closing, tripping, interlock, supervision and alarm circuit including proper functioning of component/ equipment.

V. Check terminations and connections. To check wiring related to CT and PT circuits, carryout primary injection and then check for secondary value at relay and metering instrument terminals.

VI. Wire ducting.

VII. Gap sealing and cable bunching

### 3.5.14.9 Relays

I. Check internal wiring.

II. Megger all terminal body.

III. Megger AC to DC terminals

IV. Check operating characteristics by secondary injection.

V. Check minimum pick up voltage of DC coils.

VI. Check operation of electrical targets.

VII. Check CT connections with particular reference to their polarities for differential type relays.

VIII. Relay settings.

### 3.5.14.10 Meters

i. Megger all insulated portion.

Check CT & VT connections with particular reference to their polarities for power type meter.

### 3.5.14.11 Spare Parts and Tools

Spare Parts and Tools mentioned herein are the minimum required. Any other necessary spare parts and tools required for maintenance of the equipment shall be provided by the Contractor at no additional cost.



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**Table 3-9 Spare Parts and Tools**

| Description | Unit | QTY |
|---|---|---|
| **Mandatory spare parts (for each type used)** | | |
| Main contacts for three poles complete with springs, bolts, nuts etc. | Sets | 4 |
| Closing and opening trip coils of each type used | Sets | 4 |
| Drive motor of each type used | Sets | 4 |
| Breaker ON/OFF control switches | Sets | 4 |
| Miniature circuit breakers (MCBs) used in control/interlock circuits of each type/rating | Sets | 5 |
| Single-phase current transformer of each type used | Sets | 3 |
| Single-phase voltage transformer of each type used | Sets | 3 |
| Single-phase lightning arrester of each type used | Sets | 3 |
| Trip units (LSIG) of each type used | Sets | 5 |
| Indicating and measuring instruments each type i.e., voltmeters, ammeters and indication lights etc. | Sets | 2 |
| Anti-condensation heaters of each type and rating. | Sets | 1 |
| **Maintenance Equipment** | | |
| Intelligent Instrument Transformer check device | Sets | 1 |
| Testing equipment for circuit breakers characteristics | Sets | 1 |
| Ratio automatic measuring instrument | Sets | 1 |
| Phase shifter | Sets | 1 |
| SF6 Gas leakage test set, Luma sense Model 3434i complète with all standards accessoires. This item shall be supplied only if the Generator Circuit Breaker (GCB) offered under the Contract is of the SF6 Gas-Insulated type. | Sets | 1 |
| Circuit Breaker test set omicron model CIBANO 500 advanced package VE000901 (complete with all connection cables, registered software's, modules etc.) | Sets | 1 |
| **Tools** | | |
| Circuit breaker handling truck/trolley of each type used | Sets | 1 |
| Feeder grounding trucks/trollies with VTs of each type used | Sets | 2 |



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| Description | Unit | QTY |
|---|---|---|
| Remote controlled racking assembly as per requirement cord and control station of each type used | Sets | 1 |
| Temporary earthing sticks with accessories of each type used | Sets | 2 |
| Special tools for dismantling and maintenance | Lot | 1 |

## 3.6 PROTECTION AND RELAY EQUIPMENT

### 3.6.1 Scope of Work

The scope of work covers the design, manufacture, factory testing, delivery, erection, installation, testing and commissioning of the protection systems, relays and the associated equipment for the Generators, Main Step-up Transformers and Auxiliary Transformers complete in all respects.

The scope of work shall comprise:

- Three (03) sets of complete Generator Protection System
- Three (03) sets of complete Main Step-Up Transformers Protection Systems
- Three (03) sets of complete protection systems for the Auxiliary Transformers
- One (01) set of tools and appliances
- One (01) set of spare parts

All equipment, wiring, panels, software, licenses, interconnections, settings, testing, documentation and training necessary for safe, reliable and continuous operation shall be deemed included in the scope of supply, whether explicitly mentioned or not.

### 3.6.2 Service Conditions

See Section “General Electrical Requirements”.

### 3.6.3 Standards

All equipment under these Technical Specifications shall be manufactured and tested in accordance with the latest revision of the following international standards.

In case there is contradiction between the contents of relevant clauses of any two standards, Contractor will proceed with the most applicable one with prior approval of the Employer

**Table 3-10 Standard and Codes**

| Subject | Standard |
|---|---|
| Measuring relays and protection equipment, multiple parts | IEC 60255 |
| Measuring relays and protection equipment - Part 22-1: Electrical disturbance tests | IEC 60255-22.1 |
| Measuring relays and protection equipment - Part 151: Functional requirements for over/under current protection | IEC 60255-151 |
| Programmable controllers | IEC 61131 |



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| Subject | Standard |
|---|---|
| Degrees of protection provided by enclosures (IP Code) | IEC 60529 |
| Electrical measuring transducers for converting A.C. electrical quantities to analogue or digital signals | IEC 60688 |
| Electromagnetic compatibility (EMC) - Part 4 | IEC 61000-4 |
| Communication standard for electrical substation automation system | IEC 61850 |
| Cyber security support | IEC 62351 |
| Parallel redundancy protocol (PRP) | IEC 62439 |
| IEEE guide for generator protection | C37.102 |

### 3.6.4 Protection Schemes

The general principle for the protection of Generators, Main Step-up Transformers and Auxiliary Transformers shall be that these are covered by two high speed protection schemes which shall be independent to avoid common-mode failures.

The protection equipment shall be complete with all relay panels, instruments, meters, interposing and auxiliary relays, control switches, interposing current and voltage transformers, transducers and all auxiliary equipment. The protection scheme shall be provided with Cyber security support for compliance to IEC 62351 with Centralized Account Management. Separate cores of current transformer (CT) and voltage transformer (VT) shall be used for each protection and metering. Minimum of one (01) core shall be provided as spare for each CT and VT. Whereas, separate CTs and VTs shall be used for primary and backup protection.

Protection equipment shall be designed and supplied to provide maximum discrimination between faulty and healthy circuits. All equipment is to remain inoperative during transient phenomena which may arise during switching or other disturbances to the system.

Signals and data provided by the protection relays shall be monitored by the control system.

The Contractor shall prepare and submit Control, Indication, Alarm and Trip function logic tables, protection philosophy diagrams and interlocking logic for the approval of the Employer before proceeding with the preparation of schematic diagrams.

The Contractor shall be overall responsible for proper functioning of the protection schemes and submit complete relay setting calculations, coordination studies and fault level assumptions for the Employer review and approval.

Relay shall be in accordance with IEC 60255 and shall be suitable for use with 1 A secondary current transformer and 110/63.5 V secondary voltage transformers. Annunciator relays shall be provided for the indication of operational states, alarm and danger or ground fault situations.

All static/microprocessor-based relays shall satisfy the type test withstand requirements of IEC 60255-22-1/2/3 and 4, and IEC 61000-4-4 including:

All relay cubicles shall be of degree of minimum protection IP32 to IEC 60529.

Separate relay protection cubicles comprising modern electronic relays shall be installed. Relays for primary and backup protection shall be physically and electrically segregated. The relays shall preferably be of the same make (manufacture) to build a uniform modular system.



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The functioning of the protection relays shall not depend on the control system. The relays for Generator, Main Step-up Transformers and Auxiliary Transformers will be organized in two groups so that one group provides back-up protection for the other group. Protection scheme shall be duplicate protection independent all from instruments up to protection devices.

Auxiliary power shall be taken from the 220 V D.C. system. Separate circuits shall serve the two groups of relays to obtain maximum reliability. The relays shall be capable of operation properly with voltage variations of -20% to +10%.

**Generator Protection**

The minimum generator protection shall consist of:

| | |
|---|---|
| 24G | Generator over flux protection |
| 32 | Generator reverse power protection |
| 49S | Stator winding overload protection |
| 50/27 | Inadvertent energization |
| 50BF/62 | GCB failure protection |
| 64R | Rotor earth-fault protection |
| 64S | 100 % Stator earth-fault protection |
| 81G | Under/over-frequency |
| 87G | Generator differential protection |
| 87GT | Overall differential protection |
| 27G | Under voltage protection for synchronous condenser mode |
| 40G | Loss of excitation |
| 46G | Neg phase sequence |
| 49R | Field winding overload |
| 50/51G | Symmetric overload stator protection |
| 59 | Generator overvoltage protection |
| 59NS | 95% stator earth-fault protection |
| 60VT | Voltage balance relay, VT circuit failure monitoring |
| 81 | Under frequency protection for synchronous condenser mode |
| 51GN | Shaft current protection |

**Generator Step-Up Transformer (GSU) Protection**

The minimum protection includes:

| | |
|---|---|
| 24MT | Over flux protection |
| 50/51MT | IDMT overcurrent |
| 51MT-N | Neutral earth fault |
| 87MT | Differential protection |
| 87N-MT | Restricted earth-fault protection |
| 95MT | Gas Relay |
| 49T | Oil/Winding temperature |



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| | |
|---|---|
| 50BF | GSU breaker failure protection |

Auxiliary transformers minimum protection includes:

- Overcurrent
- Thermal
- Earth fault

### 3.6.5 Testing and Commissioning

#### 3.6.5.1 General

The Works tests and the Site tests given hereunder shall be carried out by the Contractor.

#### 3.6.5.2 Test Equipment

The Contractor shall provide all test equipment and test sets required for carrying out the inspections and tests.

A training simulator based on software configuration to include all protection equipment installed on generator/turbine, transformers for ease of understanding will be handed over to Employer along with other latest digital equipment recommended by Supplier. Fault diagnostic features shall be incorporated to train maintenance and operation Employers to operate and maintain this system in most appropriate manner.

#### 3.6.5.3 Type Tests

Type tests shall be carried out on each item of the equipment to be supplied. However, duly certified and complete test reports for tests carried out by an independent, accredited authority on similar equipment may be acceptable in lieu of actual tests, subject to the satisfaction of the Employer.

All microprocessor-based relays shall satisfy the type test withstand requirements of IEC 60255, and IEC 60801 including:

- 5 kV peak 1.2/50 microsecond impulse test,
- Electrical disturbance test - 1 MHz bursts,
- Radiated electromagnetic field disturbance test level 3, 10 V/m field strength,
- Electrostatic discharge test class III, 8 kV,
- Electrical fast transient test, level 4, 4 kV.

#### 3.6.5.4 Factory Tests

All relay and associated equipment shall be type and routine tested in accordance with IEC 60255 and the tests proposed by the Contractor and approved by the Employer using special test sets and/or built-in test facilities.

Equipment containing semi-conductors shall be subjected to high frequency disturbance and transient overvoltage tests.

Control panels shall be tested for correct operation by simulating the external connections and equipment.

All cubicle wiring shall be flash tested.



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### 3.6.5.5 Site Tests

The following tests shall be carried out:

- Current transformer magnetisation curves and polarity,
- Secondary injection tests on relays,
- Primary injection tests on relays and protection schemes,
- Wiring checks, insulation resistance at 1000 V ac,
- Loop resistance of current transformer circuits,
- Special tests on busbar protection and breaker failure protection schemes,
- Operational and alarm system checks, and
- On-load tests with simulated in and out of zone faults.

### 3.6.5.6 Spare Parts, Maintenance Equipment and Tools

Spare Parts, Maintenance Equipment and Tools mentioned herein are the minimum required. Any other necessary spare parts, maintenance equipment and tools required for maintenance of the equipment shall be provided by the Contractor.

**Table 3-11 Spare Parts and Tools**

| Sr. No. | Description | Unit | Qty |
|---|---|---|---|
| | **Mandatory Spare Parts** | | |
| 1 | Primary Protection Relay (each type) | Sets | 1 |
| 2 | Backup Protection Relay (each type) | Sets | 1 |
| 3 | Breaker failure protection relay | Nos. | 1 |
| 4 | Differential protection relay | Nos. | 1 |
| 5 | Auxiliary relay (each type) | Sets | 4 |
| 6 | MCBs of each type | Sets | 2 |
| 7 | Electronic cards related to the measuring, processing and trip circuits of protection devices, comprising one (1) piece of each type | Lot | 1 |
| 8 | Electronic cards, trip relays, and other circuit components other than for protection devices, comprising one (1) piece of each type | Lot | 1 |
| 9 | DC/DC converters, power supply filters and other power supply units, comprising one (1) piece of each type | Lot | 1 |
| 10 | One lot of all switches, panel lamps, plugs and other accessories subject to wear and tear during five years of operation | Lot | 1 |
| | **Maintenance Equipment** | | |
| 1 | Relay Test Set OMICRON Model CMC356 (complete with all connection cables, registered software, modules etc.) | Sets | 1 |
| 2 | Current Transformer Test Set Megger Model 1605 (complete with all connection cables, registered software, modules etc.) | Sets | 1 |
| 3 | Secondary Injection test set to cover the range of equipment | Sets | 1 |



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| Sr. No. | Description | Unit | Qty |
|---|---|---|---|
| 4 | Plugs for Relay testing complete with connection cable to the test unit. | Set | 1 |
| 5 | Primary Injection Test Set Megger Model ODEN AT/2X (complete with all connection cables, registered software, modules etc.) | Sets | 1 |
| **Tools** | | | |
| 1 | Any tools, plugs or devices needed for occasional blocking of relay functions during commissioning or special operation conditions. | Set | 1 |
| 2 | Parameter cables (each type) | Sets | 4 |
| 3 | Application software (licensed) each for Main and backup protection relay | Sets | 1 |
| 4 | laptop with serial interface, suitable for engineering and maintenance work with all components of the protection systems | Sets | 1 |

### 3.7 DC AND UPS SYSTEM

#### 3.7.1 Scope of Work

The scope of work covers the technical requirements for the design, manufacture, supply, erection, testing and commissioning of complete, fully functional 220 V DC and UPS System for Powerhouse and Intake separately.

- One (01) set of 220 V DC and UPS system for powerhouse
- One (01) set of 220 V DC and UPS system for Intake

All equipment, accessories, interconnections, cabling, software, licenses, testing, documentation and training necessary for safe and reliable operation shall be deemed included in the scope of supply, whether explicitly mentioned or not.

#### 3.7.2 Service Conditions

See Section “General Electrical Requirements”.

#### 3.7.3 Standards and Codes

All equipment under these Technical Specifications shall be manufactured and tested in accordance with the latest revision of the following international standards.

In case there is contradiction between the contents of relevant clauses of any two standards, Contractor will proceed with the most applicable one with prior approval of the Employer.

**Table 3-12 Standard and Codes**

| Subject | Standard |
|---|---|
| International electrotechnical vocabulary. Chapter 486: Secondary cells and batteries. | IEC 60050 |
| Semiconductor converters - General requirements and line commutated converters (Parts 1 to 6) | IEC 60146 |
| Low-voltage fuses | IEC 60269 |
| Nickel-cadmium batteries. Technical specification | BS EN 2570 |



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| Subject | Standard |
|---|---|
| Secondary cells and batteries containing alkaline or other non-acid electrolytes – Vented nickel-cadmium prismatic rechargeable single cells | IEC 60623 |
| Low-voltage switchgear and control gear - Part 2: Circuit-breakers | IEC 60947 |
| Electromagnetic compatibility (EMC) - Part 4, consisting of 4 Parts | IEC 61000-4 |
| Low-voltage power supply devices, dc output - Performance characteristics | IEC 61204 |
| IEEE Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits | IEEE C62.41 |

### 3.7.4 Mode of Operation

The 220 V DC System for the Powerhouse and Intake separately comprises on each, 220VDC distribution boards, two (2) set of batteries and two (02) battery chargers. Battery shall be fed from battery charger (rectifier) at a time. Each battery charger will be supplied from 400V bus of powerhouse.

In normal operation, the chargers shall operate in parallel and each charger shall be able to float charge its own battery as well as supply the total load.

In the event of a mains failure, both batteries shall be able, when fully charged, to supply the total load, for not less than the specified standby time whilst maintaining the output voltage within permissible limits.

The 230 V AC UPS system for the Powerhouse and Intake separately comprises on inverter subsystem with static and manual bypass switch and one (1) 230 V AC distribution board. Normally UPS will take power from 400 V bus. In case of power supply failure from 400 V bus, the supply will be from 220 V DC distribution board without any interruption to the load.

### 3.7.5 Functional Specifications

Lead acid batteries shall be provided sized for 10-hour discharge rate. The end cell voltage shall be 1.80V. The end of service life shall be the time when the battery no longer delivers 80% of its rated capacity. The batteries shall be installed on racks that all the cells are available for inspection, test and maintenance purposes and shall be braced to stop movement under seismic shocks.

The battery chargers shall be of the thyristor controlled, automatic, constant voltage type with current-limiting facilities, employing dry type, full wave, silicon-controlled rectifiers and plug-in modules, permanently connected across 220V batteries. The inverter shall be of the pulse width modulation (PWM) type, providing a single-phase output.

DC switchboard shall be of type metal enclosed; dead front assemblies of fused disconnect switches / circuit breakers and control devices. DC Switchboards shall be assembled from steel sections and fabricated and bolted sheet units, of modular design. The distribution board associated with each 220 V power supply system shall be adequately sized and identified with 30% spare ways for future expansion. At least one of the spare ways shall be equal to the largest installed size. The distribution board shall be supplied with double pole miniature or molded case circuit-breakers to IEC 60947-2 with thermally operated overload trips and instantaneous magnetic trips for short circuit protection for each incoming and outgoing circuit. All MCBs shall be provided with auxiliary contacts which shall raise both local and remote



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alarms (via the PCS), for loss of supplies.

Over / under voltage protection of DC distribution board and earth fault protection of each outgoing DC feeder shall be provided.

220VDC supplies shall be arranged for DC motors, control equipment, relay protections, alarms and annunciation circuits. 230 VAC UPS supplies will be arranged as required for such control equipment that cannot operate on DC supply and for powerhouse and Intake emergency lighting system.

The Control Room equipment to be fed by the UPS system will include all computers and related equipment, telecommunication equipment, and service systems. Sufficient emergency power will be provided for startup of the standby generator and for operation of any essential controls. Alarm and Annunciation System will remain operational always. UPS shall be dimensioned for the full load with a spare capacity of at least 20%.

The design and selection of equipment and components shall be based on achieving a minimum lifetime of 20 years, when operating under the specified service and ambient conditions. Suitable de-rating of power components shall be applied where necessary.

Electronic cards shall be suitably protected for the specified environment and shall be additionally protected against dust ingress. The immunity and emission to EMC shall be in accordance to IEC standard 61000-4.

The performance of the UPS unit shall not be affected, or in any way degraded, using portable radio transmitters/receivers operating in the frequency range 27-170 MHz, at 460 MHz and at 800 MHz when the severity of the electromagnetic radiation environment corresponds to Class 2, in accordance with IEC 61000-4-3.

### 3.7.6 Batteries

The batteries shall be of VRLA lead acid type in accordance with the latest applicable standard of IEC. Batteries shall have design life of 20 years at 25°C ambient temperature and shall be protected from damage due to thermal run-away occurred during abusive charging. Batteries shall have guaranteed operation for 10 years under rated operating conditions.

**Table 3-13 Battery Technical Parameters**

| Item | Unit | Power House | Intake |
|---|---|---|---|
| **Station Batteries** | Set | **Two (2)** | **Two (2)** |
| Nominal Battery Voltage (Bank) | V | 220 | 220 |
| Number of cells | | 110 | 110 |
| Type of cell | | Lead Acid | Lead Acid |
| Nominal voltage (per cell) | V | 2.0 | 2.0 |
| Float voltage (per cell) | V | - | - |
| Boost Voltage (per cell) | V | 2.24-2.28 | 2.24-2.28 |
| End voltage used for capacity calculation (per cell) | V | 1.80 | 1.80 |



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| Item | Unit | Power House | Intake |
|---|---|---|---|
| Capacity of each battery | Ah | 500 | 300 |

The number of cells and type of battery shall be selected so that the voltage of the battery does not exceed 110% of the rated voltage during float charging.

Miniature Circuit Breakers (MCBs) or bolted cartridge fuses shall be provided in both positive and negative leads and positioned as close to the battery as possible and shall be rated at five times the charger float output rated current. These MCBs or fuses shall be mounted preferably on the end of the battery panel. The fuse links shall comply IEC 60269 or some equivalent standards and shall be mounted in fuse carriers with an insulated barrier between the poles. The MCBs shall be in accordance with appropriate standard. A fuse blown or MCB tripped alarm shall be provided to the plant alarm system.

### 3.7.7 Battery Chargers

Battery chargers of thyristor controlled, automatic, constant voltage type with current-limiting facilities, employing dry type, full wave, silicon-controlled rectifiers and plug-in modules shall be provided. Chargers shall be fully automatic, constant voltage thyristor-based systems, designed for high efficiency conversion of incoming commercial AC to DC power for charging batteries, while supplying power to continuous DC loads.

The chargers shall be completely equipped for a fully automatically controlled charging including both float and equalizing charging of the batteries. Chargers shall be of a constant voltage type with current limiting device. The charger shall maintain the batteries in a fully charged condition at the float charge setting. Normal charging time shall be of maximum eight (08) hours. A boost charge facility shall also be provided, capable of restoring a discharged battery to the fully charged condition in maximum two and half (2.5) hours without damage to the battery.

The charger efficiency shall not be less than 90%. The charger shall be rated to supply the load (comprising the delivered load together with 20% spare for future use). Chargers shall be naturally cooled.

Battery charger apparatus shall be provided with following alarm devices.

- Overvoltage (when system DC voltage rises more than 5 V above its normal automatic float voltage.
- Undervoltage (when system DC voltage falls below 85% of nominal. A time delay shall be incorporated to prevent initiation during temporary voltage drops.)
- Charger failure
- Diode/Thyristor & surge circuit protection/fuse failure detection
- Earth fault
- AC phase failure

All alarms shall be provided with potential free contacts for the DCS system.

### 3.7.8 UPS System

Major components of UPS are inverter, static bypass switch and manual bypass switch. Voltage failure shall be sensed on the output of the static switch. An automatic transfer to the



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alternate source shall occur when the output voltage of the primary source deviates by more than ±10% from nominal. Voltage of the alternate source shall be monitored. Transfer shall be permitted only if voltage of the alternate source is within ± 10% of the nominal. Static switch transfer time shall be less than ¼ cycles (5 ms). Contacts shall be provided to alarm deviation of the alternate source voltage beyond these limits. Return to normal shall be automatic for all externally caused transfers such as overload but shall be manual for internally caused transfers such as primary source failure. Automatic transfer shall occur after a preset time delay during which alternate source voltage shall remain ± 10% of the nominal voltage. Manual retransfer shall be initiated by pushbutton. Before retransfer occurs, synchronism of the output of the inverter with the alternate power source shall have been automatically accomplished.

The inverter shall consist of a solid state, static, one-phase, full wave inverter with output filter and electronic output voltage controller. The inverter shall utilize pulse width modulation technology, IGBT semiconductors, digital control, and have a digital communications interface with the plant control system. The inverters shall have equipment necessary to protect the equipment from overload, short circuits and 100% loss of load. Current limiter features shall be provided.

A two-position, manual bypass switch of electro-mechanical type shall also be mounted in the inverter cabinet. The manual by-pass switch shall select between the static switch output or the utility input, allowing servicing of the static switch without complete loss of power to the load.

### 3.7.9 Panels

Panels shall be assembled from steel sections and fabricated and bolted sheet units, of modular design with minimum ingress protection class of IP 41.

The panel shall be of modular, robust and sturdy design constructed in conformity to the relevant part of IEC 60439. The panel shall be of sheet steel floor mounting type steel sheet thickness shall be not less than 2.5mm. However, in case of type tested rigid frame design, the thickness of steel sheet may be reduced but not below 2mm according to manufacturer's standard design. The panel shall be adequately ventilated and shall be completely vermin proof. Copper grounding bus for cubicle earthing shall also be provided. Doors shall be connected to the enclosure by means of separate flexible grounding straps. Provision of pockets inside the charger front door cabinet for keeping drawings during maintenance shall be provided.

The busbars shall be insulated copper with silver plating at all bolted joints.

Each main panel shall include an intelligent controller collecting information on DC voltage, DC current in each branch, and making the information available to the control system. The incoming circuit from the batteries to each board shall be provided with an ammeter with a center zero scale of suitable range and voltmeters for DC buses. Instruments shall be digital. Circuit breaker trip alarms shall also be collected by the intelligent controller for collection by the control system.

### 3.7.10 Tests

#### 3.7.10.1 General

The chargers and inverters shall be tested at the factory in accordance with relevant IEC publications or IEEE standards. The Employer is entitled to witness all the tests.

The Contractor shall provide all special test apparatus and test sets required for carrying out



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the inspections and tests.

The boards shall be assembled at the manufacturer workshop with all apparatus, instruments and meters connected and various components shall be tested in accordance with requirement of latest relevant international standards. Tests shall be witnessed by the Employer.

### 3.7.10.2 Routine Tests

Routine tests and electrical type tests shall be carried out in accordance with applicable Standards.

Type tests shall be made on one unit of each type of different equipment. Instead of carrying out type tests, the Contractor may submit certificates of tests made on equipment of the same type. However, the Employer reserves the rights to accept these certificates or to reject them partially or totally. For the rejected part, the Contractor shall conduct the test again and submit the same to Employer for his approval.

Test Certificates shall be from KEMA (Netherland), CESI (Italy), CRIEPI Lab (Japan), KERI Lab. (S. Korea) or any other laboratory approved by the Employer.

### 3.7.10.3 Batteries, Chargers, Inverters and Distribution Switchboards

The battery materials shall be subject to appropriate tests and sample tests shall be carried out on cells according to IEC or international Standards.

The charger components shall be tested in accordance with relevant IEC or other international Standards. Following type tests shall be performed on chargers.

- DC voltage-current characteristics
- Automatic voltage regulation operation
- Conversion efficiency
- Temperature rise
- High voltage test
- Alternating current measurement
- Reverse leakage

The following routine test shall be carried out on chargers

- DC voltage-current characteristics
- High voltage test
- Visual inspection
- Operation of auxiliary devices
- Alternating current measurement
- Reverse leakage

Complete chargers, inverters and distribution boards shall be subjected to temperature rise, high voltage insulation resistance and operational tests. The ripple at the output shall be measured with no battery connected and temperature rise and other effects under permanent short-circuit at the output terminals shall be measured. Temperature rises as part of already completed Type Test is also acceptable.

Chargers and inverters shall also be subjected to radio interference tests.

Following routine test shall be carried out on DC switchboard:



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- Mechanical operation test
- High voltage test
- Visual inspection
- Resistance measurement test
- Functional test
- Wiring checks

Other tests recommended by the manufacturer

#### 3.7.10.4 Site Tests

#### 3.7.10.5 Batteries and Chargers

The insulation to earth of the complete dc installations shall be tested.

Tests shall be carried out on the batteries and chargers to confirm the charger ratings and adjustment and the operation of the battery and charger control and alarm systems. Initial charge, controlled discharge and recharge tests shall be carried out to demonstrate the rated capacity of each battery.

Ripple measurement of charger output with battery connected shall be performed.

The specific gravity and cell voltages of the batteries when fully charged shall be recorded.

##### 3.7.10.5.1 Inverters/ Static and Bypass Switches

Following tests shall be carried out:

- Visual inspection,
- Functional tests, and
- Insulation test.

##### 3.7.10.5.2 Distribution switchboards

Following tests shall be performed:

- Visual inspection,
- Functional tests,
- Dielectric tests, and
- Setting and functional tests of sequence and protective devices.

### 3.7.11 Spare Parts, Maintenance Equipment and Tools

Spare Parts, Maintenance Equipment and Tools mentioned herein are the minimum required. Any other necessary spare parts, maintenance equipment and tools required for maintenance of the equipment shall be provided by the Contractor.

**Table 3-14 Spare Parts and Tools**

| Sr. No. | Description | Unit | Qty |
|---|---|---|---|
| **220V DC Powerhouse & Intake Battery** | | | |
| 1 | Battery Cells | Nos. | 20 |



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| Sr. No. | Description | Unit | Qty |
|---|---|---|---|
| 2 | Fuses | Nos. | 24 |
| 3 | Spare Lead Connectors | Nos. | 20 |
| **Chargers for Powerhouse and Intake Battery** | | | |
| 1 | Battery charger | Nos. | 2 |
| 2 | Ammeters of each type | Sets | 2 |
| 3 | Voltmeters of each type | Sets | 2 |
| 4 | Protection relay of each type | Sets | 2 |
| 5 | Fuses of each type | Sets | 10 |
| 6 | Circuit Breakers of each type | Sets | 5 |
| **220V DC Powerhouse and Intake Distribution Board** | | | |
| 1 | DC Circuit Breakers of each type | Sets | 2 |
| 2 | Ammeter of Each type | Sets | 2 |
| 3 | Voltmeter of Each Type | Sets | 1 |
| **Complete DC System** | | | |
| 1 | Core of Fusible Cutout of each type used | Sets | 4 |
| 2 | Fuse Handle | Sets | 2 |
| 3 | Indicator Lights of each type used | Sets | 4 |
| 5 | Inverter Driving plate | Sets | 2 |
| 6 | Inverter Control plate | Sets | 2 |
| 7 | Rectifier Control plate | Sets | 2 |
| 8 | Current transformers | Sets | 4 |
| 9 | UPS Power Module | Nos. | 2 |
| 10 | UPD Control Module | Nos. | 2 |
| 11 | Components of each type such as PCB printed modules, thyristors, control/supply transformers, breakers, switches, fuses, indicating and measuring instruments etc. for battery chargers & invertors | Sets | 2 |
| 12 | Static transfer switch complete | Sets | 1 |
| **Maintenance Equipment** | | | |
| 1 | Testing Equipment necessary to test the DC system, Batteries and UPS | | |
| **Tools** | | | |
| 1 | Tools, appliances and testing equipment for the proper operation, maintenance, etc., of the installations | Lot | 2 |
| 2 | Thermometer | No. | 4 |
| 3 | Rubber Apron | Pairs | 4 |

### 3.8 11/0.4 KV STATION AUXILIARY TRANSFORMER(S)

#### 3.8.1 General



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This section specifies the technical requirements for the design, manufacture, delivery, erection, testing and commissioning of 11 /0.4 kV auxiliary transformers complete with all their accessories and necessary interconnections for safe and reliable operation.

All equipment under the technical specifications shall be manufactured and tested in accordance with the latest revision of the relevant IEC standards.

### 3.8.2 Scope of Work

The scope of work covers design, delivery to site, storage, erection, testing, commissioning and proper functioning of the equipment, including all auxiliary systems, protections and reliability tests necessary to meet the Contract requirements..

The powerhouse shall be equipped with four (04) no. 11kV/400V, 630 kVA, dry type station auxiliary transformers including one spare transformer, connecting HV side to 11 kV busbar and LV side to 400V switchgear and associated enclosure complete with accessories.

The power distribution system at intake shall be equipped with two (02) no. 11kV/400V, oil type 400 kVA auxiliary transformers including one spare transformer.

Station Auxiliary Transformers for powerhouse shall be of dry type three-phase units mounted in enclosures with suitable damp proof heating arrangement, integral with their associated 400 V switchboard.

Auxiliary Transformers for Intake shall be of pad mounted oil immersed type. The transformers shall be complete with all accessories and attachments as detailed in these specifications or otherwise required for satisfactory operation, service and maintenance under all specified operating conditions.

### 3.8.3 Operating Conditions

Dry type transformers located in the powerhouse will be in locations covered by the heating, ventilating and air conditioning (HVAC) system with ambient air temperature shall normally not exceeding 40°C.

The oil-immersed distribution transformers located outdoors shall be suitable for the following environmental conditions:

- Maximum Temperature 50°C
- Minimum Temperature - 20°C

### 3.8.4 Standards

The work performed shall be in conformance with all applicable codes and standards including, but not limited to, the latest revision of those listed below.

If there is an apparent discrepancy between any of the requirements of this Specification and those stipulated below, then the most stringent requirements shall apply.

**Table 3-15 Standards**

| Title | Standard |
|---|---|
| Power transformers | IEC 60076 |
| Thermal evaluation and classification of electrical insulation | IEC 60085 |



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| | |
|---|---|
| Degree of protection provided for enclosures | IEC 60529 |
| Determination of transformer and reactor sound levels | IEC 60076-10 |
| Sound level meters | IEC 61672-1/2 |
| Dry-type power transformers | IEC 60076-11 |
| Measuring Relays & Protection Equipment | IEC 60255 |
| Insulation Coordination | IEC 60071 |

### 3.8.5 Key Technical Parameters

#### 3.8.5.1 Dry Type Transformers for Powerhouse

Three-phase, dry type station auxiliary transformer shall meet the following requirements as a minimum:

**Table 3-16 Technical Parameters**

| Item | Unit | Value |
|---|---|---|
| Nominal Capacity | kVA | 630 |
| Rated Voltage | kV | 11 / 0.4 |
| Maximum System Voltage | kV | 12 |
| Rated Frequency | Hz | 50 |
| Vector Group | - | Dyn11 |
| Voltage Impedance | % | 6% |
| Tap Changer | - | Off-load |
| Voltage Regulation | % | ± 5 x 2.5% |
| Cooling Type | - | AN |
| Neutral point earthing mode | - | Direct Earthing |
| Lightning impulse (1.2/50 µs) withstand voltage<br>Primary HV winding<br>Secondary LV winding | kV | <br>75 kV<br>N/A |
| Power frequency withstand voltage (1 min):<br>Primary HV winding<br>Secondary LV winding, Phase | kV rms | <br>38 kV<br>3 kV |
| Noise Level | - | NEMA TR-1 |
| Temperature rises at 40ºC ambient temperature Winding | K | 85 K |

#### 3.8.5.2 Oil Type Transformers

Three-phase, oil type station auxiliary transformer for Intake supplies shall meet the following requirements as a minimum:



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**Table 3-17 Technical Parameters**

| Item | Unit | Values |
|---|---|---|
| Nominal Capacity per 3-phase unit | kVA | 400 |
| Rated Voltage | kV | 11 / 0.4 |
| Maximum System Voltage | kV | 12 |
| Rated Frequency | Hz | 50 |
| Vector Group | - | Dyn11 |
| Voltage Impedance | % | 6% |
| Tap Changer | - | Off-load |
| Voltage Regulation | % | ± 2 x 2.5% |
| Cooling Type | - | ONAN |
| Neutral point earthing mode | - | Direct Earthing |
| Lightning impulse (1.2/50 µs) withstand voltage<br>Primary HV winding<br>Secondary LV winding | kV | <br>75 kV<br>N/A |
| Power frequency withstand voltage (1 min):<br>Primary HV winding<br>Secondary LV winding, Phase | kV rms | <br>28 kV<br>3 kV |
| Noise Level | - | NEMA TR-1 |
| Temperature rises at 40ºC ambient temperature<br>Winding<br>Oil | K | <br>65 K<br>65 K |
| Insulating Liquid Mineral Oil | - | IEC 60296 |

Mineral oil shall be new, unused and uninhibited.

### 3.8.6 Functional Specifications

#### 3.8.6.1 Dry Type Station Auxiliary Transformer(s)

The dry type, three-phase units shall be mounted in enclosures, and protected by a 15 kV disconnect switch with current limiting fuses.

Dry type transformers may be of the cast resin type or open winding type, suitably braced to withstand short-circuit forces. The thermal classification to IEC 60085 shall be 200. Insulation material shall be of Class F (IEC 60076-2).

The core shall be constructed from high-grade, cold rolled, non-ageing, low loss and high permeability grain-oriented silicon steel laminations. The material shall conform to the latest edition of relevant IEC standard.

Special care shall be exercised in the selection, treatment and handling of core material (steel) to ensure that the laminations are as flat as possible and finally assembled core should be free from distortion. The core laminations shall be annealed after removing all sharp projections and each lamination shall be coated with durable baked enamel / glass insulation. The complete core shall be coated with special resin as a protection against corrosionand moisture ingress.

All parts of the cores shall be of robust design capable of withstanding any shocks to which



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they may be subjected during handling, transportation, installation and service.

Adequate provision shall be made to prevent movement of the core and winding relative to the frame during transportation, installation and in service.

The windings shall be of high-conductivity electrolytic copper and transposed winding conductors shall be employed where appropriate.

The windings shall be designed to reduce to a minimum out-of-balance electro-magnetic forces in the transformer at all voltage ratios.

Windings shall be adequately braced to prevent distortion due to any abnormal operating condition.

The terminals shall be designed to carry the fault current without damage, for a duration at least equal to the short-circuit period for which the main windings are designed, in accordance with IEC 60076.

Thermal control of coils shall be provided via two separate signal systems for alarm and tripping. RTD (PT-100) sensors shall be provided in the low voltage windings inside the cast coils for measurement of temperature. The temperature protection equipment shall be suitable for use with 220 V DC voltage.

### 3.8.6.2 Oil Immersed Auxiliary Transformers for Outdoor Installation

Oil immersed transformers shall be provided with high conductive electrolytic copper windings. Insulation material shall be according to latest IEC Standard 60076-2.

The insulation of windings and connections shall be free from insulation compositions likely to soften, shrink or to collapse during service. None of the materials used shall shrink, disintegrate, carbonize or become brittle under the action of hot oil at any load condition.

Oil filled transformers shall have galvanized steel radiators forming an integral part of the tank.

The tank and radiators shall have sufficient cooling surface area to allow continuous operation of the transformers at their self-cooled rating.

Transformers shall be with ONAN type cooling.

Transformers shall be provided with two earthing terminals of adequate size capable of carrying the maximum possible earth fault current.

The terminals shall be designed to carry the fault current without damage, for a duration at least equal to the short-circuit period for which the main windings are designed, in accordance with IEC 60076.

Each transformer shall be provided with winding temperature indication and protection. Dial type thermometer for measuring the oil temperature with two normally open contacts for temperature alarm and tripping shall be provided. Also, dial type float operated, magnetic type oil level gauge with one low level normally open contact shall be furnished.

### 3.8.6.3 Flux Density

The flux density shall not exceed 1.65 Tesla when operating at the rated voltage and frequency on any tap position.

### 3.8.6.4 Enclosures

The enclosure shall consist of a rigidly constructed steel framework which shall be completely clad in sheet steel and if necessary, with the provision of screened openings to provide natural cooling. The degree of enclosure protection shall be IP23 to IEC 60529. At 400 V, the apparatus shall be suitable for continuous operation on a three-phase, 50 Hz system. The three-phase fault level at 400 V shall be determined by the Supplier based on the final design.

Internal access shall be by means of hinged doors at the front of the enclosure and the arrangement shall ensure that the transformer can be withdrawn easily on wheels via a track.

Temperature detectors including temperature transmitters and temperature gauges shall be provided for monitoring and signaling the winding temperatures to the respective LCU.

Each enclosure shall be provided with anti-condensation heaters.

Each enclosure shall be provided with a door operated interior light. An earthing terminal shall be provided for each enclosure.

### 3.8.7 Testing and Commissioning

#### 3.8.7.1 Test Equipment

The Contractor shall provide all special test apparatus and test sets required for carrying out the inspections and tests.

#### 3.8.7.2 Factory and Type Tests

Routine tests and electrical type tests shall be carried out in accordance with IEC 60076, IEC 60255 and other IEC Standards as applicable.

Type tests shall be made on one unit of each type of different equipment at the Contractor's expense in presence of the Employer and the actual type test report shall be submitted to the Employer for approval. Instead of carrying out the type tests, the Contractor may submit duly certified and complete type test reports for tests carried out by an independent, accredited authority on similar equipment of the same type. However, the Employer reserves the right of accepting these certificates or to reject them partially or totally.

#### 3.8.7.3 Routine Tests

- Power frequency test on Primary and Secondary windings.
- Transformer turns ratio test.
- Insulation resistance test.
- Winding resistance test.
- Short circuit (load loss test).
- Induced overvoltage withstand test.

#### 3.8.7.4 Type Tests

- Temperature-rise test to IEC 60076 on transformer where type test certificates from approved institutions in respect of identical designs cannot be substituted.
- Impulse tests to IEC 60076 on transformer where type test certificates in respect of identical design cannot be substituted, and
- Noise level tests on transformer.

#### 3.8.7.5 Site Tests

Following tests shall be performed on transformers at site:



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- Visual inspection,
- Insulation resistance,
- Winding resistance and continuity on all taps,
- Polarity,
- Dielectric test of oil, and
- Functional test of all control and protection apparatus.
- Transformer turns ratio test.
- Load tests.

### 3.8.8 Mandatory Spare Parts, Maintenance Equipment and Tools

Spare Parts, Maintenance Equipment and Tools mentioned herein are the minimum required. Other necessary spare parts, maintenance equipment and tools required for maintenance of the equipment shall be provided by the Contractor.

**Table 3-18 Spare Parts**

| Sr. No. | Item | Unit | Value |
|---|---|---|---|
| 1 | Bushing of each type used complete with gaskets and accessories | No. | 1 |
| 2 | Three-phase sets of clamps | Nos. | 2 |
| 3 | Tapping switch assembly each type | Sets | 1 |
| 4 | Bushing current transformers for each type and rating supplied for HV, LV and neutral winding of transformer | Sets | 2 |
| 5 | Contacts, coils, springs, etc., required for each type of relay, contactor, breaker, auxiliary switch and other control element furnished with the transformers. | Sets | 2 |
| 6 | Consumable items for 2 years of operation | Lot | 1 |
| 7 | Thermal image temperature detectors and temperature relays, complete with accessories | Lot | 1 |
| 8 | Conventional temperature detectors or relays of each type used, complete with accessories. | Lot | 1 |
| 9 | Contact type thermometers of each type | Lot | 1 |
| **Maintenance Equipment & Tools** | | | |
| 1 | Slings | Lot | 1 |

## 3.9 LOW VOLTAGE SWITCHGEAR

### 3.9.1 Scope of Work

The scope of work covers design, manufacture, delivery, erection, testing and commissioning of low voltage switchgear and all necessary ancillary equipment complete with their accessories for Powerhouse and Intake including all interconnections, cabling within panels, and interface with control and protection systems.

### 3.9.2 Standards

The work performed shall be in conformance with all applicable codes and standards including, but not limited to, the latest revision of those listed below.

If there is an apparent discrepancy between any of the requirements of this Specification and those stipulated below, then the most stringent requirements shall apply.



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**Table 3-19 Standards**

| Title | Standard |
|---|---|
| Current transformers | IEC 61869-2 |
| Potential transformers | IEC 61869-3 |
| High voltage switchgear and control gear | IEC 62271-103 |
| High voltage cables | IEC 60502 |
| Cables | IEC 60228 |
| High voltage metal clad switchgear assemblies | IEC 62271-200 |
| Identification of insulated and bare conductor by colors | IEC 60445 |
| Power transformers | IEC 60076 |
| Transformer accessories | IEC 60076-7 |
| LV switchboards | IEC 61439 |
| Protection level circuits | IEC 60529 |
| Metering equipment for purchase of private power | WAPDA Standard Specification P-199.98 |

### 3.9.3 Functional Specifications

The equipment in the LV switchgear assemblies shall consist of low voltage power air circuit breakers, molded case circuit breakers, buses, current transformers, voltage transformers, indicating instruments, relays, control devices, associated wiring and test blocks.

Electrical separation of type ‘Form 3b’ is required as factory delivery for individual circuits to prevent electrical shock through contact with exposed-conductive-parts, which may be energized by a fault in basic insulation of the circuit. The equipment shall satisfy the requirements of “Form 4b” when installation is completed and all cable terminations are finalized.

Key technical parameters are shown in below table:

**Table 3-20 Technical Parameters**

| Item | Unit | Value |
|---|---|---|
| Rated Nominal Voltage | V | 400/230 |
| Rated Insulation Voltage | V | 2500 |
| Rated Continuous Current | A | 1250A |
| Rated Short Time Withstand Current | kA | Rated short time<br>Withstand current calculation shall be submitted by contractor and review by Employer. |
| Frequency | Hz | 50 |
| Busbars | | Copper |
| Busbar Joints | | Silver Plated |
| Busbar Insulation | | Shrink Sleeves |
| Control Voltages | VDC | 220 |



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The 400 V switchboards shall be metal-enclosed, multi-cubicle, multi-tier type factory-built assemblies of compartmented design based on the draw-out principle for indoor installation in accordance with IEC 61439 and suitable for continuous duty under site ambient conditions.

Complete protection shall be provided against approach to live parts under all normal operating and maintenance conditions.

The degree of protection IP42 to IEC 60529 shall apply to the enclosure. All ventilation openings and vent outlets shall be screened to prevent ingress of vermin.

Three-phase with neutral busbars and an earthing bus bar shall be provided throughout the entire length of the switchboards.

Provision shall be made for electric heaters with thermostat to prevent condensation, particularly when the apparatus is out of service.

All necessary monitoring, measuring and control equipment shall be provided.

Numerical protection devices fitted with test facilities are to be used throughout the LV switchgear. LSIG (Long Time, Short Time, Instantaneous and Ground) adjustable digital trip units shall be provided throughout. The Contractor shall ensure that the equipment is sufficiently protected.

Each busbar shall be adequately supported against short-circuit forces and provision shall be made to allow for thermal expansion of the conductors due to normal and pulse currents and short- circuit currents.

### 3.9.4 LV Circuit Breakers

The individual circuits of the switchboards shall be of the following type:

- Withdrawable air-break circuit breakers for incoming circuits and main outgoing feeders. Air circuit breakers shall comply with IEC 60947.
- Moulded case circuit breakers shall be provided for each distribution feeder circuit. The circuit breakers shall be in accordance with IEC 60947. All moulded case circuit breakers are manually operated, except as marked EO for electrically operated on the single line diagrams.
- MCBs shall comply with IEC 60898 and shall be high speed fault limiting thermal/magnetic trip.
- Low voltage power circuit breakers consist of 3-pole electrically and mechanically trip-free draw out type air circuit breakers and are complete with inter-pole barriers for eliminating all fault communication, arc quenchers, manual and electrical stored-energy operating mechanism, mechanical position indicator, and are mounted on a draw out mechanism in the breaker compartment.
- All three pole breakers shall have digital trip devices type LSIG. The electrically operated circuit breakers are equipped with push buttons for local control, and digital controls for remote operation from the control system.

### 3.9.5 Remote Control, Indications and Measurement

All circuit breakers shall also be remotely controlled from the operator’s console in the central control room.

The Contractor shall provide the provisions for following remote measurements and signals to



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the central control room:

- Withdrawable circuit breaker not available (in test position or withdrawn)
- Withdrawable circuit breaker ON / OFF, separate
- Withdrawable circuit breaker faulty

For each main switchgear section and each sub-distribution:

- No control voltage (group signal of individual in-coming and outgoing feeders)
- Protection activated (group signal)
- No busbar voltage

### 3.9.6 Protection and Metering

The following protection shall be provided as a minimum by the Contractor complete with current transformers, voltage transformers and necessary devices:

- Instantaneous overcurrent (50) and inverse time overcurrent (51)
- Time-definite earth-fault overcurrent protection (51N)
- Overvoltage protection
- Busbar under-voltage protection
- Trip circuit supervision relay protection

As a minimum requirement, the following local measurements shall be provided:

- Three-phase current indication of all in-feeds and outgoing feeders which are equipped with air circuit breakers and MCCBs
- Single-phase current indication for outgoing feeders equipped with air circuit breakers, MCCBs and feeders of more than 250 A equipped with hand operated load break switches or breakers feeding the DC Battery Chargers and the Change-Over units of the inverters / UPS.
- Single-phase current indication for all motor feeders equal to or greater than 75 kW.
- Voltage indication with suitable 7-way voltmeter selector for measurement of phase-to-phase and phase-to-neutral voltages in all the in-feeds equipped with air circuit breakers / MCCBs and in all in-feeds of sub-distributions of the switchgear installations

### 3.9.7 Busbar and Connections

The busbars and connections shall be continuously rated for the Site conditions and currents specified. Either insulated or uninsulated busbars are acceptable subject to approval in respect of clearances in air and evidence of dielectric tests applicable to the whole installation. Taping is not acceptable. Any insulating material used can withstand the heating effects of the rated short-time withstand current without permanent deformation or deterioration and shall comply with latest IEC standards for thermal stability and flammability.

Each busbar shall be adequately supported against short-circuit forces and provision shall be made to allow for thermal expansion of the conductor due to normal and pulse currents and short- circuit currents.

The busbars shall be contained in a separate compartment within the general casing of the switchgear and shall not be accessible by normal means.

### 3.9.8 Current Transformers



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The current transformers shall have separate cores for metering and protection.

The winding for measuring purposes shall have the following characteristics:

| | | |
|---|---|---|
| Accuracy class | : | 0.2 |
| Instrument security factor (FS): | | 5 |

Windings for protection purposes shall have the following characteristics:

| | | |
|---|---|---|
| Protection class | : | 5 P |
| Accuracy limit factor | : | 10 |

### 3.9.9 Voltage Transformers

The indoor voltage transformers shall be of the single-phase dry synthetic resin type meeting the requirements of IEC 61869-3.

The windings for measuring purposes shall be designed for accuracy according to class 0.2.

The voltage transformers shall have an additional secondary winding for earth fault protection, connected in broken delta with a resistive burden. The protection class shall be 3P for protection applications.

The secondary shall be provided with miniature circuit breakers with alarm contacts. Voltage transformers shall be protected by HRC fuses on the primary side.

The burden for voltage transformers secondary shall be between 25-80 % of the nominal burden.

### 3.9.10 Testing and Commissioning

#### 3.9.10.1 General

The testing shall be performed in accordance with the IEC recommendations for the actual equipment.

The testing shall consist of complete functional tests and technical tests to verify significant technical specifications.

The test plans and test specifications for both the factory tests and the site tests shall be presented to the Employer and approved by him in due time before the actual tests shall be performed.

All test results shall likewise be presented to the Employer for approval.

#### 3.9.10.2 Factory and Type Tests

##### 3.9.10.2.1 General

Routine tests shall be made on each unit of all equipment.

Routine tests shall be performed in the manufacturer's workshop on the individual apparatus and on the complete installation, respectively, all in accordance with IEC-Standards.

The Employer are entitled to witness all Factory and Type Tests.

##### 3.9.10.2.2 Routine Tests

The following routine tests are required:

- visual inspection



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- power frequency HV tests at main circuit
- dielectric tests of the auxiliary circuits
- functional test of the control circuits
- check of the operational sequence
- check of the denominations

#### 3.9.10.2.3 Type Tests

Type tests shall be made on one unit of each type of different equipment at the contractor's expense in presence of Employer and the actual type test report will be submitted for approval.

Instead of carrying out the type tests the Contractor may submit suitable certificates of tests made on equipment of the same type. However, the Employer reserves the right of accepting these certificates or to reject them partially or totally.

The following type tests are required:

- Dielectric test including lightning, power frequency voltage withstand test, and power frequency voltage withstand test on auxiliary and control circuits
- Temperature rise test
- Resistance measurement of main circuit
- Short time withstand current and peak withstand current test
- Verification of degree of protection
- Partial discharge test
- Mechanical operation test
- Test for auxiliary devices
- Verification of correct wiring

#### 3.9.10.2.4 Site Tests, Commissioning and Test on Completion

##### 3.9.10.2.4.1 General

Final functional and operational tests shall be carried out after the erection at Site.

The complete installation and – as far as reasonable – the individual apparatus shall be tested at Site as follows:

- Visual inspection
- Dielectric tests
- Functional test
- Test of the functional sequence
- Setting and functional test of protection devices (primary injection method)

### 3.9.11 Mandatory Spare Parts, Maintenance Equipment and Tools

Spare Parts, Maintenance Equipment and Tools mentioned herein are the minimum required. Any other necessary spare parts, maintenance equipment and tools required for maintenance of the equipment shall be provided by the Contractor.



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**Table 3-21 Spare Parts**

| Sr. No. | Description | Unit | Qty |
|---|---|---|---|
| **Mandatory Spare Parts** | | | |
| 1 | Breakers main contacts along with fitting accessories of each type | Sets | 4 |
| 2 | Circuit breaker of each type | Sets | 2 |
| 3 | Contactors of each type | Sets | 4 |
| 4 | MCBs of each type and rating | Sets | 3 |
| 5 | Protection relay of each type | Sets | 2 |
| 6 | Ammeters of each type | Sets | 2 |
| 7 | Current Transformers of each type | Lot | 1 |
| 8 | Voltmeters of each type | Sets | 2 |
| 9 | Voltmeter selector switches | Sets | 4 |
| 10 | Closing coils of each type | Sets | 4 |
| 11 | Trip coils of each type | Sets | 4 |
| 12 | Busbar insulators of each type | Sets | 6 |
| 13 | Control switches | Sets | 2 |
| 14 | Signal lamp sockets | Sets | 10 |
| 15 | Anti-condensation heaters of each type and rating. | Sets | 1 |
| **Maintenance Equipment** | | | |
| 1 | Intelligent Instrument Transformer check device | Sets | 1 |
| 2 | Testing equipment for circuit breakers characteristics | Sets | 1 |
| 3 | Ratio automatic measuring instrument | Sets | 1 |
| 4 | Phase shifter | Sets | 1 |
| **Tools** | | | |
| 1 | Circuit breaker handling truck/trolley of each type used | Sets | 1 |
| 2 | Feeder grounding trucks/trollies with VTs of each type used | Sets | 2 |
| 3 | Remote controlled racking assembly with 50-foot (15 m) cord and control station of each type used | Sets | 1 |
| 4 | Temporary earthing sticks with accessories of each type used | Sets | 2 |

## 3.10 CABLES

### 3.10.1 Scope of Work

This Section specifies the technical requirements for the design, manufacture, works testing, delivery, erection and commissioning of cables for power, control, instrumentation, communication, data cables and 11kV overhead lines including all terminations, joints, supports and accessories. The scope of supply shall include:

**11kV Overhead Lines**



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- Single-circuit line from Powerhouse to Intake Area.

**11kV Cable**

- One (01) lot of single-core cables for the Powerhouse
- Additional sets as required for connections between OH lines terminal poles and switchgear and step-down transformers

**LV Power Cables**

- One (01) lot of 400 V AC power cables for the Powerhouse, Intake and Spillway Area.
- One (01) lot of 220 DC power cables for the Powerhouse, Intake.

There shall be 400 V supply from intake to Spillway Area.

- One (01) Lot of Communication, control and instrument cables for all locations.
- One (01) Lot of fiber-optic cables for internal and external data transfer systems for all locations.
- One (01) Lot of material for supporting, laying, protecting, fixing and terminating of the cables and the OH lines for all locations.

The quantities, types of cables and 11 kV overhead lines to be provided under the Contract shall be determined by the Contractor to connect the equipment provided under this Contract and with external points as required. 10% of the final quantities required for the Project shall be provided as spares.

The Contractor shall include 11 kV network and cable length, sizes and rates for the supply and termination of additional quantities of cables as part of tender.

All the Cables and Cables Trays shall be supplied on the basis of whole reels. Remaining partial reels at the end of the work shall be turned over to Employer as spare cable.

### 3.10.2 Standards

The work performed shall be in conformance with all applicable codes and standards including, but not limited to, the latest revision of those listed below.

If there is an apparent discrepancy between any of the requirements of this Specification and those stipulated below, then the most stringent requirements shall apply.

**Table 3-22 Standards**

| Title | Standard |
|---|---|
| Thermal evaluation and classification of electrical insulation | IEC 60085 |
| Basic and safety principles for man-machine interface, marking and identification - Identification of conductors by colors or numerals | IEC 60446 |
| Specification for wrought aluminium for electrical purposes. | BS 2627 |
| Electric cables. Thermosetting insulated, armoured cables for voltages of 600/1000 V and 1900/3300 V | BS 5467 |
| Mechanical cable glands. Armour glands. Requirements and test methods | BS 6121 |
| Electric cables. Armoured cables with thermosetting insulation for rated voltages from 3.8/6.6 kV to 19/33 kV. Requirements and test methods | BS 6622 |

| Title | Standard |
|---|---|
| Electric cables. Thermosetting insulated, armoured cables for voltages of 600/1000 V and 1900/3300 V, having low emission of smoke and corrosive gases when affected by fire | BS 6724 |
| Zinc or zinc alloy coated non-alloy steel wire for armouring either power cables or telecommunication cables. Land cable | BS 10257 |
| Non shielded 0-2 kV Cables | ICEA S 95-658 |
| Conductors of insulated cables | IEC 60228 |
| Electric cables - Tests on extruded over-sheaths with a special protective function | IEC 60229 |
| Electric cables - Calculation of the current rating Part 1 to 3 | IEC 60287 |
| Tests for electric cables under fire conditions - Circuit integrity (Part 1 to 7) | IEC 60331 |
| Tests on electric and optical fibre cables under fire conditions (Several Parts) | IEC 60332 |
| Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um = 1,2 kV) up to 30 kV | IEC 60502 |
| Test on gases evolved during combustion - Determination of halogen acid | IEC 60754-1 |
| Test on gases evolved during combustion - Determination of acidity | IEC 60754-2 |
| Measurement of smoke density | IEC 61034 |
| Cable Tray Systems and Cable Ladder Systems for Cable Management | IEC 61537 |
| Optical fibre cables | BS EN 187000 |

### 3.10.3 General

#### 3.10.3.1 Cables

All MV cables shall be of cross-linked polyethylene (XLPE) insulation with sheath of low smoke zero halogen (LSZH) and either of fire retardant or of fire resistance characteristics suitable for installation in hydroelectric power plant environments. All LV power cables, signal and instrument cables shall have LSZH insulation.

All cables shall be suitable for installation in cable trays, above-ground and below-ground conduits, and in outdoor covered concrete cable trenches. Cables shall also be suitable for direct burial.

Copper conductor and armouring shall be used for all cables except specified elsewhere in specifications.

#### 3.10.3.2 11kV Overhead Lines

11 kV overhead line including lattice steel structures, surge arrestors, dropout cut out, conductor, galvanized steel wires, dead end clamps, anchor shackle, termination kits, complete earthing arrangement, danger and sign plates, cross arms, disc & pin insulators, D-shackle, stay rod and other accessories required for complete functioning of the system shall be provided.

The Contractor shall submit his Quality Assurance procedure being followed in manufacturing



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cables for the approval of the Employer.

### 3.10.4 Voltage Drop Limits

Maximum voltage drop on MV feeder = 3.5%
Maximum voltage drop on LV feeder = 2.5 %

### 3.10.5 Cable Trays, Racks and Supports

#### 3.10.5.1 General

The Contractor shall furnish, install and test cable trays, racks and supports and other necessary fittings.

#### 3.10.5.2 Supports and Other Steelwork

All cable supports including racks, trays, sunshields and other steel work with all necessary fixings, bolts, nuts, screws and clamps shall be supplied by the Contractor. Metal work shall be galvanized. The Contractor shall take all precautions to prevent damage to the galvanising. Where steelwork, racks or trays supplied in standard lengths are cut or minor damage has occurred to the galvanising the exposed steel shall be treated with zinc rich paint or other method approved by the Employer. Heavily damaged items shall be replaced as directed by the Employer at no extra cost to the Employer.

The cable trays shall include all accessories like bends, elbows, tees, etc. and shall be of the perforated type for proper ventilation of the cables. The trays shall be made from 2 mm thick mild steel sheets and the trays shall have a minimum 50 mm edge height.

Cable supports, racks and trays shall be erected in accordance with the layout drawings prepared by the Contractor and approved by the Employer. Any modification found to be necessary for satisfactory installation shall be to the approval of the Employer.

All cable trays and supporting metalwork shall be bonded to each other and to the station earthing mesh.

#### 3.10.5.3 Erection of Supports

Expansion bolts shall be used for the fixing of supports and associated steelwork to concrete and masonry.

The fixing of cable supports and associated steelwork to building structural steelwork shall be done with bolted clamps. Weld gun stud fixing will be allowed as approved by the Employer. The drilling of structural steelwork shall not be allowed except in special circumstances and then only with the prior permission of the Employer.

#### 3.10.5.4 Installation on Racks

Heavy single-core and multicore cables shall be clamped directly to the racks with cleats having bores of the correct sizes for the relevant cable diameters. The cleats shall be of silicon aluminium, glass-filled nylon or other tough, non-hygroscopic material. Single core cables shall be erected in close trefoil three-phase groups in non-magnetic clamps. Wooden cleats shall not be used.

The horizontal distance between supporting clamps for all cables having a conductor cross-sectional area greater than 125 sq mm shall be with the approval of the Employer.

The distance between rack supports for smaller power and multicore control cables shall be one metre for both horizontal and vertical runs. After installation, cables shall be neatly



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arranged and parallel to each other.

#### 3.10.5.5 Installation on Trays

Small power cables, protection, control, communication and data cables shall be run on trays and shall be secured with heavy duty plastic straps and fixings to the approval of the Employer. After installation, cables shall be neatly arranged and parallel to each other.

#### 3.10.5.6 Cable Ducts

All required cable ducts will be provided under this section of contract.

The cable ducts shall be of material LSZH. The ducts shall be of suitable sizes to carry required number of cables with 20% of free space.

#### 3.10.5.7 Cable Markers

Suitable cable markers of Aluminium with punch marks shall be provided and suitably permanently tagged to the cables for easy identification.

#### 3.10.5.8 Core Identification

Approved numbered ferrules shall be supplied and fitted to every cable core of control and instrument cables at each termination. The ferrules or sleeves shall be of insulating materials which shall have black text engraved on a white background. The ferrules or sleeves shall be unaffected by oil or damp. Adhesive markers shall not be used.

All markings for terminal blocks, cables, cable conductors and wiring shall be located on the corresponding design drawings.

A common system of ferrule numbering shall be adopted such that ferrule numbers at field terminations shall agree with ferrule numbers on the internal wiring of equipment.

### 3.10.6 Testing and Commissioning

All cables and other equipment and materials covered by these Specifications shall be subject to inspection and tests in accordance with these Specifications. The tests listed in this section are the minimum requirements.

Routine tests at Works shall be carried out as required by these Specifications.

The Contractor shall be required to carry out type tests in accordance with the internationally recognized Standards (IEC, BS etc.) unless authenticated evidence is produced to the satisfaction of the Employer to show that the type tests have already been satisfactorily carried out on each type of cable being supplied.

The Contractor shall certify that the cables and accessories offered shall be identical in all essential particulars in respect of design, materials and workmanship with the cables and accessories for which type tests are offered in support of his Proposal.

#### 3.10.6.1 Test Equipment

All apparatus, instruments and connections for the Site testing of the cables and accessories shall be provided by the Contractor

#### 3.10.6.2 Routine Test

Routine tests shall be conducted on all cables as specified in above referred IEC and BS standards.



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### 3.10.6.3 Site Test

Site tests shall be conducted on all cables as specified in above referred IEC and BS standards.

### 3.10.7 Mandatory Spare Parts, Maintenance Equipment and Tools

Spare Parts mentioned herein are the minimum required. Any other necessary spare parts, maintenance equipment and tools required for maintenance of the equipment shall be provided by the Contractor.

**Table 3-23 Spare Parts**

| Sr. No. | Description | Unit | Qty |
|---|---|---|---|
| **MV Cable** | | | |
| 1 | Clamps for all used cable size. | Set | 5 |
| 2 | Outdoor/indoor MV cable sealing ends | Lot | 1 |
| 3 | Termination and jointing kit for each type and size of 11 kV cable. | Nos. | 5 |
| 4 | All delivered type of MV cables | Meters | 500 |
| **LV, Control, Instrumentation, Protection, telecom and fiber optic Cables** | | | |
| 1 | All delivered types of 400 V power cables. | Meters | 300 |
| 2 | All delivered types of control cables. | Meters | 300 |
| 3 | Cable glands, comprising 20 (twenty) of each type | Lot | 1 |
| 4 | Cable lugs, comprising 5 % of the total quantity of each type | Lot | 1 |
| 5 | Adhesive and self-vulcanizing insulation and filler tape, comprising 100 (one hundred) meters of each type | Lot | 1 |
| 6 | Termination kit for each type and size of low voltage cable. | Nos. | 5 |
| 7 | Cable jointing kit of each type of cable | Lot | 1 |
| 8 | Fiber optical cable complete with termination joints. | Meters | 200 |

## 3.11 EMERGENCY DIESEL GENERATING UNITS (EDG)

### 3.11.1 Scope

The scope of work shall cover the design, manufacturing, supply, installation, testing and commissioning of emergency diesel generators as follows:

- One (01) No. 500 kVA* rated EDG for the Powerhouse
- One (01) No. 100 kVA* rated EDG for the Intake/Weir Area

*Note:* *The rating indicated is the minimum required. The final rating shall be determined by the Contractor and shall be subject to the approval by the Employer.

All equipment shall be manufactured and tested in accordance with the latest revision of the relevant IEC standards.

The emergency diesel generator of powerhouse is required to provide “black start” capability of the generating unit when power from normal or alternate source is not available. The generator shall also be required to meet emergency load requirements in the power plant when the power supply fails. The governor shall be of the droop type to enable paralleling the generator to the distribution system for load testing.



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The Contractor shall determine the capacity of the diesel generator based on the loads and submit to Employer for approval. The Contractor shall use the following criteria for specifying the main parameters of the emergency generator set and its control system:

- Voltage level of the system to be supplied from the generator is 400V
- Load requirements and duration
- Control and automation

The emergency diesel generators shall be furnished with speed governor, lubricating oil facility, air inhalation, cooling facility, fuel supply facility, exhaust facility, battery starting system, exciter, voltage adjuster and control panel.

The Contractor shall prepare the detailed design of the installations and submit drawings of the equipment for the installation.

The Contractor shall submit certificates of compliance, test reports and/or approval documents for the EDGs to be delivered for this Project.

### 3.11.2 Standards

The equipment shall conform to the applicable requirements of the latest edition of the following international standards:

| Subject | Standard |
|---|---|
| • Rotating electrical machines | IEC 60034 |
| • Current transformers | IEC 61869 |
| • Electrical relays | IEC 60255 |
| • Low voltage switchgear and control-gear assemblies | IEC 61439 |
| • Degrees of protection provided by enclosures (IP code) | IEC 60529 |
| • Low voltage switchgear and control-gear | IEC 60947 |
| • Reciprocating internal combustion engines performance | ISO 3046 |
| • Reciprocating internal combustion engine driven alternating current generators sets | ISO 8528 |
| • Diesel Engine Manufacturers Association Standards | DEMA |
| • National Electric Manufacturers Association | NEMA MG-1 |
| • Letter symbols to be used in electric technology | IEC 60027 |
| • International electro technical vocabulary | IEC 60050 |

### 3.11.3 Functional Requirements

The Emergency Diesel Generating Units (EDGs) shall be designed for operation of essential power plant auxiliary services, control room requirements with minimum 20% spare capacity during any outage of the grid connected power system. The EDG of powerhouse shall also provide sufficient power for black start of the power generating units including excitation, control, protection and lubrication systems.

The diesel engine and generator shall be interconnected to form a unit. The overload capacity shall be 10% of the rated output for one hour in every 12 hours of operation under the most adverse combination of climatic conditions at site.

The diesel engine shall be equipped with the following:

- Flexible flange coupling to the generator
- Speed governor, electronic
- Filters for air, fuel oil and lubricating oil
- Lubricating oil coolant pump
- Starter motor
- Fuel injection stopping coil
- Monitors of oil pressure
- Monitoring of cooling water temperature
- Radiator-type cooler with directly driven fan and ducting to wall opening

The diesel engine shall be of heavy-duty solid injection, compression ignition, exhaust gas turbocharged with intercooler, water-cooled closed circuit with radiator, air starting, four stroke, multi-cylinder with exchangeable cylinder liners, forced lubrication with lubrication oil cooler, electronic governor, suitable flywheel for flicker-free operation and exhaust silencer with necessary piping etc. all parts shall be easily accessible for inspection and repairs.

The lubricating oil system shall be closed circuit, forced feed type with duplex oil filters with an automatic bypass to avoid stoppage of oil circulation. The generator shall be continuous running duty type (SI) as per IEC 60034-1.

The generator shall be protected by housing, self-ventilated, drip proof, for tropical climate and equipped with a brushless excitation system with rotating diodes and voltage regulator.

Temperature rise of the windings shall not be more than 90°C for class-F insulation with an ambient temperature of 40°C under rated conditions.

The generator shall be designed to withstand speed of 1.2 times the rated speed.

The control panel shall contain all necessary equipment for control, protection and operation of the units. Facilities for both manual and automatic start/stop shall be available.

The generator body and control panel shall have provision for earthing. Control panel shall have auto-changeover facility, digital automatic voltage regulators, CTs, PTs, CBs, protection devices relays, indication alarms. The degree of protection provided by the enclosure for the generator shall be IP-23 as per IEC 60034-5.

The switchover of loads from diesel generating unit to station service supply after starting of one of the four units following a black-start shall be done by automatic changeover.

The long-term fuel oil storage tank shall have a capacity of at least 72 hours of continuous operation. The tank shall have double wall with leakage monitoring equipment and shall be furnished with float switch and fuel level gauge. The fuel oil day tank shall have the capacity for at least 08 hours full load running, with equipment for automatic refilling from the storage tank.

The battery shall be of the lead acid type, alternatively gel-acid type.

### 3.11.4 Operations, Interlocking and Synchronization

The EDGs shall form part of the auxiliary power supply system and shall be capable of island mode operation and parallel operation with another supply. The EDGs shall provide standby power in case of complete loss of normal power and shall have the facility for auto-start in the event of failure of the normal supplies to the main 400 V board.

Each EDGs shall be star connected, with the star point brought out via current transformers.



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Each star-point shall be earthed via neutral earthing resistor supplied by the Contractor. The resistor shall be able to withstand the continuous third harmonic current circulated during parallel operation with the auxiliary transformers. The Contractor shall submit detailed calculations on the size of the earthing resistors for approval by the Employer before start of the manufacture.

The EDG for powerhouse shall be supplied with a local control panel which shall include all facilities for remote auto-start and control by the Plant Control System (PCS) as well as facilities for the manual starting and loading. The EDG of powerhouse shall be provided with auto/manual control selection, start-up, synchronizing and sequential loading from the central control room (CCR). The Contractor shall supply necessary equipment on the Local Control Cubicle for interfacing with the PCS (Plant Control System) for remote operation from the control room.

On a complete shutdown of the system, the EDGs shall start and supply their respective boards. The synchronizing facility shall also be used for reconnection of the normal supply, following a blackout, before shutting down the EDGs.

The EDGs shall be automatically shut down in response to electrical and mechanical fault conditions, in all modes. Faults shall operate a lockout system, as required, requiring reset by operator before a start can be initiated.

### 3.11.5 Generator

The generator shall be protected by housing, self-ventilated, drip proof, for tropical climate and equipped with a brushless excitation system and voltage regulator. The generator terminal voltage level shall be readily adjustable to 10% of rated voltage. The maximum acceptable voltage variations during steady state generation shall be 2.5%, and in the transient state with load fluctuations of up 25%, the maximum acceptable voltage variations shall be 5%. This shall be achieved by incorporating automatic voltage regulator (AVR), the excitation system shall be of brushless type with rotating diodes.

The AC generator shall be of constant voltage, 50 Hz, three phase, four wire, internally air cooled, solidly grounded neutral, self-excited type with a power factor of 0.85. Damper windings shall be uniformly distributed round the rotor. Temperature rise of the windings shall not be more than 90°C for class-F insulation with an ambient temperature of 40°C under rated conditions.

The generator shall be designed to withstand speed of 1.2 times the rated speed.

The generators shall have the following ratings:

- Output *500 kVA & 100 kVA (prime rating)
- Voltage 400V, 3Ø
- Frequency 50 Hz
- Power factor 0.85 lagging
- Speed 1500 rpm
- Neutral grounding Solidly grounded

*Note: * The rating indicated is the minimum required. The final rating shall be determined by the Contractor and shall be subject to the approval by the Employer.*

### 3.11.6 Control Panel

The control panel shall be located in the Diesel Generator Room and shall contain all



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necessary equipment for control, protection and operation of the units. Facilities for both manual and automatic start/stop shall be available.

The generator body and control panel shall have provision for earthing. Control panel shall have auto-changeover facility, automatic voltage regulators, CTs, PTs, CBs, protection devices relays, indication alarms. The degree of protection provided by the enclosure for the generator shall be IP-23 as per IEC 60034-5.

The following instruments shall be provided on local control panel:

- Voltmeter and Selector Switch
- Ammeter
- Wattmeter
- Frequency meter
- Power factor meter
- Synchro scope
- Double voltmeter
- Double Frequency Meter
- Engine Speed Indicator
- Hours Run Indicator
- Lubricating Oil Temperature and Pressure
- Cooling Water Temperature
- For Turbocharge Engines, Charge Air Temperature and Pressure
- Tank Fuel Level Gauge

### 3.11.7 Fuel Oil System

The long-term fuel oil storage tank shall have a capacity of at least 72 hours of continuous operation. The fuel oil day tank shall have the capacity for at least 12 hours full load running. Both tanks shall have double wall with leakage monitoring equipment and shall be furnished with float switch and fuel level gauge

### 3.11.8 Lubricating Oil System

The lubricating oil system shall be closed circuit, forced feed type with duplex oil filters with an automatic bypass to avoid stoppage of oil circulation. The generator shall be continuous running day type (SI) as per IEC-60034-1.

### 3.11.9 Starting Battery

The battery shall be of the lead acid type, alternatively gel-acid type. Each cell shall have an individual container preferably of clear plastic. The container shall be completely closed and provided with an acid spray preventing ventilation plug. The number of cells shall be selected, to prevent that the battery voltage does exceed 110% of rated voltage during the float charging. Bolted or welded interconnections between the cells shall be provided.

### 3.11.10 Tests

#### 3.11.10.1 General

The testing shall be performed in accordance with the IEC recommendations for the actual equipment.



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The testing shall consist of a complete functional test and a technical test to verify significant technical specifications.

The test plans and test specifications for both the factory tests and the site tests shall be presented to the Employer and approved by him in due time before the actual test shall be performed. The Employer shall be entitled to witness all the factory tests.

All test results shall likewise be presented to the Employer for approval.

### 3.11.10.2 Factory Tests

Works tests shall include electrical and mechanical tests in accordance with the relevant Standards and in addition, any tests called for by the Employer to ensure that the DG Sets being supplied fulfills the requirements of these Specifications.

The following Factory tests shall be performed:

- Routine tests shall be made on each unit of all equipment.

Factory acceptance Test Program:

- Full load heat run to determine temperature
- Test run for the diesel generating units on variable loads at nominal speed, duration three hours.
- 1 hour with 10 % overload
- 1 hour with 75 % load
- 1 hour with 50 % load
- 15 min. with 10 % load

The following parameters shall be measured and recorded:

- Speed in RPM and frequency in Hz.
- Voltage and frequency variations under stated conditions
- Routine no load tests

After acceptance the engine water cooling system shall be drained prior to packing for shipment.

Type test certificates shall be supplied by the manufacturer if required.

### 3.11.10.3 Site Tests, Commissioning and Test on Completion

Final functional and operational tests shall be carried out after the erection on Site.

Site Test Program:

- Visual Inspection
- Check of cabling
- Adjustment of CB settings
- Start-up of Diesel Engine
- ½ hour no load test run
- Generator on load tests
- Checking temperature of cooling system
- Insulation resistance tests
- Continuity tests,



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- Rotational tests on all motors,
- Tests to prove correct operation of interlocks, starting, tripping and closing circuits, indication, etc.
- Synchronising tests,
- Operation of all protective gear circuits by primary and secondary injection,
- Protection gear timing test as may be necessary,
- Operation of alarm devices, and
- Interface tests of powerhouse EDG with PCS.
- Noise measurement test

#### 3.11.10.4 Spare Parts, Maintenance Equipment and Tools

Spare parts mentioned herein are the minimum required. Any other necessary spare parts for maintenance of the equipment shall be provided by the Contractor.

**Table 3-24 Spare Parts**

| Description | Unit | Qty. |
|---|---|---|
| Piston complete with rings each type. | Set | 2 |
| Piston ring sets each type | Set | 2 |
| Big end bearings each type | Set | 1 |
| Small end bearings each type | Set | 1 |
| Main bearings each type | Set | 2 |
| Fuel injectors each type | Set | 2 |
| Injector nozzles and needles each type | Set | 2 |
| Fuel high pressure pipes | Set | 2 |
| Cylinder head gasket each type | Set | 2 |
| Connecting rod complete each type | Set | 2 |
| Oil seals each type | Set | 1 |
| Carbon brushes each type | Set | 1 |
| **Maintenance Equipment** | | |
| Tools as recommended by the contractor for complete dismantling, assembly and maintenance of diesel generating unit. The tools shall be delivered with a tool cabinet. | Lot | 1 |
| Spare parts and consumables according to the recommendations of the manufacturer for 2000 hours of operation. | Lot | 1 |
| Consumable items such as filter, oils, etc. for 2-years of operation | Lot | 2 |

### 3.12 ELECTRICAL AND INSTRUMENTATION WORKSHOP

The Powerhouse will be provided with an Electrical Workshop. The scope of work will comprise the following:

- One (01) operation, maintenance and spare part management system, complete with all accessories
- One (01) lot of work benches, tool cabinets and chairs suitable for industrial



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maintenance activities

- One (01) lot of standard tools and instruments for Electrical & Instrumentation Workshop.

The proposed equipment, machines and tools will be appropriate to carry out all necessary electrical and related mechanical works for repair and maintenance of the Powerhouse electrical equipment. The Contractor shall submit a detailed list and technical specifications of all workshop equipment, tools and instruments for review and approval by the Employer prior to procurement.

The Contractor shall be responsible for delivery, installation, commissioning and demonstration of the workshop facilities, including training of Employer's personnel where required.

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## SECTION 4 PLANT CONTROL AND INSTRUMENTATION SYSTEM

### 4.1 GENERAL

The Contractor shall undertake the design, manufacture, works testing, delivery, erection, site testing and commissioning of the Control and Instrumentation (C&I) systems required for the control, alarm and protection of the power plant to satisfy requirements described in this specification and as required to complete the installation. The rules of good engineering practice and the relevant approved standards and regulations shall be observed.

The systems shall be so designed that in the event of subsequent modifications to the controls and associated signal processing, expansion of the system is convenient and straightforward.

The Contractor shall develop the detailed specification for the protection systems throughout the plant in accordance with IEC 61508 and IEC 61511. Protection functions that fall out with the scope of the above standards shall be highlighted to the Employer and designed according to good industry practice, employing redundancy to achieve reliable operation.

The Contractor shall be responsible for the supply of the complete Plant Control System including all necessary hardware, software and services that are needed to complete the systems.

The Contractor shall provide as part of the system documentation any required software licenses necessary for the Employer's perpetual, unrestricted use and application of the equipment supplied by the Contractor.

### 4.2 STANDARDS AND CODES

The control and instrumentation equipment supplied by the Contractor shall be designed, specified, selected, installed, commissioned or operated according to the applicable requirements of the latest edition of the following international standards:

| Subject | Standard |
|---|---|
| Programmable controllers | IEC 61131 |
| Controllers with analogue signals for use in industrial process control systems | IEC 60546 |
| Electrical measuring transducers for converting A.C. and D.C. electrical quantities to analogue or digital signals | IEC 60688 |
| Transmitters for use in industrial-process control systems | IEC 60770 |
| Thermocouples | IEC 60584 |
| Pressure Measurement Instruments and Apparatus | ASME PTC 19.2 |
| Temperature Measurement Instruments and Apparatus | ASME PTC 19.3 |
| Flow Measurement | ASME PTC 19.5 |
| Preparation of function charts for control systems | IEC 60848 |
| Electromagnetic compatibility for industrial-process measurement and control equipment | IEC 61000-4 |
| IEC Safety Handbook containing all basic safety standards | IEC Safety |
| Functional safety of electrical/electronic/programmable electronic safety-related systems | IEC 61508 |
| Functional Safety: Safety instrumented systems for the process industry sector | IEC 61511 |
| National Electrical Code | NFPA 70 |



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| | |
|---|---|
| National Fire Alarm and Signaling Code | NFPA 72 |
| Degrees of protection provided by enclosures (IP Code) | IEC 60529 |
| Annunciator sequences and specifications | ANSI/ISA S18.1 |
| Management of Alarm Systems | ANSI/ISA S18.2 |
| Process measurement control functions and instrumentation – Symbolic representation | ISO 3511-1 |
| Definition, specification, and analysis of systems used for SCADA and automation systems | IEEE C37.1 |
| Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems associated with Electric Power Apparatus | IEEE C37.90.1 |
| Tele-control Equipment and Systems | IEC 60870 |
| Information technology – Telecommunications and information exchange between systems | ISO/IEC TR 11802 |
| Industrial communication networks – Fieldbus specifications | BS EN 61158 |
| HART Communication Protocol Specifications | HCF-SPEC-11, 13, and others |
| Instrumentation symbols and identification | ISA S5.1 |
| Graphic symbols for distributed control/shared display instrumentation logic and computer systems | ANSI/ISA S5.3 |
| Unique identification in power plants and related facilities – principles and definitions, recommended practice | IEEE 803 |
| KKS Application Explanations for Hydro Power Plants | VGB-B106 |
| Function-related Documentation of Power Plant Instrumentation and Control in line with Operating Requirements | VGB-R 170 |
| Tests for electric cables under fire conditions | IEC 60331-111 & 21 |
| Low-voltage switchgear and control gear assemblies | IEC 61439 |

### 4.3 SCOPE

This section specifies the detailed requirements for the design, manufacture, factory testing, erection, site testing and commissioning of a modern state-of-the-art Plant Control System (PCS) for Powerhouse.

The PCS shall principally be composed of the following systems, components and ancillaries not being limited to:

- Two (2) operator workstations with double LED monitors and alarm printers;
- Two (2) LCD large screen displays with controller;
- One (1) fire detection and alarm panel with printer;
- One (1) metering station;
- One (1) archiving system for long term and spontaneous data archiving;
- One (1) training and simulation station with LED type double monitor and printer;
- One (1) Engineering Workstation with LED type double-monitors and laser color printers;
- One (1) interface with firewall to Office LAN and Web Client for remote access;
- One (1) redundant GPS master clock system with interface to secondary system;
- One (1) redundant SCADA gateway to Substation Automation System (SAS);



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- One (1) Portable Service Station;
- One (1) redundant fibre optic main Gigabit bus system according to IEC 60870-5-104;
- Three (3) unit local control panels (ULCPs) with field-bus interfaces to sub-controllers and monitors;
- One (1) station auxiliary LCU;
- One (1) lot of RTU(s) for the intake/weir gates and water level measurement monitoring;
- One (1) set of furniture for the CCR.

### 4.4 DOCUMENTATION

For this particular control system, the Contractor shall submit complete system documentation with service manuals and fault detection and rectification procedures for all control system equipment, including computer equipment and associated hardware furnished by him.

The Contractor shall also include complete software documentation including software and hardware manuals.

The operation and maintenance manual shall as a minimum contain the following:

- Technical specifications, covering the most important technical specifications of the control system equipment and associated hardware, with any reference data for data storage, processing, and any other data, the user might need during day-to-day operation.
- Block diagrams showing all major modules incorporated in the control system.
- General system description of all control system equipment and major modules, and particularly covering modules affecting the man-machine interrelationship.
- Operating instructions covering all system functions, such as start-up procedures, back-up procedures, system services management, printer operation etc.
- Instructions for routine maintenance and user's first-aid actions, such as replacing printer ribbons etc., identification of faulty equipment and patching in or transferring operation to stand-by units or modules.
- General system description of all main modules and operating features of the various systems.
- Short-form descriptions and tables of syntax and contents of the various software program modules, the operating system and any programming languages included.

### 4.5 FUNCTIONAL REQUIREMENTS

The actual implementation of the plant control system shall be proposed by the Contractor in the Basic Design. Control and operation of the power station shall include:

- Automated Plant Control System (PCS) at powerhouse Central Control Room.
- Backup control at bay/unit level.
- Auxiliary control at device level.
- Interface to the Substation Automation System (SAS), transmitting and receiving data to meet the requirements of the remote load dispatch centre
- Remote control / communication between Plant Control System (PCS) and superior remote-control system (Regional Control Centre).



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On each level it shall be possible to either select the level, thereby blocking operation from higher levels, or refer operation to the higher level.

The PCS shall include provisions for:

- Powerhouse Control and Protection.
- Generator Control and Protection.
- Transformer Control and Protection.
- Turbine Protection.
- Regulators.
- Metering.

### 4.5.1 Plant Control System (PCS)

The plant control system (PCS) shall be of the programmable distributed digital type with LED type VDUs and work stations, which are interconnected upon a duplicated data highway (fiber optic). The power plant shall be monitored by utilizing computers, with integrated control and monitoring of main equipment in the whole powerhouse achieved via operator workstations in the central control room.

Separate duplicated processors shall be provided for the turbine generator units, the switchyard equipment, station auxiliaries and water level measuring equipment. For the overall control and monitoring of the entire power plant, a modern state-of-the art microprocessor-based control system shall be delivered. The capacity of the systems shall be designed to handle future extensions. The main man-machine interface point is the central control room of the powerhouse.

The control system shall have the following salient features:

- Local control of the individual components and systems
- Manual and automatic control from the unit control boards of each unit
- Automatic and restricted manual control from the plant control room
- Interface for tele-control from a Regional Load Dispatch Centre

A central control room shall be provided in the powerhouse for the installation of plant control system equipment. The proposed control features shall allow the operation and supervision of the entire plant including the switchyard from the control room.

The equipment in the central control room shall include two operator workstations, one engineering workstation, servers, large screens display units, printers, UPS power supply, GPS clock system, tele-control gateway, network devices etc. The operator workstations shall mainly be used to complete operation automation and management of the whole powerhouse, including filing, classification, retrieval and management of historical data, generation and printing of operation report, as well as the function of man-machine interface, i.e., real-time supervision and control of equipment operation in the power plant. Two workstations work as mutual hot standby and interlock when operating. The engineering workstation shall be used to complete maintenance of the computer monitoring system and software development. A portable workstation shall be provided for routing maintenance and debugging of the plant control system (PCS) in the power plant.

The tele-control gateway shall be responsible for communication with Regional Load Dispatch Center (future provision).



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The main components of the central control room shall comprise the following control depth for the control and indication of:

- The generators, transformers, switchgears along with two large screen displays (LSD) behind the desk, with indicators showing the position of circuit breakers, disconnect switches and earth switches, etc.
- A turbine generator control equipment for the control and monitoring of generating units. The LSD shall provide a pictorial indication of the unit control system.
- 11 kV and low voltage (400V) auxiliary systems supplying the auxiliary services in the powerhouse.
- Engineering workstation and operator work stations, provided with two LED type video display units (VDUs), for control, monitoring and display of various functions.
- One sequential events recorder and printers to both operator and engineering workstation consoles.
- Remote terminal units and interface cabinets for the SCADA equipment.
- Provision for a supervisory control and data acquisition (SCADA) system shall also be made for providing future interlinking with Regional Load Dispatch Centre (future provision).

### 4.5.2 Local Control Units (LCUs)

The local control for the turbine generator units and station auxiliaries shall be located beside each individual piece of controlled equipment. Remote controls of all these equipment shall be carried out from the respective suite of control desk in the power house control room. Remote IOs/RTUs shall be provided for water level monitoring.

### 4.5.3 Training Simulator

An off-line dynamic training simulator shall be included to provide in-plant training to the operators and to simulate the effects of normal incidents, e.g., load rejection etc.

## 4.6 CONTROL LEVELS

### 4.6.1 The Plant Control Level

A computerized Plant Control System (PCS) for the supervisory control of the Power plant. The Plant Control System monitors and controls the complete power plant and covers the generating units in the powerhouse, auxiliary systems including the 11 kV and 400V switchgears and the water level monitoring at weir/intake, tailrace areas and control of intake ate operation. The PCS is located in the Central Control Room.

### 4.6.2 The Local Control Level

A Digital Local Control Unit (LCU) with local touch panel shall be provide, one for each generating unit and one for the auxiliary systems. Remote IOs/RTUs shall also be provided for water level monitoring at weir/intake and tailrace areas. The protection relays shall be part of the unit control system but operationally independent from the local computer.



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### 4.6.3 The Manual Control Level

Manual operation from the object control board and Emergency Stop from separate, independent panels.

In addition to the plant control, local and manual control level, the interface of communication in plant shall be equipped for remote control / communication. On each level it shall be possible to either select the level, thereby blocking operation from higher levels, or refer operation to the higher level.

The redundancy for programmable logical controllers at each level shall be provided.

## 4.7 DESCRIPTION OF EQUIPMENT

### 4.7.1 Plant Control System (PCS)

For the overall control and monitoring of the entire power plant complex, a computerized Plant Control System (PCS) shall be delivered, as main system for the complete power plant and associated switchyard.

Plant Control system shall have the following functions:

- Data acquisition functions
- Recording system
- Time synchronization and time tagging system
- Blocking of information
- Acknowledging of information
- Command procedure
- Regulating commands and set-point commands
- Data security-and consistency
- Personnel admission security to the system
- On-line change of data
- On-line trends
- Long-term trends
- kWh calculations, production plants etc.
- Self-diagnosis
- Blocking facilities to protect all software against virus infection
- Full graphic picture building
- Software and licenses for system configuration
- Software and licenses for system maintenance

### 4.7.2 Local Control Units (LCUs)

Computerized LCUs based on programmable logic controllers (PLC) shall be installed in cabinets with process interface, protection relays and a touch panel. The unit shall be autonomous.

The LCUs shall as a minimum comprise the following equipment:



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- Cabinets for the equipment
- Programmable logical controller (with necessary remote input/output units).
- Software as required
- Local control panel
- Measuring converters
- Signal interface equipment
- Communication Interface
- D.C. power and control voltage distribution
- Double uninterruptible internal D.C. power supply unit
- Meters with pulse contact output
- Indication and analogue Instruments
- Touch Panel
- Synchronization Device
- The programmable logical controllers (PLC) shall be capable of controlling and monitoring the following functions:
- Start and stop sequences of the generating unit
- Synchronization
- Transfer of set point values to the voltage controller, the water level controller and to the turbine governor
- Power set point to the turbine governor
- Monitoring temperatures for the generating unit
- Monitoring the operational values of the generating unit
- Local time tagging of all indications and alarms
- Alarm annunciator system
- Controlling the auxiliary feeders for the generating unit subsystems
- Communication towards the plant control system
- Automatic change over between station service transformers and emergency backup power.
- Water level monitoring

### 4.7.3 Communication System

The main communication buses of the Plant Control System shall be of optical fiber. The data communication system for the LCUs shall be arranged as dual optic fiber network.

### 4.7.4 Power Supply Systems

An uninterruptible Power Supply System (UPS) shall be used for essential A.C Power to the communication and plant computer control system (PCS). The UPS system shall be online type and equipped with its own batteries. The primary supply feed shall be from the AC



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distribution System with the backup power from batteries/UPS being made available through a rapid acting (¼ cycle) Static Transfer Switch (STS).

The 400 V TN-S system via an A.C/D.C/A.C, converter shall supply the PCS with necessary battery backup for operation of the PCS system for at least 90 minutes.

The LCUs shall also be supplied by the 220 VDC systems. Other voltages used shall be supplied from internal supplies inside LCUs. All internal power supplies shall be 100% redundant systems/back-up.

### 4.7.5 GPS Clock System

The PCS requires exact time at most of the distributed stations so as to apply time stamps accurately or to schedule time-dependent procedures. The scope comprises a complete functional clock system, including installation, cabling, commissioning and acceptance tests and shall not be limited to the following equipment:

- Clock system mounted in a free-standing cubicle
- Cable distribution system with junction terminals
- Differential frequency/ time indicator with automatic and manual adjuster in the control panel
- Antenna for receiving of international time signal (GPS) to adjust the clock automatically

The digital clock system shall have provision for time stamping of events and this time stamp shall have a resolution of 2 ms or better. The system clock used as a basis for time stamps shall be synchronized by the GPS system to give an absolute accuracy of time stamps of better than 1ms. The clock shall be equipped with the antenna and system interface module. The antenna shall be mounted on an adequate position.

### 4.7.6 Connection to the Regional Control Centre

The plant shall be capable for remote control / communications between PCS and superior remote-control system.

## 4.8 DESCRIPTION OF OPERATION

### 4.8.1 Start and Stop of the Generating Units

**Start Mode 1: Automatic Start**

Normal-start, fully automatic, with automatic synchronizing to the grid. This sequence shall be initiated manually either from the Plant Control System (PCS) or from the relevant LCU.

**Start Mode 2: Semi-automatic Start**

Automatic start sequences up to unit running, not-energized and at rated speed. Energizing and synchronizing can then be selected Automatic or Manual. This sequence shall also be initiated manually either from the Plant Control System (PCS) or from the relevant LCU.

The PCS shall be programmed for the following:

- Verify that the unit is in a condition to start i.e., no alarms up, spiral case pressure established, generator brakes off, electrical supplies established, governor and excitation systems healthy etc.



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- Start turbine, generator and transformer auxiliaries such as cooling water, governor pumps, thrust bearing pumps etc.
- Conduct all turbine, generator, transformer and switchgear pre-start checks to ensure that auxiliaries have started and supplies are established.
- Instruct the digital governor to run up the unit.
- Stop the thrust bearing oil pumps at a pre-set speed.
- Start the excitation system at a pre-set speed.
- Accept a ready to synchronize and voltage matched signal from the digital governor and AVR respectively.
- For start mode 1, continue on to close the generator circuit-breaker and load. For start mode 2, give a "Ready to Synchronize" signal then wait at speed no load for the signal to synchronize and load.

Check for excess starting time to online operation and alarm and shut down if excessive. In the case of start mode 2 the check shall be done in two stages i.e., to speed no load and to on line operation.

### 4.8.2 Control Functions during Generation

During generation the PCS shall:

- Give operator initiated set points to the digital governor for generator active power (MW) or Turbine flow (m3/s)
- The choice of parameter for set point control shall be selected from the PCS and correspondingly changed in the digital governor.
- Give operator initiated set points to the generator excitation system for MVArs.
- Monitor unit operation.

### 4.8.3 Stop Logic

The PCS shall:

- Instruct the digital governor to lower power in accordance with the pre-set unloading rule established within the governor.
- Open the generator circuit-breaker at a pre-set power.
- Close the guide vane to their fully closed position.
- Start the thrust bearing oil pumps at a pre-set speed.
- Apply the generator brakes at a pre-set speed.
- Stop the thrust bearing oil pumps at a pre-set time after dead stop.
- Release the generator brakes at a pre-set time.
- After a pre-set period, turn off turbine, generator and transformer auxiliaries such as cooling water and governor pumps.
- Activate the unit creep detection system.
- Check for excess stopping time and alarm and trip if excessive.

### 4.8.4 Unit Shutdown

There are six (6) shutdown modes as follows:



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**T1 - Rapid Shut Down for Mechanical Faults**

**Conditions**

- High bearing temperature
- Vibration trips
- Low oil levels etc.

**Actions**

- Guide vane close at rapid rate via rapid close signal to governor electro-hydraulic valve
- At zero power, generator circuit-breaker is tripped

**T2 - Rapid Shut Down for Electrical Faults**

**Conditions**

- Electrical protection operates

**Actions**

- Generator circuit-breaker is tripped, and
- Guide vane close at rapid rate via rapid close signal to governor electro-hydraulic valve

**T3 - Partial Shut Down**

**Conditions**

- Load rejection
- 132kVcircuit-breaker trip
- Unit over-speeds

**Actions**

- Generator circuit-breaker is tripped, and
- Guide vane fast run down to speed no load conditions via rapid close signal to governor electro-hydraulic valve

**T4 - Rapid Shut Down with Release of Water**

**Conditions**

- Fire or high air temperature sensed in the generator
- Generator differential protection operates
- Generator inter-turn protection operates

**Actions**

- Generator circuit-breaker is tripped, and
- Guide vane close at rapid rate via rapid close signal to governor electro-hydraulic valve

**T5 - Emergency Shut Down**

**Conditions**

- Unit over-speed indicated by electrical over-speed sensors
- Low governor oil pressure or level
- Emergency shut down push-button operated

**Actions**

- Generator circuit-breaker is tripped



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- Emergency shut down solenoid activated and guide vane close at rapid rate
- Inlet valve emergency close

**T6 - Mechanical Over-speed**

**Conditions**

- Over-speed above the electrical speed sensing

**Actions**

- Mechanical over-speed device operates hydraulic shut down valve
- Generator circuit-breaker is tripped
- Needle Valves close at maximum rate
- Inlet valve close

The shut downs shall be executed via the unit protection system with the PCS used as a back-up.

### 4.8.5 Control Functions Whilst the Unit is at Standstill

Whilst the unit is at standstill the PCS shall accept a unit creeping signal from the digital governor and, if creep is detected, start thrust bearing oil injection pump and apply the generator brakes.

## 4.9 TECHNICAL REQUIREMENTS

### 4.9.1 Plant Control System

The Plant control System (PCS) shall be complete with all necessary technical facilities for communication with the lower-level Unit control systems.

All data storage media and software shall be checked for inherent faults and virus before delivery, and shall be guaranteed error-free.

All equipment shall be of modular design. Major units such as services, primary memory modules, I/O ports, hard disk drives, peripherals controllers, internal power supplies etc., shall be easily serviceable and replaceable modules or parts of such modules.

The control system shall satisfy the response time criteria stipulated below:

Time to bring up new mimic diagram on workstation display, with all dynamic information displayed as stored in the computer databases:

Maximum [1] second

Time to regenerate the total information for the station by updating all databases with the total signal information from all LCUs:

Maximum [2] seconds

In the above time response requirements, any time required for the transfer of the necessary information between the LCUs and PCS, shall be included in the stated maximum time response limits. The response time of the displays shall not be significantly affected by any amount of communication between any units, not relevant to the information in the actual display.



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Under normal conditions there shall be no need for personnel supervision beside normal (routine) maintenance.

Any alarm condition reported, whether critical or non-critical for the operation of the power station, shall generate an audible and a visual alarm signal to alert the operators.

For test purposes and control of operation, and in case of failure of any equipment, it shall be possible from the PCS to change limit values, set point values, alarms and commands in any LCU without affecting the system.

No fault in the PCS shall interrupt or affect the operation of the power station.

Backup copying and program maintenance shall be possible without interfering with the actual operation of the control systems.

### 4.9.2 Firewall System

For the interconnection between the SCADA/DMS/ HMI and other networks, a firewall system shall be used. The purpose of this firewall system is to provide an additional layer of security (in addition to the access control mechanisms provided by the SCADA/DMS/HMI software) for the SCADA/DMS/HMI network.

By default, the firewall shall deny any network traffic from other networks destined to the SCADA/DMS/HMI network. Only traffic explicitly allowed in the firewall configuration shall pass the firewall.

The firewall system shall monitor the state of all established connections and shall automatically update its internal connection table accordingly.

There shall be one network interface connected to the SCADA/DMS/HMI. For every interconnection to other networks, one additional interface shall be used. There shall not be more than one network connected to one firewall interface.

The Proposer shall provide a detailed specification of his proposed firewall system with his offer. The Proposer shall state how many network interfaces may be installed in his proposed firewall system.

The Proposer shall define and implement a logging scheme which keeps track of all denied attempts of access to the SCADA/DMS LAN.  Firewall system

### 4.9.3 Software Functions

The software functions shall be decided during the detailed design phase and shall be subject to the approval of the Employer.

The plant control system software/hardware technical support and spares availability for at least fifteen (15) years, shall be provided by the contractor.

### 4.9.4 Data Acquisition and HMI Functions

The Control System Software shall include all normal Data Acquisition- and HMI- software function such as:

- Data acquisition from all LCU’s, including status signals, fault signals, analogue
- measurements, etc.
- Transferring commands and control outputs to the LCU.
- Alarm handling and event recording.
- Dynamic coloring



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- Dynamic presentation of the start/stop sequence for each generator set.
- Database functions for storage of momentary status, fault and measurement information and for long–time storage of measurement data for historical analysis, for trend-displays and for storage of production data, for periodical reports. Information for the last thirty (30) days shall be stored in the server memory. Long-term storage shall be stored on appropriate equipment.
- Status reports, measurement reports and production reports, etc. The reports shall be automatically presented at pre-defined times or manually initiated by the operator.
- Energy Recording Scheme:
- All individual kWh and kVArh reading for meters “kWh/kVArh meters” shall be presented on operator's request in addition, the following energy records shall be computed:
    i. Total gross production for the power plant
    ii. Total net production on outgoing transmission lines
    iii. Station consumption
- kWh production reports shall be presented automatically at pre-defined times or manually at the initiative of the operator. The kWh-reports shall present production values for each generation unit, each out-going line and computed records as above with following reports:
    i. Daily reports of hourly production values, including lowest and highest hourly value (with time identification) and average over the day.
    ii. Weekly reports of daily averages, including lowest and highest hourly value (with data and time identification) in the week.
    iii. Monthly reports of daily averages, including lowest and highest daily average and lowest and highest hourly value (with data and time identification) in the month.
    iv. Yearly reports of monthly average, including lowest and highest daily average and lowest and highest hourly value (with data and time identification) in the year.
- In the case of lost data due to faults in the acquisition system or any other faults the missing data the Supplier shall propose a replacing strategy. The software shall perform any recalculations required to correct erroneous data in the weekly, monthly and yearly reports.
- Provision shall be made for Energy Recording System.

### 4.9.5 Operation Software Implementation

The control system software shall be extended with the following applications:

- Water flow calculations.
- Joint active and/or reactive power output control, either separately according to pre-set values, or related in a percent relationship.
- Scheduled operation, where the total (active and/or reactive) power output from the station is set to automatically follow a pre-defined schedule, including start and stop of units.
- The I/O signal should cover at least the following:
    i. All breakers and isolators (open/close)
    ii. Breaker fault alarm



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iii. Transformer fault alarm
iv. Telecommunication fault alarm
v. Transformer MW/MVAr
vi. Line MW/MVAr
vii. Generator MW/MVAr
viii. Busbar voltage
ix. Frequency
x. Tap-change position of transformers
xi. Fire Alarm and Detection, Fire Fighting System I/O.
xii. Drainage and Dewatering System I/O.
xiii. Compressed Air System I/O.
xiv. Cooling water System I/O.
xv. Flow Measurement I/O.
xvi. Battery Charger and UPS, I/O.
xvii. DG Set I/O.
xviii. 132kV Switchgear I/O.
xix. Power Intake Gates and Trash Rack, I/O.
xx. Protection System I/O.
xxi. Turbine and Governors related I/O.
xxii. Water Level Measurement I/O.
xxiii. weir site equipment's I/O etc.

- The system should be complete in all respects to meet all operational requirements.

**4.9.6 Generating Units (LCUs)**

The LCUs for the generating units shall as a minimum comprise the following equipment:

- Cabinets for the equipment
- Programmable logical controller (with necessary remote input/output units, Remote I/0)
- Software as required
- Local control panel
- Measuring converters (if necessary)
- Signal interface equipment
- Communication Interface
- DC power and control voltage distribution
- Double uninterruptible internal DC power supply unit
- kWh meter with pulse contact output

Indication and programmable controllers analogue Instruments:

- Generator voltage each phase with selector switch
- HV busbar voltages
- Generator speed
- Frequency
- Active and reactive power



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- Phase currents
- Excitation current
- Excitation voltage
- Turbine stroke limiter
- Turbine guide vane
- Generator circuit breaker (open/closed)
- HV circuit breaker (open/closed)
- Excitation AC circuit breaker (open/closed)
- Excitation DC circuit breaker (open/closed)
- Inlet valve position (open/closed)
- Lamp for activated start sequence
- Lamp for stop sequence

Alphanumeric display showing all the same time:

- Alarms
- Temperatures
- Water Levels
- Speed Droop
- Voltage Droop
- Control equipment:
- Remote/Local operation selector switch
- Start mode selector
- Start push-button
- Stop push-button
- Emergency stop push-button with cover to avoid unintended operation
- Active power adjustment (increase/decrease)
- Voltage adjustment (raise/lower)
- Socket for portable synchronizing unit

The programmable logic controller (PLC) shall be capable of controlling the following functions:

- Start and stop sequences of the generating unit
- Synchronization
- Transfer of set point values to the voltage controller, the water level controller and to the turbine governor
- Power set point to the turbine governor
- Monitoring temperatures for the generating
- unit Monitoring the operational values of the
- generating unit Local time tagging of all
- indications and alarms
- Alarm annunciator system
- Local panel for manual control
- Controlling the Motor Control Centre (MCC) for the generating unit subsystems
- Communication towards the plant control system'



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The Contractor can modify the above panels as per their scheme, but the scheme shall be submitted to the Employer for the approval.

### 4.9.7 Auxiliary Systems (LCU)

The LCU shall supervise the auxiliary power supply and in addition to this, LCU shall also supervise the drainage pumps, ventilation system, the cooling water pumps, firefighting water pumps, lighting and small power etc.

The LCU shall supervise the powerhouse station power supply system and provide automatic switching to the available power sources according to agreed priority schedule.

The LCU shall cover the 11 kV and 400 V distribution systems for common subsystems of all the generating units of Power House.

The LCU shall generate an automatic startup of the powerhouse diesel generating unit in case of a power supply failure for the station power system.

The control of the MV (11 kV) switchgear (all circuit breakers) and LV (400 V) switchgear (Incoming & bus coupler breakers only) shall be carried out through PCS via operator workstations in the central control room (CCR) or from local points at the switchboards. However, the status of all circuit breakers of both MV and LV switchgears along with the bus voltages shall be displayed at the Operator workstations in the central control room. The LCU(s) shall be delivered and installed in cabinets with process interface.

The programmable logical controller shall be capable of controlling the following functions as a minimum:

- Open / Close Control of all 11 kV Circuit Breakers.
- Open / Close Control of all 400 V incoming and bus coupler circuit breakers on all the LV switchgear.
- Control and monitoring of plant auxiliary systems i.e. Drainage pumps, dewatering pumps, ventilation system, the cooling water pumps, firefighting water pumps, lighting and small power etc.
- Communication towards Plant Control System

### 4.9.8 Communications between Powerhouse and 132 kV Switchyard

Communication signaling is required between the powerhouse and the 132kV switchyard area. This shall be carried out using fiber-optic cable connecting the powerhouse to the switchyard. The SAS of the 132 kV switchyard shall be interconnected with the PCS by an optical fiber communication link through protocol converter.

### 4.9.9 Water Level Measurement

Water level monitoring system shall be provided at intake, weir and tailrace areas to monitor the water levels in these areas. Redundant water level transmitters shall be installed at each point. The water level measuring instruments shall be digital displayed with at least two decimals. Redundant remote I/Os shall be provided to interface water level measuring equipment with PCS. This water level measuring equipment shall be interfaced with PCS via remote I/Os connected to PCS and displayed on the large screen display in CCR.



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## 4.10 CONTROL ROOM EQUIPMENT

The Control System shall be a standard system or at least be based on a standard system, from an internationally well recognized Supplier. The computers shall be from an internationally recognized Vendor such as DELL, IBM, HP, DEC, SUN or equivalent.

The supply shall include all equipment, which is deemed necessary to follow the process and the layout of control system. It shall include all interconnections (interfaces) to other systems of the plant and relevant cabling.

The following equipment shall be provided, as a minimum, in the CCR:

One main control console including the following equipment;

- Two (02) Operator Workstations including:

  Two (02) 21inch color VDU (LED) monitoring screens
  Operator station electronics
  One operator keyboard
  One operator keypad
  One optical mouse
  One graphic display driver
  One A4 laser printer

- One (01) Engineering / Operator Workstation including:

  Two (02) 21 inch color VDU (LED) monitoring screens
  Operator station electronics
  One operator keyboard
  One operator keypad
  One optical mouse
  One graphic display driver
  One A4 laser printer
  One A3 color laser printer

- One portable workstation
- One alarm printer with pedestal
- Historical data archival and retrieval station
- Two 70'' Inch (Minimum) Large Screen Display.

Alarm history displays and audible alarms for each priority shall be provided. Printer failures shall be alarmed.

Centralized fire alarm system shall also be installed in the CCR.

Following furniture shall be provided as a minimum in the CCR:

- control desks
- cubicles for withdrawable connections
- Six (06) operator adjustable and movable arm chairs

## 4.11 PACKING AND SHIPMENT PREPARATION

Prior to shipment, all shipping stops, bolts, ties etc. shall be installed in cabinets and devices. The Contractor shall install additional protection as required to prevent damage during



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shipping. Any delicate modules or circuit boards shall be disconnected, packed and shipped to the site to be remounted by the Contractor's field personnel. All accessories, mounting devices and packing lists shall be packed and shipped with the equipment.

Each separately shipped group of equipment shall be prepared as an individual shipping unit and shall be braced adequately and rigidly so that no damage shall occur in transit, lifting or installation. Provisions shall be made for lifting and skidding. All lifting points shall be clearly marked. All temporary bracing shall be bolted so that no cutting torches shall be required for field installation. Disconnected wiring shall be properly supported. The equipment shall be adequately protected against the weather and mechanical damage during transit and storage.

## 4.12 TESTS

### 4.12.1 General

The testing shall be performed in accordance with the IEC recommendations for the actual equipment.

The testing shall consist of a complete functional test and a technical test to verify significant technical specifications.

The test plans and test specifications for both the factory tests and the site tests shall be presented to the Employer and approved by him in due time before the actual test shall be performed.

All test results shall likewise be presented to the Employer for approval.

### 4.12.2 Factory Tests

The Contractor shall perform comprehensive functional tests for all equipment according to a predefined schedule, suggested by the Contractor and approved by the Employer.

The Employer shall be entitled to witness all the factory tests. The test shall be on the assembled system with the communication system.

### 4.12.3 Site Tests, Commissioning and Test on Completion

The Contractor shall perform comprehensive functional tests for all equipment according to a predefined schedule, suggested by the Contractor and approved by the Employer.

## 4.13 SPARE PARTS, MAINTENANCE EQUIPMENT AND TOOLS

**Table 4-1: Spare parts maintenance equipment and tools**

| Sr. No. | Description | Unit | Qty |
|---|---|---|---|
| 01 | Operator station computer with monitor, fully configured | Nos. | 1 |
| 02 | Redundant main server core components, fully configured | Set | 1 |
| 03 | PLC processor modules for each PLC used | Set | 2 |
| 04 | PLC communication interface modules of each type used | Set | 2 |
| 05 | PLC power supply modules of each type used | Set | 2 |
| 06 | Digital and Analogue I/O modules of each type used | Set | 2 |
| 07 | Panel mounted HMI monitors | Set | 2 |



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| Sr. No. | Description | Unit | Qty |
|---|---|---|---|
| 08 | Ethernet switch of each type | Set | 2 |
| 09 | Media converter of each type | Set | 2 |
| 10 | Power supplies of each type used | Set | 2 |
| 11 | Protective relays of each type used | Set | 2 |
| 12 | Control relays of each type used | Set | 2 |
| 13 | Fuses of each type used | Set | 3 |
| 14 | Lamps of each type used | Set | 3 |
| 15 | Control switches of each type used | Set | 2 |
| 16 | 100 m fiber-optical cable complete with termination joints. | Lot | 1 |
| 17 | Printer cartridges of each type used | Set | 3 |
| 18 | Paper Reams of each type/size used | Set | 3 |
| 19 | Thermocouple and resistance temperature detectors (RTD), comprising 05 % minimum two of each type | Lot | 1 |
| 20 | 50 m Thermocouple extension wire of each type | Lot | 1 |
| 21 | Measuring inserts for TC and RTD, comprising 10 % minimum two of each type | Lot | 1 |
| 22 | Local indicators (temperature, pressure, level gauges etc.), comprising 05 % minimum two of each type | Lot | 1 |
| 23 | Local contact giving devices (flow, level, pressure switch, limit switches), comprising 05 % minimum two of each type | Lot | 1 |
| 24 | Transmitters complete, comprising 05 % minimum two of each type | Lot | 1 |
| 25 | Sensing elements and electronic cards, comprising 05 % minimum two of each type | Lot | 1 |
| 26 | Instrument valves and fittings, comprising 05 % minimum two of each type | Lot | 1 |
| 27 | Transducers, comprising 20 % minimum one of each type | Lot | 1 |
| **Maintenance Equipment and Tools** | | | |
| 01 | Portable controller set equipment incl. Test console, input/output units, instruments, connecting cables, plug sockets, adapters etc. to test functions of each controller of local control station | Lot | 1 |
| 02 | Portable communication test equipment incl. Test console, input/output units, instruments, connecting cables, plug sockets, adapters etc. for testing communication facilities and data exchange in the system | Lot | 1 |
| 03 | A/D converter checker for water level measurement (each type) | Lot | 1 |
| 04 | Digital storage oscilloscope, 100 MHz bandwidth | No. | 1 |
| 05 | Digital analyzer (min. 32 bits, synchronous and asynchronous operation, clock frequency min. 25 MHz). | No. | 1 |
| 06 | Digital pattern generator (min. 24 bits parallel output). | No. | 1 |



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| Sr. No. | Description | Unit | Qty |
|---|---|---|---|
| 07 | Bit error rate test equipment (for serial lines). | No. | 1 |
| 08 | Frequency counter/time measurement meter (frequency to min 100 MHz, time periods with 10 ns resolution or better, for portable and bench use). | No. | 1 |
| 09 | Digital tracer kit (including pulse injector and logic probe). | Nos. | 2 |

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## SECTION 5 PLANT TELECOMMUNICATION EQUIPMENT

### 5.1 TELEPHONE SYSTEM (EPABX)

#### 5.1.1 Scope of Work

The Digital telephone exchange shall be modular in design. The system shall also have provision to be upgradable to IP telephone network. The system shall be extended to the Switchyard and sufficient number of subscribers shall be provided. Additionally, this system shall be connected to the PAX system of switchyard/substation.

The proposed Telephone System shall comprise the following equipment but not limited to the following;

- Main Distribution Frame
- Main Telephone Junction Box
- Digital Telephone exchange
- Main power supply system
- Back-up power supply system
- Digital Telephone sets
- Analogue Telephone sets
- All interconnecting cables, terminations, protection devices
- All other required accessories

##### 5.1.1.1 Technical Requirements

**A. General**

The EPABX shall be state-of-the-art, digital, non-blocking type utilizing Pulse Code Modulation (PCM) and Time Division Multiplexing (TDM) and Stored program Control (SPC). It shall be field proven and conform to ITU-T A-Law Companding standard. It shall at least be equipped with 64 subscriber lines and 08 trunk lines. The system shall allow simultaneous voice and data communication over one twisted pair telephone cable.

The system shall be able to operate in the following environmental operating conditions:

| | |
|---|---|
| Temperature | 10 to 50°C |
| Humidity | 5 to 95 % |

The various types of interface circuits required are as follows:

| | |
|---|---|
| Analogue Extension: | Two wire Dual Tone Multi-frequency (DTMF) according to ITU-TQ.23 |
| Analogue Trunk: | In accordance with PTA standard |
| Digital Trunk: | 2 Mbit/sec (comprising 10 digital trunks) |

The EPABX system shall incorporate a wide range of self-initiating diagnostic routines for the monitoring of system performance and identification of errors.

The proposed EPABX should be configured to handle the following traffic:

0.35 Erlangs per each extension

0.90 Erlangs per each trunk



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Blocking of calls shall be less than one percent under normal operating conditions.

The Contractor shall state the maximum number of simultaneous calls possible within the exchange.

An adequate range of alarm and test facilities shall be provided in the EPABX to enable the maintenance personnel to rapidly access and localize the fault conditions. The facility of remote access of the EPABX for operation and maintenance purposes shall be available.

The EPABX system shall comply with the following interfaces and protocols:

- EURO ISDN BRI & PRI
- ITR6
- Q.931
- QSIG
- DPNSS
- CCS
- V.24/V.25/28/35
- LAP-D

**B. Software Features**

The system shall have following minimum features:

- Trunk direct inward dialing
- Call data recording
- Malicious call trace
- Night service
- Dial/call by name
- Password for up/down grading of traffic class
- Number redials
- Call forwarding
- Call pickup
- System speed dialing
- Individual speed dialing
- Call back on no answer
- Generation of billing reports
- Call transfer
- Three and eight party conference
- Distinctive ringing
- Timed reminder service
- Hold toggle
- Connection restriction
- Cyclic/linear comfort hunt group
- Class-of-service changeover
- PIN/follow me
- Do not disturb
- Camp-on or camp on security

**C. Telephone Sets**

**i) Desk telephone set**

Desk telephone shall be a standard single line push button analogue tone dialling set. The keypad and the dialling from the telephone set shall conform to the ITU-T Q23 standard. It shall be possible to attach a hands-free unit, if required.



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### ii) Wall mounted telephone set

Wall mounted telephone shall be a push button analogue tone dialling set designed for installation on the wall only. The keypad and the dialling from the telephone set shall conform to the ITU-T Q23 standard.

### iii) Executive telephone sets

Executive telephone shall be a push button tone dialling set with display of at least 2x24 characters to show Names and CLIP, at least 24 programmable memories, digit display, provide full hands-free operation, have programmable function keys with LED indication, support context sensitive features, name dialling and display as well as Message display.

### D. Main Distribution Frame (MDF)

The termination frames shall be housed in a self-standing 19" cabinet (separate from the EPABX cubicle) lockable from the outside. The cabinet shall be dust and vermin proof, designed to a protection class of IP54. Provision shall be made to earth the cabinet to the grounding system. The entry of cables shall be from the bottom through suitable glands provided in the plates and care shall be exercised that the glands are tightly closed after the installation of cables.

The connecting blocks shall be of the quick-connect type, each capable of accommodating at least 10 pairs. It shall incorporate over-voltage and over-current protection on all external trunk and subscriber circuits. These protectors shall be either carbon or gas tube type. Access to the connecting blocks shall be from the front. One (1) quick connect tool shall be provided with the MDF cabinet.

### E. Power Supply

In the equipment room, the mains voltage supply (230 Volt AC/50Hz) shall be available.

As reserve power, the equipment shall be equipped with a 48 Volt DC reserve system, to provide system operation in the event of a commercial power failure. The battery shall be designed to provide a maximum of eight (8) hours backup. The batteries shall be of sealed maintenance free type, supplied complete with cells, connectors, stand and all accessories.

### F. Cabling

All cabling, between the telephone sets and the EPABX and between the EPABX and MDF/communication equipment shall be supplied and installed by the Contractor in trenches/ducts and/or cable trays. The telephone cables shall be multi-pair, twisted and screened with suitable protection against vermin/rodent attack.

## 5.2 IP PABX TELEPHONE SYSTEM - (PUBLIC TELEPHONE SYSTEM)

### 5.2.1 Scope of Work

The scope of works shall include supply, Installation, Testing & Commissioning of IP Telephone system with passive work complete with equipment, accessories, tools, labor and all associated work for 100% completion of work. All Proposers shall have to visit the site to take physical dimensions of hoist way, pits overhead and machine room to verify their horizontal / vertical lengths etc. before submission of proposals. The Proposers may raise the queries for any clarification, missing information or ambiguity if any, within one week after issuance of tender documents. Any work to be carried out by the owner / main contractor, should be mentioned clearly along with the Proposal, otherwise no claim against extra work shall be acceptable. Specification, Drawings and BOQ etc. should be read carefully to comply



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specified loads, serving landings and other general and special safety features. Any deviation from specification / BOQ should be mentioned well in time before submission of Proposal.

The IP Based Telephone System works are to be performed; the requirements given in the Schedule shall be fulfilled. The Contractor shall be responsible and provide the following:

All the Major equipment e.g., Call Manager, Gateway, 19'' rack, IP Phone Executive, Analogue Phone, Server, all Software Licenses shall be provided from the same manufacturer.

- Provide the necessary hardware and software for above System:
- All software packages shall be provided in original installation media along with their licenses
- Preparing an Engineering Design Report covering, at least, the following subsystems:

1) Detailed Drawings for the IP Telephone system showing all areas of the Project.
2) The exact quantities and types of hardware and software required
3) Cable, conduit schedules and routing plan
4) Schematics and interconnection diagrams of complete IP Telephone system showing Telephone system components including Call Manager, Gateway, 19'' rack, IP Phone Executive, Analogue Phone, Server, all Software Licenses and other elements to monitor and control the processes outlined above.
5) Technical details of the hardware and software of the complete systems.
6) Details of any civil works required.
7) Detailed description of the data acquisition software, user configurable functions and software features to be provided.
8) Complete details, brochures and pictures of the proposed area.
9) Installation, testing and commissioning procedures and methodology.

- Procure, transport and deliver equipment and hardware to site, after approval of the above report(s) by the Employer. No payment shall be made without approval of design report.
- Submit Factory Acceptance Test procedures along with Schedule of Time
- Design, Install, test and commission of IP Telephone system in accordance with the procedures given in the engineering design report.
- Provide training to the Employer's personnel.
- Proposer shall submit with his Proposal the following Documents/Data for all system equipment including Call Manager, Gateway, 19'' rack, IP Phone Executive, Analogue Phone, Server, all Software Licenses.
- Brochures and data sheets of each equipment
- Test standards and design
- Backup calculations
- End user certificates
- International Standards Reports/Certificates

### 5.2.2 Standards

All equipment shall be of imported origin. Materials/Equipment shall be designed, manufactured, tested and installed according to the BS/IEC/ISO/ITU/EN/CE Recommendations. The latest edition and amendments shall apply in all cases. As a minimum, following shall be applied:



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a. EN 60950-1:2006/A11:2009/A1:2010/A12:2011/A2:2013 Information technology equipment – Safety – Part 1: General requirements.
b. EN 55032:2015 Electromagnetic compatibility of multimedia equipment – Emission requirements.
c. BS EN 61000-3-2:2014: Electromagnetic compatibility (EMC). Limits. Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems.
d. EN 55024:2011: Information technology equipment. Immunity characteristics. Limits and methods of measurement
e. EN 61000-3-2:2014: Electromagnetic compatibility (EMC). Limits. Limits for harmonic current emissions.

#### 5.2.2.1 General

The IP Telephone system shall be supplied and installed by approved Manufacturer to Employer's approval. The Telephone system is intended to establish efficient communication. The Telephone system shall be suitable for making local, long distance and overseas calls.

IP Based PABX and Telephone System shall have a lifespan of 20+ years with 100%+ output guaranteed.

The proposed Telephone system shall comprise the following equipment but not limited to;

- Hybrid PABX
- Gateways
- Network Switches
- Software's
- Main Distribution Frame
- Main Telephone Junction Box
- Analog Telephone Sets
- IP Executive Telephone sets
- All required accessories

#### 5.2.2.2 Functional Description

##### 5.2.2.2.1 IP PBX Functional Description

The IP PABX shall Supports the built-in voice mailbox service and at least Hybrid IPABX having Capacity 2000 lines Including IP Phone Executive, Analogue Phone, Gateways, Network switches, all Software Licenses and power failure for minimum with Four-hour backup.

The IP PABX shall have Hybrid IPABX having Capacity 2000 lines with VAS Support IP PBX for 2000 subscribers with VAS support, High-quality voice processing, Carrier class reliability, 700 VoIP channels, 16 E1 streams, Support for 2 built-in SD 8 GB and Hardware redundancy.

The IP Telephone system shall be supplied and installed by approved Manufacturer to Employer's approval. The Telephone system shall intend to establish efficient communication. The Telephone system shall be suitable for making local, long distance and overseas calls.

IP Based PABX and Telephone System shall have a lifespan of 20+ years with 100%+ output guaranteed.

The IP PABX should be excellent communication quality and high flexibility, the system provides a foundation for building secure VoIP solutions. The IP PABX shall Supports basic



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calling services, including communications system with wide range of services i.e., contact center and call center, communicator, chat, SMS sending, calls recording, conferences and video conferences, manageable call queuing and other.

The Trunk gateway shall be use for interfacing of signal and media streams of TDM and VoIP networks. The gateway shall be used as an IP PBX with VAS support and a universal solution for info communication new generation networks (NGN).

The gateway shall support 16 E1 streams (SS7 and PRI) and 700 VoIP channels.

The Trunk gateway shall provide high level of fault tolerance due to embedded state-of-the-art chip and uniform load distribution among sub-modules, power modules redundancy and usage of up-to-date technologies based on parallel computing. The gateway will switch to a backup sub-module in case of a primary sub-module fault.

The gateway shall have strict compliance with up-to-date protocols' requirements, recommendations and standards. The gateway shall have functional compatibility with a variety of equipment such as Digital PBX, IP PBX, Switches, VoIP gateways, SIP phones, programmable SIP clients, etc.

The hardware transcoding shall be based on Media Codecs, Mind speed Technologies helps to negotiate media streams with different VoIP codecs which shall use in up-to-date networks.

Intellectual call routing shall be based on billing system responses via the RADIUS protocol which shall allow customers to create flexible methods of call processing.

The intellectual protection shall be against unauthorized external SIP subscriber's connection and connections via http/https/telnet/ssh shall realize on the trunk gateway (Dynamic Firewall, Static Firewall, black and white lists of IP addresses and sub networks).

The main features of IP PABX shall be following as:

**i. Calls management**

- Routing based on called number (CdPN) or calling number (CgPN)
- Number modifications before and after routing
- Call recording according to number mask and dial plan
- Use of multiple dial plans
- Subscriber lines restriction
- Subscriber service mode
- Trunk group cut-off
- Direct connection of trunk groups
- Prefix for few trunk groups
- Interactive voice menu (IVR)
- Uploading/downloading of configuration as a single file
- Lines limiting for SIP interface
- Egress and ingress lines restrictions for a subscriber
- Ingress load limiting (calls per seconds) for a trunk group

**ii. Audio Compression**

- G.711 (a-law, μ-law), G.729 (A/B), G.723.1, G.726 (32 Kbps)



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**iii. Fax transmission**

- T.38 Real-Time Fax, G.711 (a-law, μ-law) pass-through

**iv. Voice standards**

- VAD (Voice Activity Detection)
- CNG (Comfort Noise Generation)
- AEC (echo cancellation, G.168 recommendation)
- AGC (automatic gain control)

**v. Quality of service (QoS)**

- Assignment for SIP and RTP
- Dynamic and Static jitter buffer
- Ingress/egress traffic rate limiting

**vi. DTMF**

- INBAND, RFC 2833, SIP INFO, SIP NOTIFY transmission methods

**vii. Billing**

- Billing data shall be recorded in CDR file. CDR files shall keep on a local HDD and remote FTP server.
- RADIUS Accounting
- Supported billing systems: Hydra Billing, LAN Billing, Porta Billing, Net UP,
- BG Billing (there is an opportunity of integration with other systems

**viii. Flexibility**

- Multiple network interfaces creation for telephony (SIP, RTP) with different IP addresses
- Operation with multiple numbering plans
- Signal SS7 channel redundancy
- Voice activity control (by the presence of RTP or RTCP)
- Individual routing for streams from a single SS7 link set

**ix. TDM protocols**

- SS7
- PRI (Q.931)
- Q.699 (PRI and SS7 interaction)
- V5.2 LE
- V5.2 AN

**x. VoIP protocols**

- SIP, SIP-T/SIP-I, SIP-Q
- H.323
- SIGTRAN (M2UA, IUA)
- H.248

**xi. Capacity**

- Up to 700 VoIP channels



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- Up to 16 E1 streams
- Maximum load intensity 14 cps

### xii. Interfaces

- 2 x 1000Base-X ports (2 slots for SFP modules)
- 3 x 10/100/1000Base-T (RJ-45) ports
- E1 (2 x CENTRONICS-36 connectors)
- 2 SATA ports (for SSD modules installation)

### xiii. Management and monitoring

- E1 and VoIP channels monitoring in web interface
- Management of channels and SS7 links in web interface
- Alarm logging with the opportunity to save entries to syslog server
- Tracings are stored on the SSD and USB storage
- Emergency notification through SNMP

### xiv. Security

- Black and white IP addresses lists
- Attempts of access to device are logged
- Automatic blocking by IP address after unsuccessful login attempts
- or/and access via http/https/telnet/ssh
- List of permitted IP addresses for access to control of the device
- Access rights delimitation - admin/user
- Delimitation of rights to access calls records
- Control of opposite RTP stream's source IP address

### xv. Redundancy

- Operation in warm redundancy mode 1+1
- The system switches the redundant part on automatically
- Automatic synchronization of main redundant module settings

### xvi. Advanced SIP/SIP-T/SIP-I functionality

- Registration and authentication of 2000 SIP subscribers
- VAS support for 1000 SIP subscribers
- SIP and SIP-T/SIP-I interaction
- Trucking and subscriber registration of SIP trunks
- Transit registration of subscribers on SIP trunk with switching to local service mode in case of server unavailability

### xvii. Value added services

- Call Forwarding
  - Call forwarding out of service (CFOS)
  - Call forwarding on no reply (CFNR)
  - Call forwarding unconditional (CFU)
  - Call forwarding on busy (CFB)
- Call Transfer



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- Music on Hold (MOH)
- Call Hold
- Call Hunt
- Call Pickup
- Busy Lamp Field
- Conference add-on (CONF)
- Conference for a list of subscribers
- 3-Way conference
- Intercom
- Paging
- Outgoing calls restrictions
- Egress communication by password (RBP)
- Password activation (PWD ACT)

**5.2.2.2.2 Password reset (PWD)Analog VoIP Gateways**

The Analog VOIP Gateway shall PBX functionality, High-quality sound, Current and voltage port protection, Measurement of subscriber line physical parameters and the length of lines shall be 5 km. The analog VoIP gateways shall be planned for voice and fax data transmission through IP networks. The gateways shall provide subscribers with high-quality phone connection with support for isolated PBX operation mode and wide range of supplementary services.

The Analog VOIP Gateway shall have

- FXS ports: 24
- FXO ports: up to 32
- Type of connector: TELCO-50
- Ethernet 10/100/1000BASE-T ports (RJ-45): 2
- VoIP protocols: SIP, SIP-T, H.323
- Fax transmission: T.38, G.711 pass through
- WAN connections types: Static, DCHP, PPPoE/PPTP
- Operating temperature: from 0 to +40° C
- Form factor: 19", 1U
- Operating humidity: ≤ 80%

The Analog VOIP Gateway shall have high quality of sound ensured by the use of the high-performance hardware based on Mind speed chip, support for main audio codecs used in VoIP networks (G.711, G.723.1, G.726, G.729), echo cancellation function, use of silence detector, comfort noise generation, DTMF signals reception and generation and prioritization mechanisms (QoS).

In case of the loss of main SIP server connection, The Analog VOIP Gateway switches shall have redundant SIP server, which shall automatically monitor the service capability of the main one. If there is a connection loss with both servers, local switching among gateway subscribers shall be saved.

The Analog VOIP Gateway shall have multilingual management interface and support for group management means based on DHCP (DHCP auto provisioning).

A unified management system shall be used for monitoring and control of a large number of gateways on a network. The system shall provide centralized management of a gateway group and its ports monitoring via the unified WEB interface

The main features of Analog VOIP Gateway shall be following as:

**a) VoIP protocols**

- SIP
- SIP-T
- H.323

**b) Voice codecs**

- G.729 (A, B)
- G.711 (a-law, μ-law)
- G.723.1 (6.3/5.3 Kbps)
- G.726 (32 Kbps)

**c) Fax**

- T.38 UDP Real-Time Fax
- G.711 (a-law, μ-law) pass-through

**d) Voice standards**

- VAD (voice activity detector)
- CNG (comfort noise generation)
- AEC (echo cancellation in accordance with ITU-T G.168)
- AGC (automatic gain control)
- PLC (packet loss concealment)

**e) Features**

- SIP server authentication with common username and password for all subscribers
- SIP server authentication with individual username and password for each subscriber
- Support for redundant SIP servers
- Support for Outbound SIP servers from DHCP Option 120
- Direct routing to the unregistered devices on a SIP server
- Internal switching is saved in case of SIP server connection loss
- Locally Supplementary Services' processing (distributed mini PBX mode)
- Regular expressions in Dial plan
- Caller and called numbers modifications
- Distinctive ring service
- User tone signals
- Limitation of simultaneous connections
- CPC (Calling Party Control): disconnect signal by circuit disruption
- Support for pay phone
- Support for operation behind NAT (STUN, Public IP)
- Signal generation when a handset is off-hooked



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- Supplementary Services management via phone added codes
- Applying of settings without reboot
- Forming of DHCP Option 82, Agent client circuit ID, Agent remote ID sub option

**f) Quality of service (QoS)**

- 4 priority queues
- Packet distribution to queues based on 802.1p and/or DSCP
- Assigning of DSCP and 802.1p priorities for SIP and RTP packets

**g) Value Added Services**

- Caller line identity presentation (CLIP)
- Issuing of a caller name and time of a call in FSK mode
- Calling line identification restriction (CLIR)
- Call Transfer
- Call Pickup
- 3-Way Conference
- Hotline/Warmline
- Call Waiting
- Call Forward (CFU, CFB, CFNR, CFOOS)
- Call Group
- Call Hold
- Music on Hold (MOH)
- Message-waiting indicator (MWI)
- Do not Disturb (DND)
- IMS (3GPP TS 24.623) for Call Hold, Call Waiting, 3-Way Conference, Hotline, Call Transfer

**h) Network functions**

- 802.1Q
- Possibility to use different VLAN for signaling, RTP and management
- SNTP
- Local and external DNS
- STP
- LLDP
- Dual homing redundancy
- IPSec
- Firewall

**i) Types of connections**

- Static IP address
- DHCP client
- PPPoE client
- PPTP client

**j) Remote monitoring**

- HTTP/HTTPS
- SNMP
- TR-069

**k) Configuring**

- HTTP/HTTPS, FTP/FTPS, TFTP
- Auto update of the firmware and configuration (DHCP)
- Command line interface (CLI) via Telnet, SSH, Console port RS-232
- Parameters configuring via SNMP (management system)
- WEB interface
- Parameters configuring via TR-069

**l) Diagnostics**

- Syslog
- Checking for a phone available on the line
- Subscriber lines parameters testing

**m) Statistics**

- Detailed statistics per port
- Call history

**n) Security**

- Username and password control
- Access rights differentiation: admin/user
- Configuration file encryption
- Access to WEB via RADIUS authentication
- Access to WEB only via HTTPS

#### 5.2.2.2.3 Operator Console Phone

The contractor shall provide Console Phone with an integrated switch. The Console Phone shall achieve high data processing speeds. The Console Phone shall support all major audio codecs used in VoIP networks (G.711 and G.729a), as well as Call Answer, Call Cancel, Audio Controls and training mode. The Console Phone shall have access to integrated hospitality features including room status, guest telephony privileges, automatic wake-up calls, room to room call blocking, occupancy status, guest check-in /check-out and guest reports. The Console Phone shall have direct connection of 48 IP Programmable Key Module that shall provide up to 96 additional Direct Station Select (DSS). The Console Phone shall have highly visible four line 80-character display which shall shows date, time, call status information, calling line identification, and calls waiting. The main feature of the Console Phone should be following as:

- 14 fixed function keys dedicated to basic and enhanced call-handling activities
- 10 Soft Keys that control access to the attendant features through call state sensitive keys
- Multiple call hold positions and line appearances
- Intelligent Directory and Live Content Suite applications support
- Support for Automatic Call Distribution (ACD) agent and supervisor
- Hands-free speakerphone operation (full duplex)



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- Secure Call Recorder Connector (SCRC) support as well as standard Record-a-Call functionality
- Two integrated headset / handset jacks
- Dual-port IP console (10/100 MB) switched
- Ethernet) – connect a computer and a console with a single Ethernet drop
- Multiple powering options (IEEE 802.3af compliant)
- Support IEEE 802.1p/q for Voice QoS
- Support RTP over UDP/TCP for Voice Traffic and Signaling
- Speak to multiple parties through conference calling
- Speak with parties in the conference individually through call splitting
- Change / clear users' status to "Do Not Disturb"
- Set / clear "Call Forward Always" on an extension
- Clear Call Forward Always, Do Not Disturb, and Message Waiting indications across all
- View system alarms and emergency call alarms
- Operating Temperature: -10°C to +45°C
- Relative Humidity: Up to 95%

#### 5.2.2.2.3.1 Medium Executive IP Phones

The IP Phone shall have these features:

- Power over Ethernet (PoE) for VP-15P
- 2 SIP accounts
- Auto provision (TR-069, DHCP)
- Headset connection
- Large LCD display

The IP phone shall have High quality of sound and high performance. All the main audio codecs shall use in VoIP networks (G.711, G.722, G.723.1, G.726, G.729). The IP Phone shall have Echo cancellation, Silence Detector, DTMF signals reception and generation as well as traffic prioritization (QoS) ensure high quality of voice data.

**a) Features and capabilities of IP Phone**

- 2 SIP accounts configuring independently
- Geographical redundancy of a SIP server (support for up to 4 SIP redundant servers)
- Flexible dial plan
- Operation without a SIP server
- Caller name and number displaying (Caller ID)
- Mute
- Redial
- Different ring-tones for different accounts
- Possibility to upload ring-tones to the phone
- Call history
- Local phonebook for 200 phone numbers



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- LDAP Remote Phonebook
- Speakerphone mode
- Short text messages transmitting and receiving (SIP MESSAGE)
- View voice mail counters
- Indication on waiting voice messages (MWI)
- Remote phonebook
- Displaying of watched subscriber line status (BLF)

**b) Value Added services**

- Call Hold
- Call Transfer
- Call Waiting
- Call Forward on Busy
- Call Forward on no response
- Call Forward unconditional
- Do not Disturb mode (DND)
- Caller Line Identification Restriction (CLIR)
- Local 3 Way-conference
- Support for remote conference according to RFC4579
- Hotline/warmline
- Intercom calls acceptance
- Automatic Call Answer
- Call Pickup

**c) Display and indicators**

- 3.2 inch (81 mm) backlit monochrome display, 128x64 resolutions
- Functional keys with LED indication: message, headset, mute, speakerphone
- Functional keys without LED indication: conference, call hold, call transfer, redial, volume adjustment keys
- 6 programmable keys

**d) VoIP protocol**

- SIP

**e) Audio codec support**

- G.711 a-law, μ-law
- G.723.1
- G.726
- G.729

**f) Voice standards**

- Voice activity detection (VAD)
- Acoustic Echo Suppression (AES)



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**g) Diagnostics**

- Device status monitoring via the web interface
- Displaying of debugging information in Syslog, Telnet

**h) Monitoring and management**

- Management web interface (Russian and English versions)
- SSH
- Telnet
- Auto provision (TR-069, DHCP)

**i) Network protocols and security**

- Data network connection: Static, DHCP, PPPoE, No IP
- Time and date synchronization via NTP
- QoS 802.1p, DSCP traffic marking
- Support for 802.1X
- Support for NAT traversal: STUN mode, Public IP
- Support for LLDP, LLDP MED
- Support for SIP over TLS
- Support for SRTP
- LDAP over TLS

**j) Technical features**

- RAM 128 MB
- Flash 16 MB
- Software redundancy
- 2xRJ45 10/100Mbps Ethernet ports
- 1xRJ9 (4P4C) for handset connection
- 1xRJ49 (4P4C) for hands-free connection
- Power over Ethernet technology
- Power adapter: 5 VDC, 2A
- Operating temperature: from +5°C to +40°C
- Operating relative humidity at +25°C: up to 80%
- Desktop case

### 5.2.2.2.3.2 Analog Phone

The instrument shall be standard single line push-button type with analogue voice transmission and adjustable volume control for the receive side. The keypad and dialing from the telephone set shall conform to the latest standard. The Employer shall approve the color of the telephone set. Type and make of the telephone along with technical information shall be supplied.

Telephone sets shall be supplied with CLI features. The telephone sets to be supplied shall comply with the following:

- Plug-in, coiled handset cord.



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- CLI
- Palladium silver contacts in the speech circuit.
- Adjustable ringing volume.
- Redial
- Flash
- Adjustable voice level.
- Service management function
- Dialing mode Pulse / Tone
- DTMF dialing system
- Last number redial function - REDIAL
- Transfer of calls function - FLASH
- Turn off the microphone during a call - MUTE
- Insert a pause between numbers dialed - PAUSE
- Ring tones - switching the ringer volume
- Signaling IN-USE
- Comfortable lightweight headset
- Mounted on a wall or desktop
- label to save your number
- Operating range - temperature from 0°C to 45°C
- Relative humidity up to 90% RH

#### 5.2.2.2.4 Main Distribution Frame

The termination equipment for the trunk and extensions circuits shall be wall-mounted type. It shall be sized to accommodate all internal and external circuits plus a twenty percent spare capacity. The connecting blocks will be of the quick-connect type. Each of the trunk circuits and outside cable pairs will be protected with over-voltage and over-current protectors. These protectors shall be either carbon or gas tube type. MDF shall have the capacity of 1x1000 Pair wiring Tag blocks.

#### 5.2.2.2.5 Power Supply

In the equipment room, the mains supply provided by WAPDA shall be available. The mains voltage (230 Volt AC/50 Hz) will be subject to possible fluctuations and variations normally encountered in the WAPDA power supply network. The Contractor shall be solely responsible to ensure that its proposed equipment is designed to function from the WAPDA mains voltage as well as on backup power supply system. Minimum four hours backup power supply shall be provided.

#### 5.2.2.2.6 Telephone Cables

The Telephone cables shall be multi-pair as mentioned in the Bill of Quantities. The cables shall be PVC insulated having 0.6 mm dia. Tinned copper conductor cables. The PVC conduits/Cable tray shall be used for the installation of Telephone System. Telephone cables Sizes shall be as per standard Length. Size of cable calculation shall be provided in drawing.

### 5.3 PUBLIC ADDRESS SYSTEM (PAS)

The system shall be modular in design, flexible and field programmable. The system shall feature an “attention alarm” signal to precede the spoken messages.

The PAS system shall be extended to the switchyard/Substation according to the requirements.

### 5.3.1 Microphone

The microphone shall be fitted on a table stand by means of a 'swan necked' flexible support. The table stand shall house the on/off switch and LED indicators, which shall indicate the "power on" status and the audio level output of the amplifier.

The microphone shall conform to the following specifications:

a. Type : Dynamic
b. Directivity pattern : Cardioid
c. Frequency range : 150-15000 Hz (3 dB points)
d. Impedance : 200 Ohm
e. Sensitivity : 1.65 mV/Pa
f. Front to rear ratio : 14 dB at 1000 Hz
g. Max. sound power level : 128 dB

### 5.3.2 Audio Amplifier and Distribution System

The audio amplifier and distribution system shall be supplied in a standard 19" rack and shall comply with the IEC standards laid down for such equipment.

The system shall be modular in structure. The electronics shall be protected against errors in switching, loading and connections as well as oscillations, open circuit and short circuits.

The input module shall accept at least two microphone inputs. Level adjustment for each input shall be provided on the front panel of the module.

The output amplifier module shall be capable of delivering up to 250 W of audio power with minimum distortion. Two such output modules shall be provided to share the total load. The audio distribution shall be such as to ensure that partial public address facility is available at all key locations in the event of failure of one power amplifier.

It shall be possible to individually select a loud speaker or a group of loud speakers by simply pressing an identified push button. The unit shall be able to handle minimum four such identification push buttons. It shall be possible to program a loud speaker or a group of loud speakers for control from any one of the identifications pushes buttons. In addition, a universal push button for broadcasting the message to all loud speakers shall also be provided.

An "attention alarm" signal module shall also be provided. The attention alarm shall be a two/four tone chime with adjustable pitch and repetition rate. It shall be activated from the microphone "on" switch at the operator's desk so that it precedes each spoken announcement. Feedback of the attention alarm signal shall be provided at the operator's desk. The electronics shall ensure that the microphone remains un-operational while the attention signal is on.

In addition to above, the audio amplifier equipment shall feature a limiter circuit to restrict the output level by reducing the amplification factor under conditions of excessively high input peaks so as to protect the amplifier from being over driven.

The amplifier equipment shall be provided with suitable indicators for following indications:

a. On/Off indication



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b. Audio output level indication

A local monitor loud speaker shall also be provided. The audio distribution shall be achieved through delay lines with adjustable delays to compensate for such problems as dead spots and reverberation. The Contractor shall determine the exact quantity of delay lines required to achieve a satisfactory solution. The PAS shall interface to EPABX to facilitate public announcements from the telephone sets.

Main technical features of the audio amplifier system shall conform to the following:

a. Power output: 250 W per output module
b. Total harmonic distortion at 1000 Hz: 0.5%
c. Effective frequency range (3 dB points): 200 to 10000 Hz
d. Signal to noise ratio (with microphone controls down): 90 dB
e. Temperature range for guaranteed operation: -10 to 50°C

### 5.3.3 Loudspeakers

#### a) Column

Column type loudspeakers shall be provided at various locations within the power house control building. The Contractor may also propose alternate type provided full justification of its benefits is elaborated. The columns shall be installed on adjustable mounting brackets.

The main technical features of the loudspeakers shall conform to the following:

a. Sound projection pattern: Cardioid (horizontal plane).
b. Beamwidth: In vertical plane shall be proposed by the Contractor according to floor dimensions, angle and height of mounting.
c. Power output: 12 W with adjustable taps for 18W&6W
d. Frequency range: 200-10000 Hz.
e. Sound pressure: 113 dB at 24 W.
f. The column shall be encased in a casing which is durable and suitable for use in industrial environment.
g. Connection to the audio amplifier of various loudspeaker columns shall be such that no appreciable mismatch with the audio amplifier would occur in case of a failure of one loudspeaker column.

#### b) Flush Mounted

Flush mounted loudspeakers shall be provided wherever false ceiling is available within the power house control building. The specifications shall, in general, be the same as that for the column type stated above.

#### c) Horns

At selected locations within the switchyard and other outdoor locations, horns loudspeakers shall be provided that cover the entire switchyard area and outdoor premises.

### 5.3.4 Cables

Sufficient microphone, loudspeaker and power supply cables shall be provided. The cables shall be installed in trenches/cable trays and no cable splicing shall be allowed.



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The main features of the microphone and loudspeaker cables shall be:

**a) Microphone Cable**

a. Impedance (wave) : 75 ohms
b. Insulation voltage (shielded pairs) : 1000 V
c. Cross-section : Stranded copper wire, suitable for microphone drain current (min. 20 mA)
d. Type of cable : Twisted (1 pair) copper shielded

**b) Loudspeaker Cable**

a. Insulation voltage : 1000 V
b. Cross-section : Min. 0.25 m2, stranded copper wire
c. Type of cable : Twisted (1 pair) copper shielded

### 5.3.5 Power Supply

The equipment shall be powered from the 220V AC power system.

## 5.4 VIDEO SURVEILLANCE (CCTV) SYSTEM

### 5.4.1 General

The Video surveillance system shall comprise CCTV cameras, power supplies and video recording equipment enabling selected locations of the power house premises to be monitored remotely from the power house control building. The objective of video surveillance system shall be to monitor the entry/exit gates, boundaries, power house premises for security purposes and operational monitoring.

Video archives for past seven days shall be maintained to facilitate post facto analyses of any untoward incidents. System design shall be flexible to permit future extension of the system. This subsystem shall comprise of the following major components:

a. Video cameras
b. A network video recorder capable of storing video bit streams generated by each camera of up to the last seven days.

The CCTV system shall be extended to the switchyard according to the requirements including outdoor-rated cameras and accessories suitable for harsh environmental conditions.

### 5.4.2 Operational and Control Philosophy

The video Surveillance system shall comprise of a number of camera sites transmitting digital (i.e., encoded) images to the Network video Recorder (NVR) installed at control building and receiving camera control commands from the system operator or the system monitor located in the at the control room. The video Surveillance system includes the control building head-end electronic subsystem, which receives, decodes, and disseminates images and data from the field and commands the control and display infrastructure. Video surveillance system shall monitor the gates and associated structure for trouble free operation and also serve as a security tool. System design shall be flexible to permit extension to give video coverage of key areas of the premises to help identify any unusual activity. CCTV video bit streams shall be switched at layer 3 network switches. All CCTV cameras shall be mounted on a suitable structure.



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### 5.4.3 Component Definitions Camera Assembly

The camera assembly shall be defined as a closed-circuit television (CCTV) color camera enclosed in a domed, environmental housing with an integral motorized lens, a camera positioner, an integral receiver/driver, a pole and/or base-mounted control cabinet, any and all mounting hardware and power supplies, a local control panel, an image encoding device, a control data transceiver, and the required communication interface device. The camera assembly shall be capable of individual, or local, camera site control by way of a Pan, Tilt and Zoom (PTZ) controller composed of dedicated hardware or soft configured on the monitoring station.

### 5.4.4 Functional Provisions

The Video Surveillance system shall be managed with commands and control from a system operator who shall decide which visual images shall be collected from the camera site. The system operator shall prescribe those images through control of the CCTV cameras field of view with the pan, tilt, and zoom feature, The Video Surveillance system shall manage the transmission of the prescribed images based on the system operator, designated monitoring terminal in the control building. The images shall then be processed and, at the option of the system operator, displayed as commanded on monitors and/or wall mounted LED mimic board. The system operator shall have the ability to control all internal and external functions of the camera assembly from the monitoring terminal.

### 5.4.5 Main Equipment Specifications

**a) Pan/Tilt/Zoom (PTZ) IP Day/Night Color Doom Camera**

a. Pan 360° endless, 0.2°/s– 350°/s
b. Tilt: 180°, 0.2°/s–350°/s
c. Image Sensor: Progressive scan CMOS 1/2.8” or higher
d. 30x Optical zoom and 12x Digital zoom
e. Auto camera tour and 20 preset points or more.
f. Support static or dynamic IP
g. Alarm Inputs: 2 or higher
h. Memory: 512 MB RAM, 256 MB Flash
i. Minimum Illumination: 0.1 Lux @F2.0
j. Auto-focus and Auto-iris
k. Supported Protocols: IPv4/v6, HTTP, TCP
l. Video Compression: H.264 (MPEG-4 Part 10/AVC)
m. Resolution:1920x1080 (HDTV 1080p)
n. Frame Rate of up to 30 fps (50/60 Hz) or more in all resolutions
o. Power: PoE (Power over Ethernet), IEEE 802.3af/802.3at
p. Casing: IP66-, IK10- and NEMA 4X-rated

**b) Fixed IP Day/Night Color Camera**

q. Image Sensor: Progressive scan CMOS 1/2.8” or higher
r. 30x Optical zoom and 12x Digital zoom
s. Auto camera tour and 20 preset points or more.
t. Support static or dynamic IP



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u. Alarm Inputs: 2 or higher
v. Memory: 512 MB RAM, 256 MB Flash
w. Minimum Illumination: 0.12 Lux @ F1.4 (30fps)
x. Lens: 3-10mm, F1.4 or higher, Digital PTZ
y. Autofocus, P-iris and IR corrected
z. Supported Protocols: IPv4/v6, HTTP, TCP
aa. Video Compression: H.264 (MPEG-4 Part 10/AVC)
bb. Resolution:1920x1080 (HDTV 1080p)
cc. Frame Rate of up to 30 fps (50/60 Hz) or more in all resolutions
dd. Power: PoE (Power over Ethernet), IEEE 802.3af/802.3at
a. Casing: IP66-, IK10- and NEMA 4X-rated

**c) Network Video Recorder (NVR)**

a. Built in network Interface 100 base TX, RI45 connector
b. Support for Internet Protocol: TCP/IP, UDP/IP, HTTP, FTP, SNMP
c. Built in digital motion detector (on/off)
d. System shall be triplex i.e. facilities for view, recording and replay.
e. MPEG-4 and JPEG dual stream output for simultaneous live monitoring and high-resolution recording.
f. View up to 8 cameras simultaneously.
g. Simultaneous recording and playback with 400 fps.
h. Network video Management system: Advanced and reliable IP camera surveillance software with full functions for advanced management, flexible scheduling, fast searching and analysis, images from multiple locations can be stored and managed centrally, allowing for authorized access from anywhere.
i. DVD Writer support. A user-friendly software utility to support the DVD writing to be provided.
j. User friendly GUI based interface of software for PTZ control and other features.
k. Data storage: Minimum 4 TB. The system shall follow FIFO recording.

### 5.5 VHF RADIO SYSTEMGeneral

This section describes services and deliverables for the two ways Radio Dispatching System required for Attabad Lake HPP.

#### 5.5.2 VHF Repeater/Base Station (BS)

Two-way VHF radio base system shall offer maximum mobility, ruggedness, and all-weather operation to allow the personnel to be instantly connected. Repeater/BS shall work in full duplex mode in frequency range of 134-174 MHz. The system shall have robust heat sink, large cooling fans and a high-performance power module to be able to provide up to 50W stable power at full duty cycle operation. A built-in backup support system shall be provided to automatically switch to an external power supply if the AC power supply fails. The cooling fan shall be thermostatically controlled to ensure a stable temperature environment. Suitable omnidirectional antenna and coaxial cable shall be provided for complete installation of the system.



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BS shall have LED display and flexible scanning features to optimize operations in a wide variety of environments.

The system shall be able to program up to 16 CTCSS/DTCS tones (TX/RX tones respectively) in a channel to allow sharing the channel with multiple personnel groups.

Additionally, the system shale be programmed to have different tones for priority/exclusive use to a specified group.

VHF BS shall be mounted on a 19" rack with self-diagnostic function to check for intimal errors and faults.

### 5.5.3 VHF Walkie Talkie Sets

Walkie Talkie sets shall be rugged, suitable for rough use typically military applications and able to withstand physical shocks due to accidental dropping of the device. Walkie Talkie sets shall be light weight, compact without sacrificing the performance and need reach required for the Project. Sets shall have powerful Li-Ion battery providing at least l6 hours of operation. Walkie Talkie sets shall be able to alert the user when it goes out of range. BS thus shall be able to alert the field unit to move back into range. Walkie Talkie sets shall have built in timer requiring the user to reset at a predetermined interval. If not reset Walkie Talkie shall enable emergency mode to alert help.

### 5.5.4 Dispatch Console

A PC based modular workstation shall be provided for maximum control and reliability for sophisticated conventional and trunking system. The dispatch console workstation shall provide fully functioned dispatch capabilities for conventional radio systems and shall be able to control multiple, wireless radio systems. The dispatch system workstation shall be based on a standard Microsoft® Windows® environment, with a touch screen capability. Dispatch console shall have simple and easy to use interface with user-friendly icons, menus and screen layouts with telephone, paging and signaling resources on one screen, which shall be able to customize conveniently for individual users and shall have quick response time. The interface shall also give users a complete overview of dispatching activity for managing information.

### 5.5.5 VHF Vehicular Mobile Station (MS)

Mobile VHF transceiver shall have MIL grade rugged construction with high quality front mounted speakers, DTMF microphone and programmable buttons. Mobile station shall have multiple 2-tones, 5-tone signaling with lone worker function. VHF mobile station shall have built in encoder/decoder CTCSS and DCS able to operate 42 and 104 CTCSS and DCS undertone frequencies respectively. VHF MS shall have automatic repeater checker and automatic warning on/off features.

1/4 wave radiating mobile VHF antenna shall be provided typically working in the frequency range of 135-175MHz with typical length of 52cm. Antenna shall be made of Stainless-steel tapered rod with vertical polarization.

### 5.5.6 Frequency Allocation

Employer shall obtain the license from FAB and PTA for the proposed 37MHz (137- 174MHz) spectrum required for the VHF communication in the powerhouse premises. Contractor shall provide full technical assistance for licensing documentation.

## 5.6 SPARE PARTS

The Proposers shall submit the list of Spare Parts with his Proposal along with unit rates for each spare.

The cost of the spare parts shall be included in the cost of equipment to be supplied

and installed by the Contractor. The list of spares shall be prepared by the Proposer on the following basis:

- The spares shall be sufficient for five (5) years of operation.
- At least one module of each type shall be included in the spare parts list, if the total amount of modules is less than or equal to ten (10).
- If the total number of modules is more than ten (10), the spare modules to be supplied shall be at least ten percent (10 %) of the total number of modules (the fractions shall be rounded off to the nearest higher integer).
- The Proposer shall demonstrate that the above criteria have been followed while submitting the spare part list.

## 5.7 TESTS / INSPECTION

### 5.7.1 General

All type and routine tests on each equipment shall be performed at the manufacturer's works in the presence of the Employer or his representative. Type tests may be waived off in case test certificates as certified by an approved standard laboratory of repute approved by the Employer. Submission or merely producing the type test certificates shall not relieve the Contractor to carry out the required standard/routine tests.

The Contractor shall inform the Employer about the date and time of test of each equipment at least two weeks in advance. The witnessing of test by the Employer or his representative shall not absolve the Contractor from his responsibility for the proper functioning of the equipment, and for furnishing the guarantees.

### 5.7.2 Test and Inspection

Within two months of the commencement date the Contractor shall submit for the approval of the Employer a Test and Inspection Plan for all items whether at the manufacture's location, the Site or elsewhere up to the date of taking over certificate in accordance with the provisions of the Contract. Such plan shall be in two parts covering factory tests and site tests respectively. The plan shall include a description of the item or part of the Works to be inspected or tested, the nature and frequency of the inspection and testing, the type and size of samples to be taken (if any), the means of recording the test and inspection data, the name and specific responsibilities of any proposed test and inspection agency and all other information necessary to describe the test or inspection to be performed. Not later than two months prior to the commencement of any particular test full details of the proposed method of test, test parameters and test circuits shall be submitted for the Employer approval and following such approval shall become part of the Test and Inspection Plan.

Such plan, as approved and modified by the Employer, shall be used for the inspection and testing and shall be revised and resubmitted for the Employer approval if the Contractor desires to change the sequence, method or nature of the test or inspection or if such a change is required by changes in the Work Program or scope of the Work.



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Measuring equipment shall be subject to the Employer approval and, if required by the Employer, it shall be calibrated at such independent laboratory as may be agreed. The cost of any such calibration shall be demand to be included in the BOQ rates and prices.

The cost of all tests required by the Specification, including the cost of providing samples where needed, shall be borne by the Contractor.

No approval of tests or inspection of the Work or portions of the Work by the Employer shall relieve the Contractor of his responsibility to complete the Work according to the Specification, including the satisfactory execution of all necessary site inspections and tests nor shall it relieve him of his duties and obligations under the Contract.

**5.7.3 Factory Acceptance Test (FAT)**

Factory Acceptance Test procedure shall be prepared by Proposer along with Quality Assurance Plan. The document shall be subject to Employer approval.

All major equipment and Extra Low Voltage (ELV) System equipment shall be tested in the factory prior to clearance for shipping. The FAT shall include individual equipment tests under fully assembled condition.

The FAT shall demonstrate adherence that the equipment meets the design standards and functional compliance. One (1) month prior to the FAT, Proposer shall submit a test procedure to the Employer for approval. Duration of FAT at manufacturer's works shall be at least one week.

Owner's representative may, at Employers sole discretion, attend the FAT. In this event, Proposer shall ensure all tests shall be carried out in the presence of Employer personnel. If Employers declines to attend the FAT, Proposer shall carry out these tests and submit the results to Employers for review. Factory Acceptance Tests (FATs) shall be documented with the results obtained and the success or failure of the test. The test results shall be submitted to Employers prior to clearance of the FAT and authority by Owner is given to ship.

"All major equipment and Extra Low Voltage (ELV) System equipment to be supplied under this Contract which has been manufactured in or outside Pakistan shall be subject to inspection by Employers or its authorized representative at its points of original manufacture before its dispatch to site. The Contractor shall make necessary arrangement and provide all the facilities required for such inspection".

Pre-Inspection Tests and Factory acceptance tests (within Pakistan and abroad) shall be witnessed by the representatives of the Employer and Employer or any other internationally certified testing agency/body as appointed by the Employer. All costs in connection with witnessing of the factory acceptance tests by the representative of Employer/testing agency/body shall be borne by the Contractor. In case the factory acceptance test is witnessed by the representatives of Employer, the Contractor shall bear all the costs that shall include the costs of first class air travel from Pakistan to place of inspection/testing and back.

Prior to taking over of the works or any section or to putting any portion of the works into service, the Contractor shall carry out Tests on Completion in accordance with the provisions of the Specification. The tests shall be carried out in the presence and to the satisfaction of the Employer.



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# SECTION 6 132 kV SWITCHYARD

## 6.1 SCOPE OF WORK

The Design, Supply, Installation, Testing and Commissioning of Plant & Equipment for 132 kV switchyard at Attabad Lake HPP which consist of Three (03) Transformer Bays ( Generator Step Up Transformers), One (01) Power Transformer Bay and Three (03) 132 kV Transmission Line Bays. The 132 Kv Transmission Line bays shall be arranged in One-and-a-Half Circuit Breaker Scheme. The Attabad Lake Hydropower Project (54 MW) shall be interconnected to the proposed 132/66 kV Regional Grid Station at Aliabad and 132/11 kV Grid Station at Sost. One Double Circuit 132 kV Transmission Line about 14.5 km long from 132 kV Switchyard of Attabad Lake HPP to proposed 132/66 kV Regional Grid Station Aliabad and one 132 kV Single Circuit Transmission Line about 70 km long from 132 kV Switchyard of Attabad Lake HPP to 132/11 kV Grid Station at Sost have been proposed for dispersal of energy generated at Attabad Lake HPP. The synchronization with the Gilgit Regional Grid system is proposed to be carried out in the Attabad Lake HPP Powerhouse Control Room. The scope of Remote end bays including 132kV transmission lines shall be covered in separate package.

The interconnection with 132 kV Switchyard and Power Plant of Attabad Lake HPP shall be through 11 kV Segregated Phase Bus in underground trench. The AC auxiliary supply shall be fed from Power Plant through One (01) feeder and the other feeder shall be taken from 132 kV Switchyard. The complete DC Supply System shall be installed in 132 kV Switchyard Control House Building.

The scope of Facilities includes Design, Manufacture, Supply, Insurance to Site, Delivery to wharf at Sea Port in Pakistan, unloading and loading at Sea Port, Transportation to the 132 kV Switchyard site, Unloading and Storage at Site, Installation, Testing and Commissioning of Plant & Equipment for 132 kV Switchyard as specified in the Employer's Requirements.

All Materials, Tools, Equipment and Services, necessary for the reliable and safe operation of the 132 kV Switchyard, whether specified in the Document or not, shall be included in the Proposal except items specifically excluded from the scope of Facilities as listed in this Section.

The Type Tests Reports for all the specified Equipment including Circuit Breakers, Disconnectors & Earthing Switches, Current Transformers, CCVTs, Surge Arresters, Protection System, Line Traps, Line Matching Units, Power Line Carrier and Protection Signaling Equipment from any of the specified Independent Authority/Independent Laboratory pursuant to Employer's Requirement shall be provided for all the specified Type Tests specific to the offered Equipment. In case the Type Test Reports are not available, these type tests shall be carried out in accordance with the relevant provisions of Employer's Requirement in the presence of the Employer and Employer's Representative at no additional cost to Employer, at the time of routine tests at the Manufacturer's Workshop. If facilities for type tests are not available at Manufacturer's premises, these type tests shall be got carried out from one of the Independent Laboratories specified in the Employer's Requirement.

The Facilities shall also include provision of Spare Parts, Erection and Testing Equipment and Maintenance Tools, and Training of the Employer's Staff in accordance with the provisions listed in the Employer's Requirement.



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The Facilities have been provided in Specifications, Drawings and indicated in the Single Line Diagram (SLD), 132 kV Switchyard Layout Plan and other relevant Drawings, shall also help in understanding the scope of work for 132 kV Switchyard.

a) The 132 kV Switchyard Equipment to be provided, Installed, Tested and Commissioned at the 132 kV Switchyard includes but is not limited to the following:

1. Circuit Breakers.
2. Disconnectors.
3. Disconnectors with Earthing Switches.
4. Current Transformers.
5. Capacitor Voltage Transformers.
6. Surge Arresters.
7. Line Traps/Fiber.
8. High voltage Bus Work.
9. Steel Structures.
10. 132 kV Switchyard Grounding System (Only Equipment Protective Earthing Connection).
11. Paging System.
12. Secure Metering System.
13. Relay Boards and Protective Relaying Systems.
14. Control and Small Power Cables.
15. AC Auxiliary Supply Board and DC Supply System.
16. Telecommunication and SCADA Systems.
17. Testing and Maintenance Equipment.
18. CCTV System and PAS System as per specifications mentioned in the Section 5 of this Document.
19. All other Auxiliary items for the completion of work including testing Devices, Equipment and Spare Parts as listed in the Specifications.
20. Cable Trays, Ladders, Conduits and Accessories inside the 132 kV Switchyard and Control House Building/Generator Room.
21. Any other item which is not included here but is necessary for integrated operation of the Plant as advised by the Employer

The Civil Works required for all the above-mentioned facilities shall not be a part of E&M EPC Contractor's Scope. The Civil Works Scope for above mentioned facilities shall be provided by Civil EPC Contractor (Package-I)

The Technical Provisions of various Equipment have been given in the relevant sections.

## 6.2 ENVIRONMENTAL CONDITIONS AND APPLICABLE STANDARDS

### 6.2.1 Site Investigation

Location of the switchyard Site is stated in Volume-II Part-III.

### 6.2.2 Applicable Standards and Codes



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All Plant for switchyard design shall be generally in accordance with latest revision of the following standards except where specifically directed otherwise. The latest applicable standards shall be those which are in force thirty (30) days prior to the date of Proposal opening.

### 6.2.2.1 General

| | |
|---|---|
| IEC 60050(151) | International Electrotechnical Vocabulary<br>Part 51: Electrical and Magnetic Devices |
| IEC 60050(441) | Chapter 441: Switchgear Control gear and fuses. |
| IEC 60050(601) | Chapter 601: Generation, transmission and distribution of electricity - General. |
| IEC 60050(604) | Chapter 601: Generation, transmission and distribution of electricity - Operation. |
| IEC 60059 | IEC Standard current ratings. |
| | IEC 60050 International Electrotechnical Vocabulary |
| IEC 60071-1 | Insulation Co-ordination Part-1: Definitions, Principles and Rules. |
| IEC 60071-2 | Insulation Co-ordination<br>Part 2: Application Guide |
| IEC 60417 | Graphical Symbols for Use on Equipment, Index, Survey and Compilation of Single Sheet |
| IEC 60417L | Eleventh Supplement |
| IEC 60417M | Twelfth Supplement |
| IEC 60417N | Thirteenth Supplement |
| IEC 60417O | IEC 417 Supplement O |
| IEC 60417P | Fifteenth Supplement |
| IEC 60617-1 | Graphical Symbols for Diagrams. Part 1: General Information, General Index Cross - Reference Table. |
| IEC 60617-2 | Graphical Symbols for Diagrams - Part 2: Symbol Elements and other symbols having general application. |
| IEC 60617-3 | Graphical Symbols for Diagrams - Part 3: Conductors and Connecting Devices |
| IEC 60617-4 | Graphical Symbols for Diagrams - Part 4: Passive Components |



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| | |
|---|---|
| IEC 60617-5 | Graphical Symbols for Diagrams - Part 5: Semiconductors and Electron Tubes. |
| IEC 60617-6 | Graphical Symbols for Diagrams - Part 6: Production and Conversion of Electrical Energy. |
| IEC 60617-7 | Graphical Symbols for Diagrams - Part 7: Switchgear, Control gear and Protective Devices |
| | Graphical Symbols for Diagrams - Part 8: Measuring Instruments, Lamps and Signaling Devices |
| IEC 60617-9 | Graphical Symbols for Diagrams - Part 9: Telecommunication Switching and Peripheral Equipment |
| IEC 60617-10 | Graphical Symbols for Diagrams - Part 10: Telecommunication and Transmission |
| IEC 60617-11 | Graphical Symbols for Diagrams - Part 11: Architectural and Graphical Installation Plans and Diagrams |
| IEC 60617-12 | Graphical Symbols for Diagrams - Part 12: Binary Logic Elements |
| IEC 60617-13 | Graphical Symbols for Diagrams - Part 13: Analogue Elements |

**6.2.2.2 Insulation Media**

| | |
|---|---|
| IEC 60156 | Insulating Liquids - Determination of the Breakdown Voltage at Power Frequency - Test Method |
| IEC 60247 | Measurement of Relative Permittivity, Dielectric Dissipation Factor and D.C. Resistivity of Insulating Liquids. |
| IEC 60296 | Specifications for Unused Mineral Insulating Oils for Transformers and Switchgear |
| IEC 60376 | Specification and Acceptance of New Sulphur Hexafluoride |
| IEC 60376A | First Supplement: Section Thirteen. Mineral Oil Content |
| | Second Supplement: Clause 26 |
| IEC 60475 | Method of Sampling Liquid Dielectrics |
| IEC 60480 | Guide to the Checking of SF6 Taken From Electrical Equipment |

### 6.2.2.3 Generator Step-Up Transformers

Specifications/standards of the Generator step up transformers are given in the plant electrical section-3.

### 6.2.2.4 Switchgear

| | |
|---|---|
| IEC 62271-1 | Common Specifications |
| IEC 62271-100 | High Voltage Switchgear and Control gear<br>Part-100:<br>High Voltage Alternating Current Circuit Breakers |
| IEC 62271-102 | Part 102: High Voltage alternating current disconnectors and earthing switches. |
| IEC 62271-200 | Part-110: Inductive Load Switching<br>Part-200: AC metal-enclosed switchgear and control gear for rated voltages above 1 kV and up to and including 52 kV.<br>Part-101: Synthetic Testing.<br>Part-*(300): Guide for Seismic qualification of high voltage alternating current circuit breakers.<br>Part-*(303): Use and handling of Sulphur hexafluoride (SF6) in high voltage switchgear and control gear.<br>Part-*(307): Use of electronic and associated technologies in auxiliary equipment of switchgear and control gear.<br>Part 308: Guide for asymmetrical short-circuit breaking test duty T100a.<br>Part-309: TRV parameters for high voltage switchgear and control gear for rated voltages above 1 kV and less than 100 kV.<br>Part 310: Electrical endurance testing of circuit breakers rated 72.5 kV and above.<br>*(xxx) Final number to be given by IEC. |
| IEC 60947 | Low-Voltage Switchgear and Control gear |
| IEC 62271-103 | HV Switchgear and Control gear for Rated Voltages Above 1kV up to and Including 52kV |
| IEC 60265-1-am1 | Amendment No. 1 |
| IEC 60265-1-am2 | Amendment No. 2 |
| IEC 62271-104 | High-voltage switchgear and control gear - Part 104: Alternating current switches for rated voltages higher than 52 kV |
| IEC 60265-2-am1 | Amendment No. 1 |



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| | |
|---|---|
| IEC 60439-1 | Low-Voltage Switchgear and Control gear Assemblies - Part 1: Type Tested and Partially Type Tested Assemblies. |
| IEC 60439-1-am1 | Amendment No. 1 |
| IEC 60439-1-am2 | Amendment No. 2 |
| IEC 60439-6 | Low Voltage Switchgear and Control gear Assemblies - Part 6: Particular Requirements for Busbar Trunking Systems (Busways) |
| IEC 60439-2-am1 | Amendment No. 1 |
| IEC 61439-3 | Low-voltage switchgear and control gear assemblies - Part 3: Distribution boards intended to be operated by ordinary persons (DBO) |
| IEC 60439-3-am1 | Amendment No. 1 |
| IEC 61439-4 | Low Voltage Switchgear and Control gear Assemblies Part 4: Particular Requirements for Assemblies for Construction Sites (ACS) |
| IEC 60439-4-am1 | Amendment No. 1 |
| IEC 60439-5 | Low-voltage switchgear and control gear assemblies - Part 5: Assemblies for power distribution in public networks. |
| IEC 60943 | Guidance concerning the permissible temperature rise for parts electrical equipment, in particular for terminals |

**6.2.2.5 Power & Control Cables**

| | |
|---|---|
| IEC 60183 | Guide to the Selection of High Voltage Cables |
| IEC 60183-am1 | Amendment No. 1 |
| IEC 60230 | Impulse Tests on Cables and their Accessories |
| IEC 60287-1-1 | Electric Cables - Calculation of the Current Rating - Part 1: Current Rating Equations (100% load factor) and Calculation of Losses - Section 1: General |
| IEC 60287-1-1-am1 | Amendment No. 1 |
| IEC 60287-1-2 | Electric Cables - Calculation of the Current Rating - Part 1: Current Rating Equations (100% load factor) and Calculation of Losses - Section 2: Sheath Eddy Current Loss Factors for Two Circuits in Flat Formation |
| IEC 60287-2-1 | Electric Cables - Calculation of the Current Rating - Part 2: Thermal Resistance - Section 1: Calculation of Thermal Resistance. |



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| | |
|---|---|
| IEC 60287-2-2 | Electric Cables - Calculation of the Current Rating - Part 2: A Method for Calculating Reduction Factors for Groups of Cables in Free Air, Protected from Solar Radiation. |
| IEC 60287-3-1 | Electric Cables - Calculation of the Current Rating - Part 3: Sections on Operating Conditions - Section 1: Reference Operating Conditions and Selection of Cable Type. |
| IEC 60287-3-2 | Electric Cables - Calculation of the Current Rating - Part 3: Sections on Operating Conditions - Section 2: Economic Optimization of Power Cable Size. |
| IEC 60287-3-2 - am1 | Amendment No. 1 to IEC 287-3-2 |
| IEC 60228 | Conductors of insulated cables |
| IEC 60811 | Common test methods for insulating and sheaths material of electric (Series) cables. |
| IEC 60502-1 | Power Cables with Extruded Insulation and their Accessories for Rated Voltages from 1kV (Um=1.2kV) up to 30kV (Um=36kV) - Part 1: Cables for Rated Voltages of 1kV (Um=1.2kV) and 3kV (Um=3.6kV) |
| IEC 60502-2 | Power Cables with Extruded Insulation and their Accessories for Rated Voltages from 1kV (Um=1.2kV) up to 30kV (Um=36kV) - Part 2: Cables for Rated Voltages from 6kV (Um=7.2kV) up to 30kV (Um=36kV) |
| IEC 60502-4 | Power Cables with Extruded Insulation and their Accessories for Rated Voltages from 1kV (Um=1.2kV) up to 30kV (Um=36kV) - Part 4: Test Requirements on Accessories for Cables with Rated Voltages from 6kV (Um=7.2kV) up to 30kV (Um=36kV) |
| IEC 60529 | Degree of protection provided by Enclosures (IP Code). |
| IEC 61000-4-3 | Electromagnetic compatibility (EMC),<br>Part 4-3: Testing and Measurement Techniques - Radiated, Radio Frequency, electromagnetic Field Immunity Test. |
| IEC 61000-4-2 | Testing and Measurement Techniques - Electrostatic Discharge Immunity Test. |



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### 6.2.2.6 Batteries

| | |
|---|---|
| IEC 60896-11 | Stationary Lead Acid Batteries - General Requirements and Methods of Test - Part 11: Vented Types. |
| IEC 60896-1-am1 | Amendment No. 1 |
| IEC 60896-1-am2 | Amendment No. 2 |
| IEC60896-21 | Stationary Lead Acid Batteries - Test Methods |
| IEC 60896-22 | Stationary Lead Acid Batteries - General Requirements |

### 6.2.2.7 Insulator and Bushing

| | |
|---|---|
| IEC 60137 | Insulating Bushings for Alternating Voltages above 1000V. |
| IEC 60168 | Test on Indoor and Outdoor Post Insulator of Ceramic Material or Glass for System with Nominal Voltages Greater than 1000V. |
| IEC 60168-am1 | Amendment No. 1 |
| IEC 60273 | Characteristics of Indoor and Outdoor Post Insulators for Systems with Normal Voltages Greater than 1000 V. |
| IEC 60383-1 | Insulators for Overhead Lines with a Nominal Voltage above 1000V Part 1: Ceramic or Glass Insulator Units for A.C. Systems - Definitions, Test Methods and Acceptance Criteria. |
| IEC 60383-2 | Insulators for Overhead Lines with a Nominal Voltage above 1000V Part 2: Insulator Strings and Insulator Sets for A.C. Systems - Definitions, Test Methods and Acceptance Criteria. |
| IEC 60437 | Radio Interference Test on High Voltage Insulators. |
| IEC 60471 | Dimensions of Clevis and Tongue Couplings of String Insulator Units. |
| IEC 60471-am1 | Amendment No. 1 |
| IEC 60506 | Switching Impulse Tests on High Voltage Insulators |
| IEC 60507 | Artificial Pollution Tests on High Voltage Insulators to be used on A.C. Systems |
| IEC TR 60575 | Thermal-Mechanical, Performance Test and Mechanical Performance Test on String Insulator Units |
| IEC 60815 | Guide for the Selection of Insulators in respect of polluted conditions. |



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### 6.2.2.8 Surge Arresters

| | |
|---|---|
| IEC 60099-1 | Surge Arresters Part 1: Non-linear Resistor Type Gapped Arresters for A.C. Systems |
| IEC/TR 60099-3 | Surge Arresters Part 3: Artificial Pollution Testing of Surge Arresters. |
| IEC 60099-4 | Surge Arresters - Part 4: Metal Oxide Surge Arresters Without Gaps for ac System. |
| IEC 60099-5 | Surge Arresters - Part 5: Selection |

### 6.2.2.9 Instrument Transformers

| | |
|---|---|
| IEC 61869-2 | Instrument Transformers:<br>Part 2: Additional requirements for current transformers |
| IEC 61869-3 | Part 3: Additional requirements for inductive voltage transformers |
| IEC 61869-4 | Part 4: Additional requirements for combined transformers |
| IEC 61869-5 | Part 5: Additional requirements for capacitor voltage transformers |
| IEC 61869-6 | Part 6: Requirements for Protection Current Transformers for Transient Performance. |

### 6.2.2.10 Relays

| | |
|---|---|
| IEC 60255 | Electrical Relays |

### 6.2.2.11 Switchyard Automation System

IEC 61850
IEC 60870-5-101/04

### 6.2.2.12 High Voltage Test

| | |
|---|---|
| IEC 60052 | Voltage measurement by means of standard air gap |
| IEC 60060-1 | High Voltage Test Techniques<br>Part-1: General Definitions and Test Requirements. |
| IEC 60060-2 | High Voltage Test Techniques<br>Part-2: Measuring Systems |
| IEC 60060-2-am1 | Amendment No. 1 to IEC 60060-2 |
| IEC 60270 | High Voltage Test Techniques -<br>Partial Discharge Measurements |
| IEC 62271 | High-voltage switchgear and control gear |



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### 6.2.2.13 Telecommunication and Tele-protection

| | |
|---|---|
| IEC 60663 | Planning of (SSB) PLC Systems |
| IEC 60353 | Line Traps for A.C. Power Systems |
| IEC 60481 | Coupling Devices for PLC Systems |
| IEC 60358 | Coupling Capacitors and Capacitor Divider |

### 6.2.2.14 Steel Structure

| | |
|---|---|
| ASCE Manual No. 74 | Guidelines for Transmission Line Structural Loading Published by American Society of Civil Engineers in 2010 (3rd Edition) |
| ASCE 10-97 | Design of Latticed Steel Transmission Structures |
| ASCE Manual No. 113 | Switchyard Structure Design Guide |
| EN 10025 | EURONORM Standard Specification for Structural Steel; Rolled Steel, Steel Sheets and Plates etc. |
| ASTM A123/A123 | Standard Specification for Zinc (Hot - Dip Galvanized) Coatings on Iron and Steel Products |
| ASTM A153/A153M | Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware |
| ASTM A384 | Standard Practice for Safeguarding against warpage and distortion during Hot-dip Galvanizing of Steel Assemblies. |
| ASTM B201 | Standard Practice for Testing Chromatic Coatings on Zinc and Cadmium Surfaces |
| ASTM E94 | Standard Guide for Radiographic Testing |
| ASTM A143 | Standard Practice for Safe-guarding against embrittlement of hot-dip galvanized structural steel products and procedure for detecting embrittlement. |
| ISO 898-1 | Mechanical Properties of Fasteners made of carbon steel and alloy steel |
| DIN 267 | Fasteners technical delivery conditions steel spring washers for bolt/nut assemblies. |
| DIN 7990 | Hexagon head bolts for structural steel bolting for supply with nut. |
| DIN 555 | M5 to M100 x 6 hexagon nuts. |
| DIN 7989 | Flat Washers |
| DIN 7967 | PAL Self Locking Counter Nut |



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### 6.2.2.15 Conductors

ASTM B-231, JIS H-2110.

| | |
|---|---|
| IEC 61089 (1991-06) | Round Wire Concentric Lay Overhead Electrical Stranded Conductors. |
| IEC 61089-am1 (1997-05) | Amendment No. 1. |

### 6.2.2.16 Civil Works

For material and civil design, any of the following standards and publications may be applied.

| | |
|---|---|
| ASTM | American Society for Testing and Materials |
| ACI | American Concrete Institute |
| ISO | International Standard Organization |
| ASTM A615 | Standard Specification for Deformed and Plain Billet - Steel Bars for Concrete Reinforcement (Grade-60) |
| ASTM C33 | Standard Specification for Concrete Aggregates |
| | ASTM C39Test Method for Compressive Strength of Cylindrical Concrete Specimens. |
| ASTM C150 | Standard Specification for Portland Cement |
| ASTM C260 | Standard Specification for Air Entraining Admixtures for Concrete |
| ASTM C494 | Standard Specification for Chemical Admixtures for Concrete |
| ASTM C989 | Ground Granulated Blast Furnace Slag for use in concrete and mortars |
| ASTM D1556 | Standard Test Method for Density and Unit |
| ASTM D1557 | Test Method for Laboratory Compaction |
| ASTM D1586 | Standard Penetration Test |
| ASTM D2937 | Standard Test Method for Density of Soil in Place by the Drive - Cylinder Method |

### 6.2.2.17 Heating, Ventilating and Air Conditioning (HVAC) Works

| | | | |
|---|---|---|---|
| a) | ASME | - | American Society of Mechanical Engineers |
| b) | ASTM | - | American Society for Testing & Materials |
| c) | ASHRAE | - | American Society of Heating, Refrigerating and Air-conditioning Engineers |
| d) | NFPA | - | National Fire Protection Association, USA |
| e) | ARI | - | Air-conditioning and Refrigeration Institute, USA |
| f) | SMACNA | - | Sheet Metal and Air-conditioning Contractors National Association, USA |
| g) | I.E.E. | - | Institute of Electrical Engineers, London |
| h) | NEMA | - | National Electrical Manufacturers Association, |
| i) | USA. | - | United State of America |
| j) | AMCA | - | Air Moving and Control Association Inc., USA |



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k) P.S. - Pakistan Standards.
l) B.S. - British Standards.
m) TIMA - Thermal Insulation Manufacturer's Assoc. USA

The Contractor shall provide four (04) sets of standards of these documents as part of the as-built documentation. However, an additional set of the standards, comprising the standards listed herein and other standards that the Contractor will intend to use in the design, construction, testing and commissioning, shall be submitted to the Employer for his reference within two months of the signing of the Contract Agreement.

## 6.3 132 KV SWITCHYARD DESIGN

### 6.3.1 General

These Specifications cover the requirements for Design, Supply, Installation, Testing and Commissioning of Plant and Equipment for 132 kV Switchyard Attabad Lake HPP. The design of Civil Engineering Facilities associated with this Contract (Cable Trenches, Equipment Foundations, Earthwork, Control House Building, Guard Rooms, Metering Room, Boundary Walls, Drainage etc.) shall be the responsibility of Civil EPC Contractor and included in separate Package-I. The Single Line Diagram (SLD) and Equipment Arrangement Plans indicate the Details of Facilities to be carried out.

The EPC Contractor shall prepare detailed design drawings on the basis of information provided in the Employer's Requirements listed herein.

### 6.3.2 Physical Design Parameters

The Plant and Equipment to be installed in the switchyard and covered by these Specifications shall be for outdoor use and shall be suitable in every way for continuous and reliable service. The conditions under which it will operate are to be considered throughout.

#### 6.3.2.1 Outdoor Ambient Air Temperature (Referred to power plant data)

| | |
|---|---|
| Maximum, degree C | 40 |
| Maximum mean over any 24 hours | 35˚C |
| Mean in any year | 30˚C |
| Minimum, degree C | -23 |

#### 6.3.2.2 Relative Humidity

The relative humidity may approach 100 percent. During the monsoons high humidity may persist for many days along with temperature ranging from 30°C to 40°C.

#### 6.3.2.3 Altitude

The height above mean sea level of the switchyard Site is almost 2500 meters.

#### 6.3.2.4 Wind Loading

(1) Maximum wind gusts velocity of 45m/sec. for 5 seconds acting at a height of 10 meters above ground level.

(2) The wind load factor on outdoor structures shall be:

1 x projected area for cylindrical structures



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2 x projected area for square rectangular lattice structures.

(3) The design wind speed given above shall be escalated to give an increased velocity depending on the height above ground level of the Plant upon which the wind force is acting in accordance with the following formula:

$$V = 45(H/10)^{1/7}$$

Where V is the wind velocity in meters per second
H is the height above ground level in meters.

#### 6.3.2.5 Earthquake Factor

All the joints and all the base mounted fastenings of free-standing electrical Plant and Equipment, transformers, circuit breakers, disconnectors, surge arresters, instrument transformers, line traps and bus bars shall be designed for a horizontal acceleration intensity as per zone 3 of the Uniform Building Codes or may be refer to other part of Employer's requirements.

### 6.3.3 Electrical Design Parameters

Following design parameters shall be considered as a guideline for design of the 132 kV Switchyard (where applicable):

| | | |
|---|---|---|
| (1) | Nominal system voltage, kV, rms. | 132 |
| (2) | Rated voltage for the equipment, kV, rms. | 145 |
| (3) | Frequency, Hz. | 50 |
| (4) | Rated continuous current at 40°C ambient temperature A, rms. | |
| | a) Busbars | 2000 |
| | b) Feeders | 2000 |
| (5) | Bay width, center lines of columns, mm. | 12000 |
| (6) | Bay equipment clearances: | |
| | (a) Phase to Phase (center lines), mm | 3000 |
| | (b) Average height of equipment live parts in the bay from the foundations level, mm. | 4250 |
| (7) | Bus bar conductor clearances. | |
| | (a) Phase to Phase (Center lines), mm | 3500 |
| | (b) Average height of live parts from the foundations level, mm. | 10000 |
| (8) | Minimum clearance lives part to ground, mm. | 1750 |
| (9) | Height of overhead shield wire, mm. | 16900 |



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| | | |
|---|---|---|
| (10) | Minimum creepage distance, mm. | 4495 |
| (11) | Lightning impulse withstand level, kV, peak. | 650 |

The Contractor shall check and submit calculations for the adequacy of the busbars current ratings keeping in view the future extension of the switchyard as specified in the Specifications Drawings.

The clearances/heights specified under items (6), (7), (8), (9) & (10) are the minimum requirements. The Contractor shall study and prove that with these clearances adopted all the equipment and conductors are fully protected against lightning and these clearances are adequate for safety of the personnel. The Contractor shall also check the clearances due to increase of altitude as almost 2500m from sea level.

The lowest portion of any support insulator of HV equipment shall be at height of minimum 2300 mm above finished ground level.

### 6.3.4 Electrical Service Conditions

#### 6.3.4.1 AC Circuit Voltage

Supply, Nominal:

- 3-Phase 400 volts neutral grounded
- 1-Phase 230 volts

| | |
|---|---|
| Fluctuation of supply Voltage | + 10 percent<br>- 15 percent |

For equipment rating:

| | |
|---|---|
| - 3-Phase | 400 Volts |
| - 1-Phase | 230 Volts |

#### 6.3.4.2 Frequency

50 Hz

#### 6.3.4.3 DC Control Voltage

| | |
|---|---|
| - Nominal | 110 Volts D.C. |
| - Range | + 10 percent<br>- 15 percent |

#### 6.3.4.4 DC Voltage for Telecommunication System

| | |
|---|---|
| - Nominal | 48 Volts |
| - Range | + 10 percent<br>- 15 percent |

### 6.3.5 Overhead Lightning Protection

Overhead shielding wires and surge arresters, as specified in Section 6.5 & 6.10 respectively of the Technical Specifications, shall be provided to adequately protect the equipment against the lightning protection and surges. Earthed masts shall be provided wherever necessary. The Contractor shall also provide design calculations of the shielding system for Employer review



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and approval. Shield wire shall be connected directly to each of the respective steel structure. Shield wire shall additionally be connected to the grounding mesh of the switchyard at the points identified in the Conceptual Drawings, Volume-II Part-III of the Employer Requirements.

### 6.3.6 Tension and Suspension Insulators

Tension and suspension insulator strings shall be designed using insulators, the characteristics of which are given in Section 6.5 of these Specifications.

### 6.3.7 Cable Trenches

Cable trenches for 132kV switchyard shall be designed in accordance with requirements of Site and as approved by the Employer. The sizes of the cable trenches shall be provided by E&M Contractor and construction will be carried out by Civil Contractor.

### 6.3.8 Cable Laying

Control and power cables shall be laid in cable trenches and cable conduits. Direct burial of cables shall not be allowed. Joints shall not be used for control & small power cables and 11 kV XLPE cables (if used).

Cable trenches shall be designed in accordance with requirements of Specifications drawings.

Fire barriers shall be provided in the cable trenches to prevent spreading of fire.

Cable conduits, cable trays, racks and their supports shall be designed in accordance with requirements of Section 6.15 of these Specifications.

### 6.3.9 Steel Structures

Steel structure for equipment supports and switchyard tower gantries shall be designed in accordance with requirements of Section 6.4 of these Specifications.

### 6.3.10 Cubicles/Panels

#### 6.3.10.1 General

Cubicles/panels (local control cubicles, marshalling kiosks, marshalling boxes, relay panels, control panels, AC/DC panels, fault and event recorder panels inverters, fire protection panels etc.) of all the equipment shall be fabricated from sheet steel not less than MSG 2.5 mm thick. However, in case of type tested rigid frame design, the thickness of the steel sheets may be reduced, but not below 2mm, according to manufacturer's standard design. The exterior color of cubicles/panels shall be of designation RAL 7032 while interior color shall be RAL 9010. The cubicles/panels shall be of vertical type construction, seam welded at corners and ground smooth. All the outdoor cubicles/panels shall be vibration free, weather proof and vermin proof conforming to protection class IP55. Protection class of indoor cubicles/panels including cubicles/panels of relay board, metering board, fire protection, inverter and any other cubicle/panel with front door shall be IP54. Except where specified otherwise, cubicles/panels of indoor control boards and auxiliary control panels without front door and with control, annunciation and indication devices and indicating instruments/meters mounted at the front shall conform to at least protection class IP54. Neoprene gasket between the door and frame shall be provided to prevent the ingress of moisture. Structural backing shall be provided, where required, in such a manner that the complete assembly shall be rigid, self-supporting and free of vibration, twist and weave.



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### 6.3.10.2 Cubicles/Panels Interior

No component shall be mounted less than 300 mm above the floor of the cubicle/panels or 150 mm from the roof. Any unused area of cubicles/panels shall be kept free of wiring to permit the installation of possible future components.

### 6.3.10.3 Doors And Latches

Each cubicle/panel shall be equipped with a hinged door with hinges on the left. The door shall have its edge bent inwards for rigidity. There shall be a three-point latch and activating handle. The handle and door shall have matching projections with a 12.5 mm diameter hole suitable for locking the cubicle/panel door with a padlock. Alternately, facility for locking the door with a key-operated lock shall be provided.

### 6.3.10.4 Lighting, Outlets and Telephone Jacks

Florescent lamps fixtures shall be provided in each outdoor/indoor cubicle/panel one on each side. Appropriate type of lamps fixtures shall be provided in the small boxes where florescent lamps cannot be provided. The lamps shall be door operated type.

A 240 V, 5A single phase three pin outlets along with its MCB to fit standard prong plugs shall be installed inside each cubicle assembly. MCBs shall have auxiliary contacts for remote signaling and sensitive earth fault protection for personnel safety. Plugs shall also be provided for each power socket.

A telephone jack/socket shall be provided in each cubicle/panel. A hook for supporting head set shall be provided conveniently close to the jack in the outdoor cubicle/panel. Telephone jacks/sockets in all the indoor and outdoor cubicles/panels shall be inter wired to effect the direct wire telephone system specified in relevant section.

### 6.3.10.5 Ground Bus

A copper ground bus bar shall be provided with tapped holes and screws and shall be connected to the shields or associated earth continuity conductors of all incoming cables.

### 6.3.10.6 Control Circuit

110V DC miniature circuit breakers (MCBs) shall be provided for protecting DC control circuits. MCBs shall be fitted with auxiliary contacts for remote signaling.

### 6.3.10.7 Terminal Blocks and Terminals

Terminal block for VT shall be disconnecting type. For CT circuits terminal block shall be disconnecting and shorting type and terminal blocks for control wiring shall be molded with marking strips and covers. White marking strips shall be provided for circuit designation. Each connected terminal of each block shall have the circuit designation. Terminal studs and wires shall be numbered or otherwise marked in accordance with the applicable schematic and wiring diagrams with permanent contrasting marking fluid.

Terminal blocks shall be arranged with sufficient room for any connection of incoming cables. Parallel rows of terminal blocks shall be spaced at least 150 mm apart. At least 20% spare terminals shall be provided in each block or group of blocks. Blocks shall be mounted in vertical columns along the sides of cubicles or on vertical panels specially provided for terminal block.

### 6.3.10.8 Component Wiring

Wiring between terminals of various devices shall be point to point (no splicing or `T' connection shall be allowed). All internal wiring shall be neatly truncated in wiring troughs.



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All groups of bundled conductors to hinged doors and panels shall use extra-flexible wire arranged so that a twisting, rather than a bending motion is imparted to the moving conductor bundle.

All wires shall be identified at both ends according to the interconnection diagrams.

#### 6.3.10.9 Heaters

Space heaters of sufficient capacity along with thermostat, humidistat, control switches and circuit breakers shall be supplied for each cubicle to reduce condensation which may occur. However, for smaller cubicles thermostat-controlled heater shall be provided. `Auto-Manual' selector switch shall be provided for space heaters. Visual indication shall be provided to show ON or OFF status of the heater.

### 6.3.11 132kV Switchyard Control Room

The equipment layout plans in the 132kV switchyard control house building is provided in Conceptual Drawings Volume-II Part-III. The Contractor shall design, manufacture, supply, install, test and commission the following equipment in the switchyard control room:

(1) Metering Panels and Energy Meters.
(2) Telecommunication and SCADA equipment.
(3) Protection/ Mimic/BCU Panels/SAS.
(4) AC and DC systems and other ancillary equipment.
(5) Fire Protection System for outdoor and indoor equipment and Fire Extinguishers.
(6) Cable trays, cable mounting racks, control and small power cables for equipment interconnection and power cables.
(7) Any other equipment required to comply with the Specifications.

#### 6.3.11.1 Cables Layout

The cables layout design in the Control room shall incorporate the following requirements:

(1) All cables should enter the control and relay panels from bottom of the panels through appropriate size of cable gland.

(2) The panels in this portion of the building shall be placed on the same raised false flooring and the cables shall enter into the panels through opening from below. All necessary equipment/material that may be required in addition to those already mentioned shall be supplied by the Contractor.

### 6.3.12 Levelling of Site

The Contractor, shall level the Site as required and to the extent considered necessary by the Employer. The Contractor shall also remove the grass, bushes etc. to clear the Site.

### 6.3.13 Independent Laboratories

For the specified requirement of type tests and type test reports by an independent authority/independent laboratory, the following laboratories will be considered as independent laboratories:

(1) KEMA Labs, Holland.
(2) CESI Labs, Italy.
(3) CRIEPI Labs, Japan.
(4) HV & SC Labs, Pakistan.



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(5) any other laboratory accredited by EA (European Co-Operation for Accreditation) or a member thereof.

(6) any other laboratory accredited by ILAC (International Laboratory Accreditation Cooperation) or a member thereof.

(7) any other laboratory accredited by 1AF (International Accreditation Forum) or a member thereof.

(8) any other laboratory accredited by STL (Short-Circuit Testing Liaison) or a member thereof.

### 6.3.14 Secured Metering System (SMS) for Tariff Metering

Secured Metering System (SMS) comprising main and backup for tariff metering at electrical energy exchange points (132 kV side of step-up transformer). SMS shall be designed, installed, tested and commissioned according to the Specifications provided in the Employer Requirements. For this purpose, dedicated/independent 132 kV instrument transformers (CTs and PTs) and a separate metering room in 132 kV switchyard shall be constructed.

### 6.3.15 Drawings, Technical and Descriptive Data Proposal Drawings and Descriptive Data

(1) Proposed general arrangement of equipment in the switchyard along with sections, details of the equipment, busbar heights and clearances fully dimensioned.
(2) Proposed arrangement and layout of equipment in the Control room.
(3) Proposed arrangement and layout of trenches and ducts.
(4) Type test reports.
(5) Technical literature, data and information required necessary to demonstrate compliance with the Specifications..

#### 6.3.15.1 Approval of Drawings

The drawings to be submitted by the Contractor for approval shall include, but not be limited to the following:

1) Single Line Diagrams.
2) Switchyard Layouts and Sections
3) Protection and Metering Diagrams
4) Telecommunication Diagrams
5) Schematic Diagrams
6) Trip Logic Diagram
7) Interconnection Diagrams
8) Panel Wiring Diagrams
9) Conduit and Cable Drawings
10) Equipment Drawings
11) Trench Layout plans
12) Equipment loading diagrams
13) Lightning Protection System for outdoor bays
14) AC and DC Station Service Drawings
15) Instrument transformers performance calculations



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16) Relay settings calculations
17) Telephone system, paging system drawings
18) Current transformer/voltage transformer performance calculations
19) Voltage drops calculations for AC/DC circuits
20) Protection concept and logic diagram.
21) Any other drawing/data/calculation required by the Employer.

#### 6.3.15.2 Details on Drawings

The drawing of 132kV switchyard Control house building shall show at least the following details:

(1). Equipment layout plan drawing.
(2). Any other detail necessary for installation of equipment in the buildings.

## 6.4 STEEL STRUCTURES

### 6.4.1 General

This Section comprises the Standards and Specifications pertaining to the fundamental requirements of design, manufacture, testing, inspection, supply and erection of steel support structures for line terminations, supporting buses and other equipment such as earth/lightning masts, circuit breakers, disconnectors/isolators, instrument transformers, line traps, surge arresters and post insulators.

All drawings and statements shall be in English language and Metric System of measurements shall be used.

### 6.4.2 Scope of Work

Design, manufacturing, testing, inspection, supply, erection, installation, commissioning and guaranteeing of all steel support structures required or specified or implied herein are included in the scope of the Contract. The material and fabrication shall be the best of their respective kinds and to a standard not less than specified herein.

General configuration of structures for the switchyard provided in the Contract Documents indicate details of Work to be carried out.

Lattice type structure with height as specified based on electrical requirements comprises structural steel members with connecting bolts, nuts, washers, check nuts and step bolts (if required) shall be furnished. All steel material shall be hot dip galvanized after fabrication. The Contractor shall ensure proper fitting and alignment of offered structures.

The Contractor shall be responsible for submitting all detail designs and drawings as required or specified herein on the basis of information provided in the Contract Documents and as directed by the Employer. The Contractor shall prepare as-built drawings/documentation and submit to the Employer.

### 6.4.3 Design Standards

Unless otherwise specified in these Specifications or in the drawings, the Contractor shall conform to the applicable requirements of the latest revisions of the following standards or equivalent as approved by the Employer. The latest applicable standards shall be those which are enforced thirty (30) days prior to the date of Proposal opening.

AS ASCE 7 (Minimum Design Loads for Buildings and Other Structures)



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| | |
|---|---|
| ASCE 10 | Design of Latticed Steel Transmission Structures |
| ASCE Manual No. 74 | Guidelines for Electrical Transmission Line Structural Loading |
| ASCE Manual No. 113 | Switchyard Structure Design Guide |

### 6.4.4 Structural Loadings

Calculations for loadings on terminal structures used for dead ending of conductors, overhead shield wires and switchyard bus structures shall be carried out by the Contractor and submitted to the Employer for approval. A twenty (20) degree angle of entry for terminal structures with conductor tension acting on one side with terminal span 60 to 80m shall be assumed.

Loading and design shall be in accordance with the requirements of the latest ASCE Manual No. 113 and ASCE Standard 10 based on the information hereof.

#### 6.4.4.1 Wind and Ice Loads

Structures shall be designed for (i) wind acting at 90 degrees to the surfaces (ii) wind acting at 135 degrees (45 degrees) to the surfaces. Wind pressure corresponding to 160 km/hr wind velocity acting horizontally in any direction at 25˚C everyday temperature shall be used. Ice loading should also be considered on structures and overhead wires.

#### 6.4.4.2 Vertical and Tension Loads

Equipment weights and dead loads (including conductors, overhead shield wires, insulators and assembly hardware) together with estimated construction/maintenance loads as required.

#### 6.4.4.3 Loading due to Thermal Forces

Thermal stresses caused by a temperature variation as indicated in Volume-II Part-I shall be taken and expansion joints shall be provided at the appropriate locations.

#### 6.4.4.4 Earthquake Intensity

Horizontal earthquake acceleration of an intensity of 0.32g acting in any direction shall be considered for the design of ground structures acting in any direction irrespective of their height and flexibility. The above value shall be considered as the Zero Period Acceleration (ZPA).

All the joints and base mounted fastening of free-standing electrical equipment such as circuit breakers, dis-connectors/isolators, instrument transformers, line traps, bus bars, surge arresters and post insulators shall be designed to resist the effects of an acceleration intensity 0.32g in any direction.

#### 6.4.4.5 Short Circuit Loads

Short circuit loads shall also be considered in the design of steel structures as per maximum short circuit level.

#### 6.4.4.6 Load Cases and Load Combinations

The above loads shall be combined with tension of conductor loading on the structure. The various load combinations and load cases to be used shall be as per relevant Standards and Codes.



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### 6.4.5 Design

#### 6.4.5.1 General

The Contractor shall submit complete details of the structure design proposes to furnish, showing outline dimensions together with member dimensions, stresses and calculations in sufficient detail to determine compliance with the Contract Documents.

The switchyard shall be adequately protected against direct lightning strokes, by the use of shield wires located on the switchyard structures. The height, location, and number of shield wires shall be such as to protect the equipment installed within the switchyard to a failure rate of shielding from direct lightning strokes of not greater than 1 per annum.

#### 6.4.5.2 Slenderness Ratio (L/R)

Determination of L/r ratio and allowable compressive stress shall be based on ASCE 10 "Design of Latticed Steel Transmission Structures".

The maximum L/r ratio of a member shall not exceed to the following limits:

| | | |
|---|---|---|
| (a) | For main compression member | 150 |
| (b) | For secondary members carrying calculated stresses | 200 |
| (c) | For redundant members without calculated stresses | 250 |

#### 6.4.5.3 Allowable Unit Stresses

All parts of the structure shall be so proportioned that the unit stresses in members, produced by design load factors shall not exceed the values as given in ASCE Standard 10 and as summarized below.

Members shall be of such size, shape and length as to preclude damage or failure from vibration or stress reversal.

**a) Compressive Stress**

The allowable unit stress on the gross section of axially loaded compression members shall be calculated as:

$F_c = [1- \{(KL/r)^2/ (2C_c^2)\}].F_y$ --------- ---------- (1)

when $KL/r \leq C_c$

OR

$F_c = 200,000/(KL/r)^2$ --------- ---------- (2)

when $KL/r > C_c$

in which $C_c = \pi\sqrt{(2E/F_y)}$ --------- ---------- (3)

where,

$F_y$ = Minimum guaranteed yield strength, $kg/mm^2$
$F_c$ =Allowable compressive stress in member, $kg/mm^2$
E =Modulus of Elasticity of the material, $kg/mm^2$
KL/r =Largest effective slenderness ratio of any un-braced segment of the member and provided that the largest (b/t) ratio is not more than the limiting value given by:

$(b/t)_{Lim}=66.289/\sqrt{F_y}$ --------- ---------- (4)

in which,



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b = Distance from the edge of fillet to the extreme fiber
t = Thickness of the material

If the width-thickness ratio exceeds $(b/t)_{Lim}$, equations (1) and (3) shall be modified by substituting for $F_y$ the value $F_{cr}$ given by:

$F_{cr} = [1.8 - \{0.8(b/t)/(b/t)_{Lim}\}] F_y$ --------- ---------- (5)

where $(b/t)_{Lim} \leq b/t \leq 99.433/\sqrt{F_y}$

$F_{cr} = 5900/(b/t)^2$ --------- ---------- (6)

where $b/t > 99.433/\sqrt{F_y}$

**b) Tensile Stress**

Allowable Tensile Stress ($F_t$) through the minimum Net Section shall be taken as applicable yield point ($F_y$).

**c) Bending Stress**

Allowable Bending Stress ($F_b$) on Extreme Fibers shall be taken as the applicable yield point ($F_y$).

**d) Shearing Stress**

Allowable Shear Stress ($F_s$) shall be taken as 5/8 of the applicable yield point ($F_y$).

**e) Bearing Stress**

Allowable Bearing Stress, for all steel materials specified herein shall be taken as 1.65 times the applicable yield point ($F_y$).

**f) Combined Compression and Bending**

Members simultaneously subjected to both axial compression and bending stress shall be designed as:

$$f_c/F_c + f_b/[F_b(1 - f_c/F_c)] \leq 1$$

$f_c$ = Actual axial compressive stress (resultant axial force divided by the effective cross-sectional area of the column).

$f_b$ = Actual bending stress, tension or compression whichever is greater at extreme fiber (bending moment divided by the Section Modulus).

**g) Combined Shear and Tension**

Where applicable, maximum stress resulting from combined shear and tension shall be investigated.

**6.4.6 Materials**

All materials shall be of the highest grade free from defects and imperfections of recent manufacture, unused and of the classification and grades designated, conforming to the requirements of the latest revision of the relevant Standards cited herein. All structural steel sections, plates and its connection bolts, nuts, washers, check nuts and step bolts (if required) shall be hot dip galvanized after fabrication.



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#### 6.4.6.1 Structural Steel

All rolled steel sections and plates shall be supplied in accordance with latest edition of EN 10025 (minimum S355J2 grade) or equivalent Standard. The following minimum steel thickness shall apply:

| | | |
|---|---|---|
| (a) | Main members | 6 mm |
| (b) | Secondary members carrying calculated stresses | 5 mm |
| (c) | Redundant members without calculated stresses | 4 mm |
| (d) | Gusset Plates | 6 mm |
| (e) | Size for stub | 8 mm |

#### 6.4.6.2 Bolts And Nuts

All steel structure connection bolts and nuts shall be of steel and shall conform to the requirements of ISO 898-1 (minimum 6.8 property class), ISO 898-2 (minimum 6.8 property class), DIN 7990 and DIN 555. All steel structure connection bolts, nuts, washers and check nuts shall be of minimum 16 mm size.

All connections shall be bolted type and shall be designed for 100% member capability. 5% surplus of bolts, nuts, washers and check nuts shall also be supplied. A connecting bolt shall contain one nut, one washer and one check nut.

**a) Bolt Spacing**

Minimum spacing of bolts shall be as follows:

| Bolt Diameter | Minimum Bolt Spacing |
|---|---|
| 16 mm | 40 mm |
| 20 mm | 50 mm |
| 22 mm | 60 mm |

**b) End Distances**

The minimum end distances measured from the centre of the bolt hole to the end of the member shall be as follows:

**(i) For Compression Members**

One and one-half bolt diameter.

**(ii) For Tension Members**

In an end connection of not more than three bolts, the end distance shall not be less than that given in (i) above or the following value, whichever is greater.

$$\frac{0.865P}{F_y \times t} + 0.38d$$

Where,

P = Ultimate load on bolt, kg
t = Thickness of member, mm
d = Nominal bolt diameter, mm
$F_y$ = Yield stress of material, $kg/mm^2$

**c) Minimum Edge Distance**

Minimum distance from any hole centre or edge member shall be as follows:



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| Bolt Diameter | Minimum Edge Distance | | |
|---|---|---|---|
| | Rolled Edge | Sheared Edge | Flamed Edge |
| 16mm | 19mm | 24mm | 27mm |
| 20mm | 26mm | 30mm | 33mm |
| 22mm | 32mm | 33mm | 36mm |

For gusset plate one and half bolt diameter.

#### 6.4.6.3 Washers

All washers shall be of galvanized malleable iron or steel conforming to the requirements of DIN 7989 and shall be provided for all bolts. Only one washer per bolt shall be used.

#### 6.4.6.4 Check Nuts

Galvanized check nuts of the type approved by the Employer conforming to the requirements of DIN 7967 shall be provided for all bolts.

#### 6.4.6.5 Step Bolts

Galvanized step bolts shall be provided on one leg of gantry columns and shall have minimum16mm diameter. The length of bolts shall be 180 mm. Steps shall be spaced approximately 300 mm to 350 mm apart.

### 6.4.7 Steel Fabrication

#### 6.4.7.1 Holes

All holes shall be clean-cut without torn or ragged edges. All burrs resulting from reaming or drilling shall be removed. All holes shall be cylindrical and perpendicular to the member. The diameter of the finished hole shall be 1.5mm greater than the nominal diameter of the bolt.

#### 6.4.7.2 Welding

Welding shall be performed in accordance with the latest edition of "Code for Arc and Gas Welding in Building Construction", as formulated by the American Welding Society or equivalent Standard.

A shielded arc-welding process shall be used. All welds shall be made in such a manner that residual shrinkage stresses will be reduced to a minimum.

#### 6.4.7.3 Galvanizing

All plates and shapes shall be hot dipped galvanized after fabrication in accordance with ASTM Designation A123 or equivalent Standard. All bolts, nuts and washers shall be hot dipped galvanized in accordance with ASTM A153 or equivalent Standard. Re-threading of bolt threads after galvanizing will not be permitted.

All necessary precautions shall be taken in the selection of steel and its fabrication and preparation for galvanizing to prevent embrittlement of any item or parts of item including bolts and nuts.

Material on which galvanizing has been damaged shall be re-dipped. Any member on which the galvanized coating becomes damaged after having been dipped twice shall be rejected.

All material shall, prior to shipping, be dipped in a suitable solution to protect the galvanizing from “white rust” corrosion during transit. Full details of the treatment proposed shall be



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submitted to the Employer for approval. The effectiveness of the treatment shall be verified in accordance with ASTM Standard B201.

#### 6.4.7.4 Repairs of Damaged Steel

**(a) Correction of Mis-fabricated and Damaged Steel**

All shop errors and damaged steel shall be reported to the Employer or their representatives who will decide the manner in which corrections shall be made. All costs incurred due to punching, drilling or cutting shall be deemed to be included in the steel erection costs.

Pieces bent in handling may be used if they can be straightened to the satisfaction of the Employer, without structurally damaging the material. If bent pieces cannot be satisfactorily repaired, they shall be replaced.

**(b) Damage to Galvanizing**

Small areas of galvanizing damaged by abrasion, in straightening bent pieces or by necessary clipping in the field, shall be repaired by carefully cleaning the affected area and painting. The appropriate paint will be furnished by the Contractor.

Damaged area shall be wiped with clean rags saturated with Xylene or equivalent solvent, followed by wire brushing then re-cleaned with solvent to remove residue, and painted with one coat of "Galvanox", or approved equivalent.

Galvanizing damaged by drilling or punching shall be repaired by applying an aluminium paste or zinc rich coating material to completely fill all voids between the bolt and the surfaces bared, or all exposed steel surfaces around the holes or on cuts on which such corrective work is permitted. The coating material shall be "Galvanox" or approved equivalent.

#### 6.4.7.5 Prototype Assembly

Before starting mass fabrication of steel structures, one structure of each type shall be shop assembled and vertically erected on a suitable foundation bed to assure proper fit of all parts as finally manufactured. Following should be kept in view during shop assembly.

(a) Check carefully each member while assembling the prototype to revise and amend the detailed drawings according to the correct solution.
(b) For each member, the length, position of holes and interface with other members shall be checked accurately for proper fitness.
(c) Quantity of each member and bolts shall be carefully checked from the bill of materials when assembling the prototype.
(d) On the assembled structure eventual modifications shall be examined and performed, if necessary, without modifying its functionality.
(e) Drawings and bill of materials, sizes of bolts, fillers etc. shall be put up-to-date accordingly, in all details before starting mass production.

All changes/modifications incorporated in the drawings shall be brought to the notice of Employer along with corrected final copies of the drawings for approval. The Manufacturer shall also submit details of all the changes/modifications carried out.

The Employer may witness a shop assembly of any or all types of steel structures before shipment.



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#### 6.4.7.6 Marking

All structural members shall be marked with the correct designation shown on the shop drawing. Marking shall be done by stamping the members prior to galvanizing with numerals or letters of minimum 12mm height, and shall be clearly legible after galvanizing.

#### 6.4.7.7 Tolerances

Ease of assembling the structure in the field is of utmost importance. The structure shall be so manufactured that all members carrying the same mark shall be interchangeable when assembled. The structure shall fit without undue pressing and no reaming or drifting of holes shall be required. When erected, the structures shall not deviate from the vertical by more than 1/300.

The Contractor shall be responsible for the correct fitting of all parts and shall replace free of cost any defective materials discovered during erection. The Contractor shall also be responsible for the correction in the field of any errors not previously discovered.

The permissible variation from dimensions for structural size steel shapes shall not exceed the prescribed limits in ASTM A6 Standard.

### 6.4.8 Tests

#### 6.4.8.1 Manufacturer's Tests

The Manufacturer shall select two samples from each heat to carry out the following tests to satisfy himself that the products comply with the Specifications.

**(a) For Sections and Plates**

(i) Chemical composition (Ladle Analysis)
(ii) Tensile test
(iii) Bend test

**(b) For Nuts and Bolts**

(i) Proof load test
(ii) Ultimate tensile strength test
(iii) Ultimate tensile strength test under eccentric load
(iv) Cold bend test
(v) Hardness test
(vi) Galvanizing test

**(c) For Washers and Ring Fillers**

(i) Hardness test
(ii) Galvanizing test

The Manufacturer shall maintain a record of tests carried out by himself for examination by Inspectors during pre-shipment inspection.

#### 6.4.8.2 Acceptance Tests

The Contractor shall provide sampling plan prior to pre-shipment inspection for Employer approval. The following acceptance tests shall be carried out during pre-shipment inspection.

**(a) For Sections and Plates**

(i) Visual examination



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(ii) Verification of dimensions and weights
(iii) Prototype assembly tests
(iv) Chemical composition
(v) Tensile tests
(vi) Bend tests
(vii) Galvanizing tests

**(b) For Nuts and Bolts**

(i) Verification of dimensions
(ii) Visual inspection
(iii) Proof load tests
(iv) Ultimate tensile strength tests
(v) Galvanizing tests

**(c) For Washers and Ring Fillers**

(i) Verification of dimensions
(ii) Visual inspection
(iii) Galvanizing tests

The Contractor shall render all necessary assistance to the Inspectors during above-mentioned tests.

### 6.4.8.3 Acceptance and Rejection

**Chemical Composition**

To indicate adequately, the chemical composition of a heat or a lot, the minimum number of samples selected to represent the heat shall be as follows:
50 tons or more 2
50 tons or less 1
If a piece fails to meet the requirement the lot shall be rejected.

**Tensile Properties of Section and Plates**

Sample plan for tension and bend tests shall be made for each grade of steel. Three (03) tension and two (02) bend tests shall be made (for every 50 tons' lot) from the finished offered material for each grade of steel.
If a test piece fails to meet the requirement the lot shall be rejected.

**Tensile Properties of Bolts and Nuts**

Sample plan for proof and tension tests shall be made for each size of bolts and nuts. Twenty (20) proof and tension tests shall be made (for every 50 tons' lot) from the finished offered material for each size of bolts and nuts.
If a test piece fails to meet the requirement the lot shall be rejected.

**Galvanizing**

The acceptance and rejection on the basis of galvanizing test will be according to the specified Standards. The galvanizing test shall be carried out on all ferrous parts complying with the following requirements:
(i) Weight of zinc coating
(ii) Uniformity of zinc coating
(iii) Adherence of zinc coating
(iv) Zinc coating thickness



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Test samples for determination of compliance to the tests specified shall be performed in accordance with relevant ASTM Specification and shall be taken from each lot. The lot shall consist of a quantity as specified in the relevant standards.

### 6.4.9 Drawings and Descriptive Data

Drawings and descriptive data for each structure shall include, but not limited to:

(a) Outline drawings
(b) Design calculations, 3D computer models, and stress diagram by using SAP2000 software. Design calculations along with computer printouts shall be fully documented.
(c) Erection drawings
(d) Bill of materials

### 6.4.10 Design and Drawings for Gantry Steel Structures

The Contractor shall submit detailed design calculations, load analysis and supporting information for design of gantry steel structures for review and approval by the Employer. However, the Employer may provide the prevailing steel structure drawings during execution of the Contract for fabrication in which case there is no need to design the gantry steel structures.

Any modifications in the specified designs for adaptation thereof to the Project specific requirements shall be Contractor's responsibility and shall be done without any additional cost to the Employer.

Since the Project is to be executed under an EPC Contract, the Contractor shall verify the adequacy of the designs with regard to the intended application per the switchyard layout and equipment arrangement, to be proposed by him and to be subsequently reviewed and approved by the Employer.

## 6.5 HIGH VOLTAGE BUS WORK

### 6.5.1 General

These Specifications cover the requirements of design and manufacture of conductors, insulators and hardware for switchyard buses and overhead shield wire.

### 6.5.2 Conductors and Buses

#### 6.5.2.1 General

The 132 kV bus bar shall have mechanical strength to withstand stresses arising from symmetrical short circuit currents of 40 kA. The continuous current rating for main bus shall not be less than 2000 A under the specified conditions. The continuous current ratings for the overhead conductors to be used for equipment inter-connections shall not be less than the continuous current ratings of the equipment i.e. 2000A under the specified conditions.

Two bundle all aluminum "Coreopsis" conductor shall be used for main busbar of 132 kV switchyard. Overhead buses to be used for line/transformer feeder shall be "Coreopsis" conductor.

Ground connections shall be provided on equipment buses at all the necessary locations for temporary earthing on both sides of the equipment(s) under maintenance. Design, quantity to be supplied and locations of connectors shall be subject to approval by the Employer's Representative.



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Span between switchyard gantry and transmission line towers (terminal tower) shall be furnished by others. However, the Contractor shall supply and install all necessary hardware and conductor for connections between 132kV transmission lines and 132kV switchyard equipment.

### 6.5.2.2 Stranded Conductor

The AAC (All Aluminum Conductor) to be supplied shall conform to requirements of ASTM designation B 231-95, Class AA, or equivalent standard with the following characteristics:

All Aluminum Stranded Conductor

| | | |
|---|---|---|
| (1) | Conductor Type | **Coreopsis** |
| (2) | Conductor size, kCM | 1590 |
| (3) | Stranding, Aluminum wires: | |
| | Number. | 61 |
| | Diameter, nominal, mm. | 4.115 |
| (4) | Conductor diameter, nominal, mm. | 37.04 |
| (5) | Mass, nominal, kg/km. | 2216 |
| (6) | Rated strength, kN. | 120 |
| (7) | Number of conductors per bundle | 2 & 1 |
| (8) | Bundle configuration | Twin & Single |
| (9) | Bundle spacing, mm | 200 for twin bundle Conductor |

### 6.5.2.3 Rigid Tubular Conductor

Rigid tubular conductor shall be used, where applicable, in the switchyard. Tubing shall be commercially sound and of uniform thickness throughout.

Continuous current carrying capacity of 80 mm diameter tube with wall thickness of 10 mm (or higher size, as required to meet the specified requirements) to be used for 132 kV equipment interconnections shall be not less than 2000A at 30°C temperature rise above an ambient temperature.

Expansion joints and/or expansion terminals shall be provided for strain free installation.

The ends of the conductor shall be fixed to the ends of tube to prevent movement of the stranded conductor, (in case of a tube to stranded conductor joint).

The following provisions shall be made to prevent vibrations of the tube. The installation arrangement shall be analyzed to determine the type and frequency of vibrations:

- If fundamental frequency of the tubular conductor is above 7 Hz, a single stranded conductor used for the strain bus shall be installed inside the respective tube. Necessary end capping and jointing of tubular conductor shall be provided to avoid slipping of the conductor.
- If the fundamental frequency is below 7, Hz the use of special vibration absorbers is necessary. These absorbers should be adjustable to the resonance frequencies of the relevant tube.



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#### 6.5.2.4 Shield Wire

The overhead shield wire shall conform to extra high strength grade, Zinc Coated Class B Steel stranded in accordance with ASTM A-363-98 or equivalent Standards. The shield wire shall have the following characteristics:

| | | |
|---|---|---|
| (1) | Diameter of galvanized steel wire, mm. | 9.15 |
| (2) | Number of strands of wire. | 7 |
| (3) | Diameter of each coated strand, mm. | 3.05 |
| (4) | Grade of wire. | Extra High Strength (EHS) |
| (5) | Nominal weight of the wire, kg/km. | 406 |
| (6) | Minimum breaking strength of wire, kN | 68.4 |
| (7) | Weight of Zinc Coating, $kg/m^2$, of uncoated strand surface | 0.52 (Class B) |
| (8) | Elongation, % | 4.0 |

#### 6.5.2.5 Spacing and Clearances

The minimum spacing and clearances shall be as given in Section 6.3 of these Technical Specifications.

### 6.5.3 Insulators

#### 6.5.3.1 Dead-End and Suspension Type Insulators

The dead-end and suspension type insulators shall conform to the following:

**(1) Characteristics and Requirements**

(a) The insulators shall be high impact strength, glazed, wet process porcelain type.

(b) The entire exposed surface shall be glazed and free from imperfections.

(c) The insulators shall have clevis and tongue fittings, securely connected to insulators.

(d) Care shall be taken when providing the required leakage distance to avoid designs in which skirts are mechanically fragile.

(e) A suitable permanent identification of the rated strength of each insulator shall be included in the glazed finish with the initials or Trade Marks of the manufacturer and year of manufacture. All markings shall be plainly legible and durable.

(f) The design of the insulators shall be such that breakage of the porcelain cannot materially affect the mechanical strength of the insulators.

(g) Dead-end/Tension and suspension type insulators for insulator assemblies shall comply with the requirements of ANSI C29.1 and ANSI C.29.2 latest edition or equivalent IEC standards. The creepage distance of the assembly shall be 4495mm for 132kV respectively.

(h) The insulator shall be modern Fog type design embodying deeper outer skirts and shallow inner grooves. The Contractor shall prove to the satisfaction of the Employer that the contamination collection properties of the insulator unit are 50-60 percent of the standard 254 x 146 mm disc.



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(i) The insulator assembly shall be of double string for main busbar. Tests shall include all of the applicable tests specified in ANSI C29.1 and ANSI C29.2 (latest edition) or equivalent IEC standards. Each insulator shall also be subjected to the tension proof test at the minimum load of half the Mechanical and Electrical strength of insulators.

For verification of design, ten (10) insulator units shall be selected at random from lot and tested for thermal-mechanical performance in accordance with the latest revision of IEC Publication 60575 except temperature variations which shall be from -10°C to 65°C. The criteria for acceptance of the insulators shall be as follows:

(1) The results of the Performance Tests shall match the results of ordinary Electro-Mechanical or mechanical failing load test. Thus, the specified electro-mechanical or mechanical failing load that applies to the ordinary electro-mechanical or mechanical failing load test should be reached also in the performance tests.
(2) Fracture pattern shall not change.
(3) Electrical puncture should not occur before reaching the maximum load and the ultimate fracture.
(4) The quality index Qs should be equal to or greater than the acceptance constant K to meet the requirements of the test. The acceptance constant K shall be 3 for a sample size of ten insulators. The quality index is defined by:

$$Q_s = \frac{R-R_s}{S}$$

R = Mean value of the test
$R_s$ = Specified Electro-Mechanical or mechanical failing load (rated load value)
S =Standard deviation.

**(2) Minimum Electrical & Mechanical Requirements**

| | | |
|---|---|---|
| (a) | ANSI Class. | 52-6 |
| (b) | Dimensions: | |
| (1) | Disc diameter, mm. | 254 |
| (2) | Disc spacing, mm. | 146 |
| (c) | Flashover values: | |
| (1) | Power frequency: | |
| (i) | Dry, kV, rms. | 95 |
| (ii) | Wet, kV, rms. | 55 |
| (2) | Critical impulse | |
| | 1.2x50 μ sec wave | |
| (i) | Positive, kV, peak | 125 |
| (ii) | Negative, kV, peak | 130 |
| (d) | Radio interference voltage: | |
| (1) | Test voltage to ground, kV | 10 |



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| | | |
|---|---|---|
| (2) | Max. RIV at 1000 kHz micro volts. | 50 |
| (e) | Leakage distance, mm. | 432 |
| (f) | Dry arcing distance, mm | 203 |
| (g) | Power frequency puncture voltage, kV, rms. | 110 |
| (h) | Combined, electrical and mechanical strength, kg. | 11300 |
| (i) | Impact strength, kg-cm. | 104 |
| (j) | Glaze color | Chocolate Brown |

**6.5.3.2 Station Post Type Insulators**

The insulators shall be of the outdoor, solid core station post type as specified below. The insulators shall conform as a minimum to the applicable requirements of IEC 60168 latest edition or equivalent standards.

The Contractor shall submit calculations to show that the cantilever strength of the post insulators is at least 250% of the maximum force encountered during a full short-circuit for the longest span and full wind load including effect of circuit breaker auto-reclosing.

Porcelain shall be manufactured by the wet process and shall be one piece, non-porous, homogeneous and free from cavities or other flaws. The glazing shall be uniform in brown color and free from blisters, burns and other defects and shall meet all applicable requirements of IEC Standard Publication 60273.

The characteristics of the insulators shall be as follows:

| | | |
|---|---|---|
| **(a) Electrical Values (minimum)** | | **132 kV** |
| (i) | IEC Designation (may vary with altitude correction factors) | *C10-650 |
| (ii) | Lightning impulse withstand, voltage, kV, peak (may vary with altitude correction factors) | 650 kV |
| (iii) | Switching impulse withstand voltage, wet, kV, peak | - |
| (iv) | Power frequency 1 min. Withstand wet, voltage, | 275 kV |
| (v) | Radio interference voltage: | |
| | (a) Test voltage, kV rms to ground | 92 ($1.1xU_r/\sqrt{3}$) |
| | (b) Max. RIV, at 1000kHz, micro volts. | 500 |



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(vi) Creepage distance, mm. 4495

& may vary with altitude correction factor

**(b) Mechanical Values, Failing Load (minimum)**

1. Bending, N.10000
2. Torsion, Nm **4000

Proposer to select the insulators according to the specified requirements and the layout of the equipment. The insulator ratings/IEC designation shall be subject to approval by the Employer.

The Contractor shall supply post insulators of higher torsional strength if so required for the offered type of disconnectors.

### 6.5.4 Hardware

#### 6.5.4.1 General

All hardware such as connectors, joints and clamps shall be designed for specified aluminum conductor or aluminum tubing.

#### 6.5.4.2 Connectors

All connectors shall be of aluminum and shall have a current carrying capacity and strength equal to or greater than the buses/equipment for which they are used but shall not be less than 2000A corresponding to buses/equipment continuous rating of 2000A. The material of connectors for aluminum conductors practically shall be free from copper.

**(1) Connectors for Stranded Conductors**

Compression type connectors shall be used for dead-end and jumper terminal connections suitable for specified all aluminum conductors. All other connectors shall be of bolted type.

The dead-end compression connectors shall consist of steel tongue and an aluminum body for the stranded conductor and an aluminum terminal for the jumper terminal. Each dead-end assembly shall be supplied with a jumper connector suitable for straight or 30 degree vertical offset terminations and shall be furnished with clevis, clevis bolts and cotter pin etc.

The compression dead-end connectors shall be supplied with sufficient amount of high grade inhibitor to fill all the assemblies plus 20% spare inhibitor.

The conductivity of dead-end bodies shall not be less than the conductor itself.

The compression connectors as well as bolted type connectors shall meet the specification requirements of heat cycling duty given hereunder when subjected to Heat Cycling test. This requirement shall be met for compression dead-end connectors when bolted jumper terminals are included in the test.

One compression connector and bolted type connector of each type shall be subjected to the heat cycling duty test.

The test shall be as follows:

The test current shall be the power frequency current and should raise the surface temperature of the conductor to 140 degrees centigrade. The ambient temperature shall be kept between +15°C and +30°C. The minimum length of conductor used for determining this current shall



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be 2 meters and the conductor temperature shall be measured near the center of the test length.

The joint shall be assembled in accordance with the manufacturer's recommendations on conductor of the size and type with which it is to be used. The assembly to which a tensile load not exceeding 20% of the UTS of the conductor may be applied, shall be directed indoors so that the conductor is roughly horizontal. Air shall be able to circulate freely around the assembly which shall not however, be exposed to draughts. The minimum length of conductor on each side of the fitting shall be 2 meters.

The test current shall be passed continuously through the assembly for a period of 30 minutes. The current shall then be interrupted, and the assembly shall be allowed to cool to within 5°C above the ambient temperature. The sequence of operation shall be repeated so that 500 cycles of heating and cooling are applied. Temperature of joints, jointed conductor and of room shall be recorded continuously.

During the last 5 cycles, the maximum temperature measured when the test current is flowing at any point on the surface of the fittings, shall not exceed that of the conductor.

The strength of the joint and that of the reference conductor shall be measured before and after completion of heat cycle test. All measurements to be made at ambient temperature. There shall be no sign of local heating, burning or fusing of any part of the joint or of the conductor.

The bolted connectors shall meet the following requirements:

- Spring washers, tooth lock washers and other locking devices against loosening of screws are not admissible for bolted connectors. Plain stainless steel washers of high tensile strength must be provided beneath screw head and nut. For bolted flat, plain stainless steel washers of about 5 mm thickness and extended outside diameter shall be used.
- Clamping screws shall be made from hot-dip galvanized steel of tensile strength class 8.8 or from stainless steel of grade A2-F80. Screws of aluminum or aluminum alloy are not admissible. The minimum thread diameter of 10 mm shall be adhered to in any case.
- The conductor groove of connector shall be adapted to the conductors to be connected (no diameter range admissible).
- The contact surface of connectors shall be machined.
- The conductor groove for stranded aluminum conductors shall be provided with a suitable corrugation.
- Connectors made from forged aluminum alloy shall preferably be used for aluminum conductors.
- On connectors fitted with covers, forged covers shall preferably be used due to mechanical requirements.
- The Contractor shall submit test reports of heat cycle test along with other type tests reports on each type of bolted connector used for Employer's review.
- The Employer shall study the test reports and advise the contractor of the tests to be performed.

**(2) Connectors for Solid Conductors (Tubes, Studs, etc.)**

- The radius of conductor grooves shall bear such a ratio to the radius of tube that an abrasive contact be produced on the current-carrying connector components.



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- The bearing of tubes in the clamps of supports require thermally stable friction bearings of low coefficient of friction. A permanent and reliable transmission of charging current to the support shall be ensured.
- The angle of deflection of tubes in the suspension clamps shall be 8 degrees in all directions.
- The mechanical and electrical connection on expansion clamps shall be separated within the clamp. The current may be only conducted via the electrical connection.
- All-aluminum conductors of short lay length shall be used for the current transmission on expansion clamps. The conductors shall be connected with the connector by inert gas shielded arc welding. The welding's shall be protected from infiltrating and retaining humidity.
- The conductors of jumper shall be arranged such that the current be distributed over the conductors as uniformly as possible.
- The expansion of tubes in expansion clamps shall not be impeded. In case that the provided expansion be exceeded, the locking device shall prevent the tube from falling out of the suspension clamp.

**(3) Connectors for Equipment Terminals**

The connectors to be fixed with the terminals of various equipment shall be of monometallic or bimetallic types depending upon the material of the terminal's aluminum or copper.

#### 6.5.4.3 Conductor Suspension Clamps

Conductor suspension clamps shall be suitable for specified conductors which will be used for the buses. each suspension clamp shall be capable of holding the conductor without slipping when the conductor is under tension of 35 percent of its ultimate strength. bus support clamps shall be designed to allow for thermal expansion.

#### 6.5.4.4 Conductor Tension Assembly

The assembly shall be designed with two strings of insulators for main 132kV bus bar and shall withstand without permanent deformation of any of the components at a conductor tension equal to the full rated ultimate strength of the conductor applied simultaneously on all the conductors in the bundle.

#### 6.5.4.5 Corona Performance

Complete insulator tension as well as suspension strings assembled with all fittings in a manner as nearly as possible to the arrangement to be used shall be tested for maximum riv at (1.1xvr/√3) kv rms shall not exceed 500 micro volt.

#### 6.5.4.6 Strain Clamps for Shield Wire

Strain clamps for overhead shield wire shall be of galvanized malleable iron, bolted type and shall have an ultimate strength of not less than 7000 kg.

### 6.5.5 Drawings, Technical and Descriptive Data

#### 6.5.5.1 Proposal Drawings

Drawings and catalogue data for conductors, tubular bus, shield wire, insulators and fittings and hardware incorporating the dimensions, materials and finish shall be supplied in specific facilities data at the time of Proposal.

### 6.5.5.2 Approval Drawings

All Specific Facilities Data of AAC conductors, tubular conductors, insulators and hardware, the Contractor/Manufacturers Drawings and calculations shall be submitted for the approval of the Employer.

## 6.6 CIRCUIT BREAKERS

### 6.6.1 General

These Specifications cover the requirements for design, manufacture, testing, supply, installation and and commissioning of 132kV circuit breakers.

The circuit breakers shall be SF6 type, with self-contained power operated mechanism. Circuit breaker shall be designed, manufactured and tested in accordance with latest edition of IEC 62271-100, IEC 62271-1 and up-to-date experience incorporating any latest improvements in design and manufacture as currently employed in the industry.

The 132 kV circuit breakers shall be of the single pressure Sulphur hexafluoride (SF6) type with self-contained power operated spring charged operating mechanism.

The 132 kV circuit breakers shall be three-pole outdoor type suitable for automatic tripping and automatic reclosing and complete with all necessary accessories to make a complete operating unit. The circuit breakers shall be suitable for single shot, 3-pole rapid auto reclosing.

The design of the circuit breakers shall be such as to minimize over voltages due to current chopping. The breaker shall be able to withstand the stresses created by evolving faults. The circuit breaker, with the contacts in either fully open or closed position, shall be capable of withstanding without puncture or flashover of any of its parts, the values specified for low frequency and full wave impulse voltage, when applied to the terminals of the breakers. The rated lightning impulse withstand voltage level of all parts shall be based upon a pressure equal to the minimum pressure of the interrupting medium required for a successful interruption at the circuit breaker rating.

### 6.6.2 Standards

The circuit breakers shall be designed, manufactured and tested in accordance with the latest edition of IEC publications.

In case the requirements laid down herein differ from those given in the above publications in any particular case, the circuit breaker shall comply with the requirements listed herein referred to that item.

### 6.6.3 Ratings

The circuit breakers shall be rated conforming to the requirements of latest edition of IEC 62271-100 and IEC 62271-1 except as other-wise specified herein and as follows:

| | | |
|---|---|---|
| (1) | Nominal system voltage, kV, rms | 132 |
| (2) | Rated voltage, (Ur) kV, rms | 145 |
| (3) | Rated insulation level: | |
| | (a) Rated one minute power frequency, withstand voltage, kV, rms. | |
| | - Phase to earth and between phases | 275 |



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| | | |
|---|---|---|
| | - Across open breaker | 275 |
| | (b) Rated lightning impulse withstand voltage, kV, peak. | |
| | - Phase to earth and between phases. | 650 |
| | - Across open breaker | 650 |
| (4) | Rated normal frequency, Hz. | 50 |
| (5) | Rated current at 50 Hz and 50°C not less than, A. | 2000 |
| (6) | Rated short-time withstand current, kA, rms | 40 |
| (7) | Rated peak withstands current, kA, peak. | 100 |
| (8) | Rated duration of short circuit, second | 1 |
| (9) | Rated short-circuit breaking current at rated voltage and 50 deg. C, not less than kA, rms. | 40 |
| (10) | Percentage of DC component, %. | 30 |
| (11) | Rated short-circuit making current, kA, peak. | 100 |
| (12) | Rated operating sequence | O-0.3sec-CO-3min-CO |
| (13) | Rated out-of-phase breaking current, kA, rms | 10 |
| (14) | Rated line charging breaking current, A | 50 |
| (15) | Rated cable charging breaking current, A | 160 |
| (16) | Classification for re-strike performance during capacitive current switching | Class C2 |
| (17) | Rated break time, ms. | 40-60 |
| (18) | Maximum RIV at (1.1xVr/√3) kV rms line to ground micro volts | 500 |
| (21) | First pole-to-clear factor | 1.3*<br>1.5 (for test duty T1) |



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| | | |
|---|---|---|
| (22) | Classification for number of mechanical operations the circuit breaker shall be capable to perform | Class M2 |
| (23) | *Minimum creepage distance, mm. | 4495 |
| (24) | No of breaks per pole | 1 |
| (25) | Percentage of spare auxiliary switches: | |
| | - Normally open | 25% |
| | - Normally closed | 25% |

(26) Insulation levels, creepage distance and other rating shall be adjusted as per IEC to make equipment suitable for installation at almost 2500m altitude from sea level.

*Note:* *(for test duties T100, T60 and T30)

### 6.6.4 Switching Requirements

The circuit breaker shall be suitable for switching transmission lines for any type of fault.

The circuit breakers shall be suitable for single shot high speed three pole auto-reclosure for 132kV circuit breakers.

The circuit breaker shall be capable of interrupting the charging current of transmission lines and cables up to the value specified under sub-clause 6.6.3 above at rated voltage. The requirements of capacitive current switching shall be as outlined in Clause 6.111 of IEC publication 62271-100, Edition 2.0.

The circuit breaker shall meet the requirements of simultaneity of poles specified in Clause 5.101 of IEC 62271-100, Edition 2.0.a

The break time at 25 percent current rating with normal control voltage applied, shall not exceed the rated break time. No re-strikes at the main contacts shall be permitted under any operating duty.

The maximum noise level of the circuit breaker, when operated to close or open the three poles simultaneously shall be less than 140 dB(A) at 1-meter horizontal distance at the perimeter of circuit breaker with cabinet closed.

The circuit breaker shall be suitable to meet the requirements for full out-of-phase switching. The interrupting capability shall not be less than 25% of rated short circuit current at a voltage across one phase of value equal to two times the maximum rated phase voltage.

The circuit breaker shall be capable of handling the Short-line fault conditions associated with line switching in accordance with IEC Publication 62271-100 (latest addition).

### 6.6.5 Performance Requirements

#### 6.6.5.1 Temperature Rise

The temperature rise of any part of the circuit breakers shall not exceed the temperature rise limits specified in IEC Publication 62271-1. The reference ambient temperature shall be 40°C.



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#### 6.6.5.2 Voltage Equalization (Not Used)

The voltage across series connected interrupting contacts of circuit breaker shall be made as nearly equal as economical design permits by shunting interrupting contacts with suitable capacitors.

#### 6.6.5.3 Radio and Telephone Interference

All equipment shall be designed and constructed so as not to cause interference with radio reception or telephone communication circuits in accordance with the most modern practice. Limits of radio influence voltage is 500 micro volts when breakers are tested at 1.1xUr/√3 line to ground voltage as per IEC 62271-1.

### 6.6.6 Controls and Auxiliaries

#### 6.6.6.1 Tripping and Closing Requirements

The circuit breaker closing and tripping circuits shall be rated for 110 V D.C. Electrical tripping facilities for the operating mechanism of 132 kV 3-pole circuit breaker shall be duplicated to include, but not necessarily limited to the following:

(1) Two electrically independent and identical trip coils for each pole of the breaker and arranged to minimize the probability of failure of one trip coil affecting the operation of the second trip coil.

(2) Two electrically independent and identical sets of wiring, terminals and protecting equipment for connection to two 110 V DC for 132kV circuit breaker independent tripping power circuits.

(3) Auxiliary switches and auxiliary circuits shall be capable of carrying at least 10 A continuously without exceeding the temperature limits specified in IEC 62271-1 at temperature of 40°C ambient.

(4) The control system shall include circuitry to trip the breaker by energizing both sets of trip coils if pole- disagreement should occur and alarm shall be initiated in the control room. A timer shall be furnished in the control cubicle to permit allowable phase discrepancy condition during single pole auto- reclosing. The setting range of timer shall be between 0.5 seconds to 2.0 seconds.

(5) The closing device shall be capable of closing the breaker for any value of voltage between 85% and 110% of rated control voltage and tripping device shall be capable of tripping the breakers for any value of voltage between 70% and 110% of rated control voltage.

#### 6.6.6.2 SF6 Gas Requirements

The Contractor shall supply all relays, switches and accessories to provide for fail-safe operation of the circuit breakers during conditions of low gas density. The density shall be sensed in two stages, the first stage indicating an alarm. The second stage shall prevent closing or tripping of the breakers in case the SF6 gas density is too low, for safety reasons, and shall also give annunciation on control board. One temperature-compensated density meter for 132 kV circuit breakers shall be provided properly enclosed in a suitable enclosure.

The SF6 gas sealing system shall guarantee minimal leakage under extreme temperature conditions and effectively restrict the entry of moisture or other gases. Maximum permissible leakage rate shall be 1% per annum. The material used for sealing system shall not deteriorate due to the exposure of the gas, vapors, temperature variations and mechanical forces during



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the long-term service. Maintenance of the sealing system should generally be possible without dismantling the breaker pole and draining the SF6 gas. The breaker design shall prevent liquefaction and partial condensation of moisture of the insulating parts of the breaker operating mechanism and SF6 containers.

SF6 gas conforming to IEC Publication 60376 shall be used.

#### 6.6.6.3 Additional Requirements

All circuit breakers shall be designed for closure and tripping by remote and local electrical controls. Local electrical control shall be from the outdoor control cubicle by means of a local close-trip control switch. The control location shall be selected by a local-remote transfer switch provided within the outdoor control cubicle. The `local' operation of the circuit breaker shall be possible only when associated disconnectors are open. A two position `maintenance - off' switch shall also be provided in the outdoor marshalling kiosk for operating the breaker when it is under maintenance. This switch shall normally be in `off' position. In maintenance position, the breaker shall be locally operable provided the associated disconnecting switches are open. The breaker shall also be disconnected from the remote control and protection system when the switch is placed in `maintenance position'.

Necessary provisions shall be made to exhibit indications in the control room when the LOCAL-REMOTE transfer switch is in the LOCAL position.

All output contacts including breaker auxiliary switch contacts shall be wired out to terminal blocks. The circuit breakers shall be mechanically and electrically trip free and have an anti-pumping feature.

#### 6.6.6.4 Interlocking System

Electro-mechanical interlocking shall be supplied with each breaker. Electro-mechanical interlocking shall be provided to prevent operations of the associated disconnectors when circuit breaker is closed.

### 6.6.7 Construction

#### 6.6.7.1 General

Main assemblies shall be of modular design having same opening distance between the fixed and moving contacts. Any interrupter shall be removable without affecting the other interrupter or support column insulator in any manner so that it shall be unnecessary to drain sf6 from the whole pole when only one interrupter has to be inspected or replaced.

The circuit breaker shall be autonomous in gas supply, and no permanent external gas accumulators or piping shall be required. For refilling purposes, portable SF6 gas bottles shall be furnished. Refilling shall be possible while circuit breaker is in service.

The construction of the circuit breaker and the associated equipment shall ensure safety of personnel. The isolation from live parts shall be by elevation. All moving parts shall be suitably covered.

#### 6.6.7.2 Phase-Spacing between Poles (Not Applicable)

The circuit breaker shall be installed with not less than the specified distance between poles. The minimum distance between poles of 132 kV circuit breakers are specified in Specification Drawings.



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#### 6.6.7.3 Line Terminals

The circuit breaker terminals shall be suitable for the specified conductors

#### 6.6.7.4 External Insulation

The external insulation shall be designed, manufactured and tested in accordance with relevant IEC Publication. These shall be SF6 gas insulated type. The porcelain shall be of the wet process, homogeneous, free from cavities and other defects. Circuit breaker support columns shall be designed to withstand internal pressure of at least three times the maximum operating pressure. The color of porcelain shall be chocolate brown.

#### 6.6.7.5 Ground Terminals

Each mounting column, of each pole of the circuit breaker shall be provided with two copper grounding lugs suitable for 185 sq.mm standard copper conductor. Terminals shall be capable of carrying rated short-time current of the breaker.

#### 6.6.7.6 Finish

On all outside surfaces of metal parts, one coat of metal primer and two coats of outdoor paint shall be applied. During application, special attention shall be given to welded seams. All exposed nuts and bolts shall be treated to prevent corrosion.

### 6.6.8 Operating Mechanism

The operating mechanism and appurtenances shall conform to IEC Standard Publication No. 62271-100 The operating mechanism for 132 kV circuit breakers shall be 110V DC motor operated spring charged only.

The circuit breakers equipped with spring charged operating mechanism shall be closed by the stored energy of charged springs. The mechanism shall be designed such that the failure of spring will not prevent tripping and will not cause tripping or closing. The energy stored in motor-compressed spring shall be sufficient for an OPEN-CLOSE-OPEN operation at rated short circuit current. The charging motor shall be direct current. The motor shall not require more than 15 seconds to recharge the closing springs after a close-open operation. Means shall be provided to prevent operation of the mechanism when maintenance work is being done.

The operating mechanism shall be capable of performing the duty cycle as specified in Clause 6.6.3 of these Technical Specifications.

Working parts of the mechanism shall be of corrosion resisting materials, and all bearings which require frequent greasing shall be equipped with pressure-type grease fittings and shall be readily accessible without dismantling the mechanism or housings. The mechanism and control system shall be strong, robust, positive, fast and shall not have objectionable rebound or require critical adjustments or frequent maintenance.

The mechanism shall be designed so that it will not cause tripping or closing when there is no control command.

Provision shall be made on the circuit breakers for the attachment of a device to record the operation of valves, contacts, etc., so that timing tests can be made to verify the sequence of operation as prescribed.



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For purposes of inspection and adjustment, means shall be provided to permit local operation of the breaker, so designed that the contacts of the breaker may be operated slowly for adjustment.

Mechanical position indicator to indicate the position of the breaker shall be provided. Open position shall be indicated by using letter "O" with green color as background while closed position shall be indicated by letter "C" with red as background color. Separate operation counter shall be provided for each pole of the circuit breaker.

Motor over-running indication feature shall be incorporated to signal the excessive running of the motor of hydraulic pump due to any gas leakage.

### 6.6.9 Provisions for SCADA and Remote Control Functions

Provisions shall be made for remote `open' and `close' operations, position indications and failure alarm (at remote stations) for 132 kV circuit breaker as specified.

Identified terminals in the control boards shall be wired to auxiliary contacts of the circuit breakers. The auxiliary contacts shall comprise separate parts for NO and NC potential free contacts for open and close positions respectively.

### 6.6.10 Outdoor Cubicles and Components

#### 6.6.10.1 General

Outdoor cubicles of all the circuit breakers shall be vermin proof and weather proof, of protection Class IP55. The master control housing shall contain all breaker indicating devices, MCBs for AC and DC circuits, closing and tripping controls, and alarm relays for all the necessary mechanical and electrical apparatus and accessories required. All mcbs shall be provided with auxiliary contacts and sensitive earth fault protection for personnel safety. Separate MCBs shall be provided for heating and lighting circuits.

There shall be a neoprene gasket between the door and frame to prevent the ingress of moisture. Each of the cubicles shall be mounted so as to be accessible from ground level. Structural backing shall be provided, where required, in such a manner that the complete assembly shall be rigid, self-supporting and free of vibration, twist and weave.

#### 6.6.10.2 Cubicle Interior

No equipment shall be mounted less than 300 mm above the floor of the cubicle or 150 mm from the roof. Any unused areas of panels shall be kept free of wiring to permit the installation of possible future components.

#### 6.6.10.3 Doors and Latches

Each cubicle shall be equipped with a hinged door with hinges on the left.

The door shall have its edge bent inwards for rigidity. There shall be a three-point latch and activating handle. The handle and door shall have matching projections with a 12.5 mm diameter hole suitable for locking the cubicle door with a padlock

#### 6.6.10.4 Lighting, Outlets and Telephone Jacks

Interior lighting operating from a door switch shall be provided within each cubicle assembly.

A 240 V, 5A single phase three pin convenience outlet along with its MCB to fit standard prong plugs shall be installed inside cubicle assembly.

A telephone jack shall be provided in each cubicle assembly. A hook for supporting head set shall be provided conveniently close to the jack. Telephone wiring up to control desks, relay room and PLC room in the control building shall be provided for work during erection and maintenance.

#### 6.6.10.5 Ground Bus

A copper ground bus bar shall be provided with tapped holes and screws and shall be connected to the shields or associated earth continuity conductors of all incoming cables.

#### 6.6.10.6 Control Circuit

110V DC miniature circuit breakers shall be provided for protecting DC control circuits 132 kV circuit breakers.

#### 6.6.10.7 Terminal Blocks and Terminals

Terminal blocks for control wiring shall be molded type with marking strips and covers. White marking strips shall be provided for circuit designation. Each connected terminal of each block shall have the circuit designation. Terminal studs and wires shall be numbered or otherwise marked in accordance with the applicable schematic and wiring diagrams with permanent contrasting marking fluid.

Terminal blocks shall be arranged with sufficient room for easy connection of incoming cables. Parallel rows of terminal blocks shall be spaced at least 150 mm apart. At least 20% spare terminals shall be provided in each block or group of blocks.

Blocks shall be mounted in vertical columns along the sides of cubicles or on vertical panels specially provided for terminal blocks.

#### 6.6.10.8 Component Wiring

Wiring between terminals of various devices shall be point to point (no splicing or 'T' connection shall be allowed). All internal wiring shall be neatly truncated in wiring troughs.

All groups of bundled conductors to hinged doors and panels shall use extra-flexible wire arranged so that a twisting, rather than a bending motion is imparted to the moving conductor bundle.

All wires shall be identified at both ends according to the interconnection diagrams.

#### 6.6.10.9 Heaters

Space heaters of sufficient capacity along with thermostat, humidistat, control switches and circuit breakers shall be supplied for each control cabinet to reduce condensation which may occur. `Auto-Manual' selector switch shall be provided for selecting the operating mode of the heaters.

#### 6.6.10.10 Schematic Diagram

A schematic diagram of the control circuit block of the circuit breaker shall be provided.

#### 6.6.10.11 Motors

All motors shall conform to IEC standards for motors and as specified herein:

Fractional horsepower motors shall be rated for 230 V, single phase, 50 Hz supply. All other and reversing motors shall be rated for 400 V, three phase, 50 Hz.



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The motors shall be squirrel-cage induction type, direct on line starting, normal starting torque, low starting current.

The motor shall be single speed having a continuous service factor of 1.0.

Motors for circuit breakers equipped with spring charged operating mechanism will be rated for 110V DC for 132 kV circuit breakers.

#### 6.6.10.12 Structures

The structural steel supports for the circuit breakers as well as all necessary related steel materials shall be designed in accordance with design parameters and instructions given in Section 6.4 of these Specifications. Supporting structures, mounting bolts, nuts and accessories shall be as specified in Section 6.4 of these Specifications.

#### 6.6.10.13 Material and Workmanship

The material and workmanship throughout shall be of the best quality in accordance with accepted modern practices. The design shall be such that installation, replacements and general maintenance may be undertaken with a minimum of time and expense. Each complete unit shall be designed for continuous operation at full-rated capacity and liberal factors of safety shall be used throughout the design. All screw threads and bolt sizes shall comply with ISO Standards for metric threads.

#### 6.6.10.14 Shop Cleaning and Painting

All interior and exterior surfaces of tanks, enclosures, cabinets and other metal parts which are not galvanized and are exposed to oil or weather shall be thoroughly cleaned by degreasing and abrasive blasting, or other equivalent means to remove all grease, scale, corrosion, and foreign substances, subject to the approval of the Employer. All interiors and exteriors except tanks which shall receive the Manufacturer's standard treatment shall be given at least one priming coat and one finish coat of light colored paint or enamel. Interiors of operating compartments shall have a finish coat of gloss white. All exteriors shall be given not less than 3 coats of paint consisting of primer and finish enamel. The finish coat shall have high grey color. The total dry film thickness of the 3 or more coats of paint shall not be less than 0.09mm, of which not less than 50% shall be finish enamel.

All machine-finished or bright surfaces shall be thoroughly cleaned, coated with a suitable, easily removable, corrosion resisting compound and wrapped or otherwise protected from damage during shipment.

Four liters of finish paint shall be furnished for re-finishing damaged surfaces after erection.

### 6.6.11 Tests

#### 6.6.11.1 General

The circuit breakers shall be subjected to tests in the shop and at site in the presence of the Employer for conformity to the requirements of the Specifications.

Six (6) certified copies of the tests made, and of the results thereof after the tests are made, shall be furnished by the Contractor to the Employer for approval. The results of these tests shall be in such form as to provide means of determining compliance with the applicable Specifications for the material tested. If any item of the plant is of a new design or if essential parts have been redesigned, additional test reports to verify this data shall be submitted for Employer approval.



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Tests required herein shall be carried out in accordance with the latest issue of IEC Publication of IEC 62271-100 and IEC 62271-1.

### 6.6.11.2 Type Tests

One representative circuit breaker with associated equipment out of the circuit breakers of the same design which shall be supplied, shall be assembled complete in the factory and type tests shall be carried out in accordance with the latest issue of IEC Publications 62271-100 and IEC 62271-1. However, duly certified and complete test reports for tests carried out by an independent laboratory on similar circuit breaker shall be acceptable in lieu of actual tests. Independent laboratories are specified in Clause 6.3.13 of these Technical Specifications. Six copies of the test reports shall be submitted for Employer review and approval.

The required type tests are as follows:

(1) Dielectric tests.
(2) Radio interference voltage (RIV) tests.
(3) Measurement of the resistance of the main circuit.
(4) Temperature rise tests.
(5) Additional tests on auxiliary and control circuits.
(6) Short-time withstand current and peak withstand current tests.
(7) Tightness tests.
(8) Electromagnetic compatibility (EMC) tests.
(9) Mechanical and environmental tests.
(10) Short circuit making and breaking tests.
(11) Capacitive current switching tests.
(12) Verification of the degree of protection.
(13) Extended mechanical endurance tests.
(14) Static terminal load test.
(15) Critical current tests.
(16) Short-line fault tests.
(17) Out-of-phase making and breaking tests.
(18) Single phase tests.
(19) Shunt reactor current switching tests.
(20) **Contacts Opening/Closing Time:** The circuit breaker shall be tested to demonstrate that all main contacts in different poles open or close within the times specified in clause 5.101 of IEC 62271-100.

### 6.6.11.3 Routine Tests

Routine tests shall be carried out on all circuit breakers and porcelain enclosures and supports furnished under this Contract at the factory after final assembly, in accordance with the latest issue of IEC Publication 62271-100. Six copies of the certified test reports shall be submitted for Employer review and approval in accordance with Employer Requirements. No equipment shall be shipped until the required routine tests have been approved by the Employer.

(1) Dielectric test on the main circuit.
(2) Tests on auxiliary and control circuits.
(3) Measurement of the resistance of the main circuit.



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(4) Tightness test.
(5) Design and visual checks.
(6) Mechanical operating tests.

The Contractor/manufacturer shall arrange inspection of spare parts to be supplied under the Contract during witnessing of Factory Acceptance Tests (FATs) at manufacturer's premises.

### 6.6.12 Porcelain Enclosures and Supports

Each porcelain enclosure of the offered circuit breakers and support or insulating tube or piping which is, or may be, subjected to internal pressure from the breaker shall be given a pressure test of not less than 2 times the maximum pressure to which it could be subjected in service, held for a period of one minute.

### 6.6.13 Name Plates

A non-corrodible metal nameplate shall be attached to each circuit breaker and its operating devices in a position which shall be clearly visible to a person standing on the ground. The nameplate should list the data specified in Clause 5.10 of IEC Publication 62271-100.

A nameplate shall also be attached to each piece of equipment giving full identification and rating data by its manufacturer as specified in Sub-Clause 5.10 of IEC Publication 62271-1.

Coils of operating devices shall have a reference mark permitting the complete data to be obtained from the manufacturer.

### 6.6.14 Drawings, Technical and Descriptive Data

The following drawings, information and descriptive data shall be supplied:

(1) Technical Data of circuit breakers as per the format of Specific Facilities Data to Proposal provided in Employer Requirements.
(2) The requisite information required to be supplied with the Proposal in accordance with Sub-clause 9.101 of IEC Publication 62271-100 and shall be supplied in the manner and form given therein.
(3) Outline drawings, photographs, descriptive sheets and sketches to describe clearly the construction and operation of the circuit breaker.
(4) The details of the minor and the general maintenance requirements for servicing and replacement of the contacts, and the requirements of maintenance on the number of switching operations at:
    (a) Full short circuit capacity (100 percent).
    (b) Half short circuit capacity (50 percent).
    (c) Quarter short circuit capacity (25 percent).
(5) The minimum electrical clearance between stationary and moving conducting parts when the circuit breaker is in the normal open position.
(6) The minimum phase spacing.
(7) Full description of any device incorporated in a circuit breaker to limit or control the rate of rise of restriking voltage across the circuit breaker contacts.
(8) The details of the operating mechanism, literature and catalogue data showing full details of the opening and closing sequences of the mechanism under all conditions.
(9) Type test reports.
(10) Instruction manual.



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(11) Experience records for the offered type of breakers.

#### 6.6.14.1 Approval of Technical Data / Drawings / Documents

(1) Technical Data of circuit breakers as per the format of Specific Facilities Data to Proposal provided in Employer Requirements.
(2) Approval Drawings shall show the detailed physical arrangements of the breaker, high voltage connections, wiring and schematic diagrams of the control scheme.
(3) Also provided shall be the transport, storage, installation, erection, maintenance and operation instruction books. These instructions to be written in accordance with IEC Publications 62271-100 and 62271-1.
(4) Impact loading of circuit breaker during the opening and closing operations.
(5) Test reports.
(6) Any other information that the Employer may require.

## 6.7 DISCONNECTORS AND EARTHING SWITCHES

### 6.7.1 General

These Specifications cover the requirements for design, manufacture and testing of 132kV disconnectors with or without earthing switches. The design manufacture and testing shall be in accordance with the latest edition of IEC Publications 62271-102 and 62271-1 and the requirements listed herein and shall incorporate the latest improvements in design and manufacture as currently employed in the industry. In case the requirements laid down herein differ from those given in the specified standards in any particular case, the disconnectors and earthing switches shall comply with the requirements listed herein referring to that item.

The disconnectors shall be air switches with or without earthing switches as specified. These shall be outdoor, motor operated, three-pole for 132kV with grouped operation and will be used for isolating equipment and earthing of the line circuits. The 132kV disconnectors shall be horizontal center-break type. The earthing switches shall also be motor operated.

### 6.7.2 Ratings

The ratings and electrical characteristics of the disconnectors and earthing switches, where applicable, shall be as follows:

| | | |
|---|---|---|
| 1. | Nominal system voltage, kV, rms. | 132 |
| 2. | Rated voltage, kV, rms | 145 |
| 3. | Rated insulation level: | |
| | (i) Rated 1 min. power frequency withstand voltage: | |
| | (a) Phase-to-earth and between phases, kV, rms | 275 |
| | (b) Across the isolating distance, kV, rms | 315 |
| | (ii) Rated lightning impulse with-stand voltage: | |
| | (a) Phase-to-earth and between phases kV, peak | 650 |



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| | | |
|---|---|---|
| | (b) Across the isolating distance, kV, peak | 750 |
| 4. | Frequency, Hz. | 50 |
| 5. | Rated normal current at 50°C not less than, A, rms | |
| | (a) Bay disconnectors | 2000 |
| 7. | Rated short-time withstand current for disconnectors and earthing switches, kA, rms | 40 |
| 9. | Rated duration of short circuit, sec. | 1 |
| 10. | Rated peak withstands current for disconnectors and earthing switches, kA | 100 |
| 11. | Rated short-circuit making current for earthing switches, kA, peak | 100 |
| 12. | For earthing switches: | |
| | a) Rated induced current for electro-magnetic coupling A (rms) | 80 |
| | b) Rated induced voltage for electro-magnetic coupling, kV (rms) | 2 |
| | c) Rated induced current for electro-static coupling, A (rms) | 2 |
| | d) Rated induced voltage for electro-static coupling, kV (rms) | 6 |
| 13. | Minimum creepage distance, mm | 4495 |
| 14. | Maximum time required to open or close the disconnector, seconds | 5 |
| 15. | Maximum RIV at ($1.1xU_r/\sqrt{3}$) rms line-to-ground voltage, and 1000 kHz, micro volts. | 500 |
| 16. | Number of operations (CLOSE-OPEN), disconnectors shall be capable to perform. | 10,000 |
| 17. | Percentage of spare auxiliary switches: | |
| | - Normally open | 25% |
| | - Normally closed | 25% |



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18. Insulation levels, creepage distance and other rating shall be adjusted as per IEC to make equipment suitable for installation at 2500m altitude from sea level.

### 6.7.3 Construction

#### 6.7.3.1 General

The disconnectors shall be mounted on station post type insulators specified in Clause 6.5.3.2 Transmission of motion to the blades shall be via rotating insulators. The disconnectors shall be complete with steel structure supports, bases, mounting bolts, operating rods with hardware, electro-mechanical interlock facilities, ground and line terminal connectors, earthing switches where specified, operating mechanisms and all other accessories necessary for satisfactory operation. The disconnectors/earthing switches and mechanisms shall be designed to prevent entrance and accumulation of water or dirt.

#### 6.7.3.2 Mechanical Strength

Disconnectors and earthing switches when installed shall be able to bear on the terminals the total forces (including static mechanical terminal load, wind load and electrodynamic forces on the attached conductors) relating to the application and rating without impairing their reliability or current carrying capacity. The conductors attached to the disconnectors shall be as per the approved layout and sections drawings of the respective switchyard.

#### 6.7.3.3 Switch Base

The base of each switch pole shall be of galvanized steel structure, rigid and self-supporting without cross bracing between phases. The disconnectors and earthing switches shall operate properly when the base is mounted on the supporting steel structures.

#### 6.7.3.4 Bearings and Gears

All bearings and gears shall be contained in weather sealed housings providing ability for maximum axial and lateral loading with minimum friction. Each rotating insulator stack shall have double roller or double ball bearings at the base, and at the top end. The vertical operating pipes, if 3 meter or more in length, shall be suitably supported by ball or roller thrust bearings. The ball and roller bearings shall be greaseless and maintenance free type and shall be accessible for dismantling and replacement at site.

#### 6.7.3.5 Insulators

All switches shall be provided with solid core post type insulators as specified in Clause 6.5.3.2 and shall have provision for alignment of insulator stacks. The adjusting means shall not require removal of insulators, bolts, or cap screens. The color of insulators shall be chocolate brown.

#### 6.7.3.6 Contacts and Blade

Blades of the poles of the disconnectors / earthing switches shall be designed for synchronized operation. The contacts shall be high pressure self-cleaning silver plated type. The disconnector / earthing switch shall be manufactured from high conductivity copper or aluminum alloy. The current path shall not be through any spring, hinge or movable pin connection. The formed contact ends of blades shall be silver-plated to ensure good contact transfer characteristics. The contact pressure shall be developed by movement of the entire blade. The contacts of the disconnectors / earthing switches shall be so designed that blade opening shall be prevented during short circuits.



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Fixed guides shall be provided so that proper seating of the contacts will be obtained when a blade is out of line in either direction. The disconnector/earthing switch contacts shall be outfitted with corona rings.

#### 6.7.3.7 Terminals

Terminals shall be suitable for the conductors to be used as per the approved layout for 132kV switchyards.

#### 6.7.3.8 Terminal Connectors

The switches shall be provided with terminal connectors as required.

#### 6.7.3.9 Grounding Lugs

Copper grounding lugs suitable for 185sq.mm stranded copper cable shall be furnished for connecting each disconnector base and the lower end of each vertical operating rod to the steel structure. The base shall be connected to the grounding grid at two diagonally opposite points.

#### 6.7.3.10 Finish

All ferrous parts shall be galvanized in accordance with ASTM specification A-153 or A-123 standards.

#### 6.7.3.11 Earthing Switches

Earthing switches shall be provided on all three poles of the line disconnectors. The earthing switches shall be motor operated with a hand wheel or a crank for manual operation and electrically and mechanically interlocked so that it cannot be closed when the line disconnector is closed and conversely the line disconnector cannot be closed when the earthing switch is closed. A flexible copper braid with a current carrying capacity equivalent to a 185sq.mm stranded copper cable shall be provided on each earthing switch for connection to the grounding lugs. The earthing switches shall ground the jaw end of the disconnectors on the line side.

#### 6.7.3.12 Interlock

Necessary electro-mechanical interlocks shall be furnished for disconnectors for lines and circuit breakers.

The electro-mechanical interlocks shall perform the following functions:

1. To prevent operation of each circuit breaker disconnectors when associated circuit breaker is closed.
2. To prevent operation of line disconnector when associated breaker is closed.
3. To prevent remote/local operation of disconnectors when associated circuit breaker is being maintained (whether open or closed).
4. To prevent closing of earthing switch when line disconnector is closed.
5. To prevent closing of line disconnector when earthing switch is closed.
6. The arrangement shall be made to ensure that the disconnector cannot be operated mechanically with manual operating handle when the associated circuit breaker(s) is (are) in closed position.



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7. Arrangement shall be made to ensure that the line earthing switch cannot be closed when line is energized from the remote end.

#### 6.7.3.13 Mounting

The disconnectors shall be installed on steel supporting structures of galvanized steel construction as specified in Clause 6.7.3.3 hereof.

#### 6.7.3.14 Ground Bus

A copper ground bus shall be provided with tapped holes, screws, and connecting lugs for terminating a 120 mm2 bare ground conductor, in the interior of the control cubicle.

**TAGS**

Wires shall be tagged with a neoprene disc or equivalent, stamped with the cable number for easy identification.

All devices shall be identified in accordance with the schematic and wiring diagram associated with the panel.

#### 6.7.3.15 Control Circuit

Control voltage shall be 110 V DC for 132 kV disconnectors. DC control supply with MCBs as required shall be provided.

#### 6.7.3.16 Terminal Blocks

Terminal blocks for control wiring shall be molded disconnecting type with marking strips and covers. White marking strips shall be provided for circuit designation. Each connected terminal of each block shall have the circuit designation and wires shall be marked in accordance with the applicable schematic and wiring diagrams with permanent contrasting marking fluid AC, DC circuits shall be physically separated in groups. Terminal blocks shall be arranged with sufficient room for easy connection of incoming cables. Parallel rows of terminal blocks shall be spaced at least 150 mm apart. At least 20% spare capacity will be provided in each terminal block or group of blocks.

#### 6.7.3.17 Component Wiring

Wiring between terminals of various devices shall be point to point (no splicing or 'T' connection shall be allowed). All internal wiring shall be neatly truncated in wiring troughs.

Outgoing wiring shall be connected to terminal blocks suitable for connection to multi-conductor cables. One wire shall be connected to each terminal point. All outgoing wires of terminal blocks shall be grouped.

All wiring shall be identified at both ends.

#### 6.7.3.18 Humidity Control and Interior Lighting

Space heaters of sufficient capacity along with thermostats and humidistats shall be provided for each operating housing to reduce condensation which may occur. The heaters shall be arranged and protected so as to create no hazard to adjacent equipment. The heaters shall be rated for 230 V, single phase, 50 Hz.

Local control cubicles/housings shall be provided with interior illuminations. Lamps shall be controlled with door operated switches.



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Separate MCBs shall be provided for space heating and interior illumination. MCBs shall be equipped with sensitive earth fault protection and auxiliary contacts.

### 6.7.4 Operating Mechanism

#### 6.7.4.1 General

The operating mechanism of the disconnector and earthing switch shall be operable both electrically and manually. The disconnectors equipped with pneumatic operating mechanism shall not be acceptable. The mechanism shall be mounted on the base supporting the switch structure and shall affect a smooth and thoroughly controlled movement throughout the entire operating cycle and shall be permanently lubricated. The mechanism(s) shall be provided with operation counter and shall also be grounded in a suitable manner.

#### 6.7.4.2 Electrical Operation

The electrical operation of 132kV disconnectors shall be through 110 Volts DC motor which shall be capable of operating the disconnectors or the earthing switches for supply voltage between 85% and 110% of the rated value.

The motor shall be protected by suitable MCBs. The possibility of over-travel shall be eliminated by limit switches, opening the motor circuit and by application of mechanical brake(s). The limit switches and the operating rod travel shall be adjustable for various operating gear ratios.

All disconnectors and earthing switches shall be designed for closure and opening by remote and local electrical controls. Local electrical control shall be made from outdoor control cubicle by means of a local Close - Open control switch. The control location shall be selected by a Local - Remote selector switch provided on the outdoor control cubicle. Local controls shall be provided right at the disconnector/earthing switch location as well as in the relevant bay marshalling kiosk.

When the selector switch is in the "Local" position, it shall not be possible to operate the disconnector from the control room. When the Local/Remote Switch, is in the "Remote" position, the disconnector shall not electrically operate locally.

Any opening or closing operation once initiated, shall be completed under the action of seal-in contacts and limit switches.

The auxiliary switches consisting of at least twelve electrically separate SPDT contacts rated at 110 V, as specified, 10A minimum, shall be provided in an enclosure, in or near the operating mechanism for signaling, interlocking and control. The auxiliary switches shall be wired to the terminal block, in the outdoor control cubicle.

#### 6.7.4.3 Manual Operation

For emergency operation, an adequate manual operating device with a hand wheel or a crank handle shall be furnished. A suitable hanger shall be provided on the outside of the housing to hold the crank when not in use.

A means of disengagement shall be provided between the power operated mechanism and the manual mechanism such that the power operating device will not operate when manual operation is being performed. If the disconnector has been opened manually, it shall be possible to close it electrically or vice versa.

The auxiliary switches and the limit switches shall continue to function normally when the equipment is manually operated.



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#### 6.7.4.4 Provisions for SCADA and Remote Control Functions

Provisions shall be made for remote `Open and Close' operation and status indication for each 132kV disconnector and earthing switch.

Identified terminals in the interface panel shall be wired to auxiliary contacts of disconnectors and earthing switches for the above purpose.

The auxiliary contacts shall comprise separate parts for N/O and N/C potential free contacts for close and open positions.

The auxiliary contacts shall be of the type which change state only when the disconnectors/earthing switch has completed its opening or closing operation. The auxiliary contacts shall monitor the open, close and intermediate position of the disconnectors.

### 6.7.5 Name Plates

All disconnectors shall be provided with metal nameplates one located on each switch base and one on the operating mechanism where it can be readily seen from ground level. All the nameplates shall be corrosion proof. The nameplates shall give full identification and rating data by its manufacturer in accordance with IEC Publication 62271-102 (latest edition).

### 6.7.6 Tests

#### 6.7.6.1 General

The disconnectors and earthing switches shall be subjected to tests in the shop and at site in the presence of the Employer for conformity to the requirements of the Specifications.

Six (6) certified copies of the tests made, and of the results thereof after the tests are made, shall be furnished by the Contractor to the Employer for approval. The results of these tests shall be in such form as to provide means of determining compliance with the applicable Specifications for the material tested. If any item of the plant is of a new design or if essential parts have been redesigned, additional test reports to verify this data shall be submitted for Employer approval.

One complete 3-pole disconnector and earthing switch shall be assembled in the factory to prove the design. In addition, the live parts of each pole of each disconnector and earthing switch shall be assembled and mounted on base (less insulators) and tested to check operation and alignment.

Tests required herein shall be carried out in accordance with the latest issue of IEC Publication 62271-102 and IEC 62271-1.

#### 6.7.6.2 Type Tests

All type tests but not limited to the following shall be carried out on disconnectors/earthing switches in accordance with the latest issue of IEC Publication 62271-102 and IEC 62271-1. However, duly certified and complete test reports for tests carried out by an independent authority/laboratory on an identical disconnector/earthing switch shall be acceptable in lieu of actual tests. Independent laboratories are specified in Clause 6.3.13 of these Technical Specifications. Six copies of the test reports shall be submitted for Employer approval.

(1)Dielectric tests.

(2)Radio interference voltage (RIV) tests.

(3)Measurement of the resistance of the main circuit.



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(4)Temperature rise test.

(5)Short-time withstand current and peak withstand current tests.

(6)Verification of the protection.

(7)Electro-magnetic compatibility test (EMC)

(8) Tests to prove the short-circuit making performance of earthing switches, if applicable.

(9)Operating and mechanical endurance tests.

(10) Operation at the temperature limits.

(11) Bus transfer current switching tests (for 132kV disconnectors)

(12) Induced current switching tests.

#### 6.7.6.3 Routine Tests

Following routine tests shall be carried out in accordance with the latest issue of IEC Publication 62271-102 and IEC 62271-1. Six copies of the certified test reports shall be submitted to the Employer for review. No equipment shall be shipped until the required routine tests have been approved by the Employer

(1) Dielectric tests on the main circuit.
(2) Dielectric tests on auxiliary and control circuits.
(3) Measurement of the resistance of the main circuit.
(4) Design and visual checks.
(5) Mechanical operating tests.

#### 6.7.6.4 Electrical Equipment Test

(1) **Motor:** All motors shall be tested at the factory. Tests shall consist of at least those defined as routine factory tests by the appropriate IEC Standards for each type of motor, including but not necessarily limited to:

(a) Power frequency dielectric withstand tests on windings.
(b) Inspection of bearings
(c) Measurement of winding resistance

(2) **Assemblies:** All electrical assemblies other than motors shall be tested at the factory. Tests to be made shall include:

(a) Power frequency dielectric withstand tests on power and control circuits, including wiring and equipment, in accordance with IEC Publications.
(b) Continuity of control circuit wiring and of the grounding of non-current carrying parts of equipment
(c) Operation tests under simulated service conditions to ensure correct operation of all equipment and devices, proper mechanical functioning of all parts of the assembly, and correct mutual functioning of inter-related components.

### 6.7.7 Drawings, Technical and Descriptive Data

#### 6.7.7.1 Drawings, Technical and Descriptive Data to be supplied with the Proposal

Proposal Drawings and descriptive data shall show the main constructional and operating features of the disconnectors, earthing switches and associated accessories. Following information shall be submitted as minimum:

(1) Technical Data of disconnectors and earthing switches as per the format of Specific Facilities Data to Proposal provided in Employer Requirements.
(2) Outline drawings, photographs, descriptive sheets and sketches to describe clearly the construction and operation of the disconnectors/earthing switches.
(3) The minimum phase spacing.
(4) Literature and catalogues showing details of operating mechanism.
(5) Control Scheme.
(6) Certified reports of type tests carried out by an independent authority.
(7) Instruction manual.
(8) Supply list.

#### 6.7.7.2 Approval Drawings / Documents

(1) Technical Data of disconnectors and earthing switches as per the format of Specific Facilities Data to Proposal provided in Annexure-I at the end of this document.
(2) Approval drawings shall show the scheme of connections diagrams incorporating the various desired features of the disconnectors/earthing switches and accessories. Following drawings/documents shall be submitted:

   (a) Outline drawings, catalogues/ drawings showing constructional details.
   (b) Drawings showing the interlocking.
   (c) Schematic and wiring diagrams.
   (d) Outdoor control cubicle details.
   (e) Nameplate drawing.

(3) Installation, erection, maintenance and operation instruction book.
(4) Test reports.

### 6.8 CURRENT TRANSFORMERSGeneral

These Specifications cover the requirements for design, manufacture, testing and commissioning of current transformers for 132kV switchyard and for current transformers for special applications (secured energy metering system) of 132kV switchyard. The current transformers for special applications (secured energy metering system) shall be supplied as specified.

The current transformers shall be single pole, free standing, hermetically sealed, oil filled, self-contained, outdoor type. These shall be supplied complete with oil level indicators, steel support structures, solderless clamp type HV connectors for connection to conductor and/or aluminum tube, terminal boxes with terminals for outgoing secondary wires, grounding terminals and marshalling boxes as specified. The oil shall conform to latest issue of relevant IEC Publication.

The current transformers shall be multiple ratio type for 132kV switchyard.

The current transformers shall be designed, manufactured and tested in accordance with the latest issue of relevant IEC Publications and particulars listed herein which shall be taken as the minimum requirements. Upward revision of any of the parameters found necessary at the time of detailed engineering by the Contractor and development of current transformer performance characteristics shall be made while finalizing the design of the current transformers without any additional cost. All taps shall be selectable from secondary side. Selection of taps from primary side shall not be acceptable.



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### 6.8.2 Ratings

The current transformers shall have the following ratings

| | | 132 kV | SMS |
|---|---|---|---|
| 1 | Nominal system voltage, kV, rms. | 132 | 132 |
| 2 | Rated voltage for the equipment, kV, rms. | 145 | 145 |
| 3 | Rated frequency, Hz. | 50 | 50 |
| (a) | Rated switching impulse withstand voltage, kV, peak. | – | – |
| (b) | Rated lightning impulse withstand voltage, kV, peak. | 650 | 650 |
| (c) | Chopped lightning impulse withstand voltage, kV, peak. | 748 | 748 |
| (d) | Rated power frequency withstand voltage, kV, rms. | 275 | 275 |
| 5 | Rated short-time (one-second) thermal current rating (Ith), kA, rms. | 40 | 40 |
| 6 | Rated dynamic current rating [Idyn = 2.5(Ith)], kA, peak. | 100 | 100 |
| 7 | Rated primary current, A, rms. | 2000 | 2000 |
| 8 | Rated secondary current, A, rms. | 1 | 1 |
| 9 | Transformation ratios (by means of taps on the secondary windings) | 1600-800-400-150/1A | 1600-400-150/1A |
| 10 | Number of secondary cores | 5 | 1 |
| (a) | Accuracy Class – Measuring core (1) | 0.2S | 0.2S |
| (b) | Accuracy Class – Protection cores (4) | 5P20, TPS (IEC 61869) | – |
| 12 | Instrument security factor for measuring core | 5 | 5 |
| 13 | Rated output of each secondary winding at the lowest tap, VA | 15, 30, 30, 30, 30 | 15 |
| 14 | Between sections insulation: Rated power frequency withstand voltage, kV, rms. | 3 | 3 |



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| | | | |
|---|---|---|---|
| 15 | Secondary winding insulation: Rated power frequency withstand voltage, kV, rms. | 3 | 3 |
| 16 | Interturn insulation: Rated withstand voltage over complete secondary winding, kV, peak. | 4.5 | 4.5 |
| 17 | Maximum temperature rise in the insulating oil above ambient of 50°C | 55 | 55 |
| 18 | Minimum external creepage distance, mm | 4495 | 4495 |
| 19 | Radio interference voltage at 1.1 Ur/√3 kV and 1000 kHz, µV | 500 | 500 |
| 20 | Maximum permissible partial discharge level | As per Table 6 of IEC 61869-2 | |
| 21 | Insulation levels, creepage distance and other ratings adjusted for installation at 2500 m altitude | | |

### 6.8.3 Accuracy Classification

The accuracy classification given in Clause 6.8.2 shall be achieved without secondary turn compensation.

The protection cores of the current transformers to be supplied under this contract shall meet the requirements of 5P20 accuracy class for 132 kV switchyard. In addition to this, the protection cores shall fulfill the transient dimensioning requirements of IEC 61869-2 for TPS class current transformers.

### 6.8.4 Construction

#### 6.8.4.1 General

The current transformers shall be constructed to provide adequate insulation for the insulation class specified and to withstand mechanical and thermal stresses produced under short circuit conditions. All insulation and magnetic materials shall have proven and well established physical and electrical properties such as to give continuous and prolonged service without deterioration.

The current transformers shall be hermetically sealed with the arrangement other than nitrogen gas cushions such as synthetic or stainless steel bellows or expandable cells to accommodate oil level variation. Suitable grade of stainless steel shall be used if steel bellows are provided with the provision of suitable device for indicating the position of bellows.

#### 6.8.4.2 Secondary Terminals and Terminal Boxes

The secondary leads shall be brought out through the current transformer tank wall by means of multiple bushings, equipped with connectors for 2.5 sq.mm to 10 sq.mm stranded copper conductor and shall terminate in a low voltage weather proof box mounted on the side of the tank. The name plate shall be fixed at the outside of the terminal box to be visible with the box closed. Connection diagram shall be affixed inside the secondary terminal box so that it can be easily read while working in the box.

#### 6.8.4.3 Cores and Windings

The cores shall be made of high quality non-aging grain oriented silicon steel, carefully selected, tested and annealed to provide the best magnetic characteristics.

The cores and windings structure shall be rigidly braced and clamped to sustain given mechanical short time rating. The design of cores and windings shall be such as to ensure high accuracy, uniform impulse distribution throughout the winding and low leakage reactance. Each secondary winding shall be wound on a separate core.

#### 6.8.4.4 H.V. Bushings

The current transformers shall be equipped with H.V. bushing of an insulation class not less than that of winding terminal to which they are connected and of creepage distance as specified in Section 6.8.2.

The bushings shall be manufactured from wet type porcelain and suitable for continuous outdoor service. The bushings shall be so constructed as to produce a uniform electrical stress distribution throughout, contain no voids, and be leak proof at all temperatures. Provisions shall be available for power factor testing of each bushing. Each current transformer shall be equipped with bellows position indicator readable from ground level.

#### 6.8.4.5 Tank

The tank shall be constructed of corrosion-proof, high-quality cavity free cast aluminum alloy and shall be suitably reinforced to withstand handling and excessive pressure under fault conditions without distortion. All welded joints pipe work and valves etc. shall be oil leak tested. A clamp on cover shall preferably be provided to allow access to component parts within the tank without undue difficulty. Grounding lugs complete with connectors suitable for 185 Sq.mm stranded copper conductor shall be provided.

#### 6.8.4.6 Accessories

The current transformers shall be provided with the following accessories:

(1) Lifting lugs.
(2) Drain and filling valves with stainless steel plugs.
(3) Bellows and level indicators.
(4) Insulation/Gas monitoring system (Hydrant type or approved equivalent).

### 6.8.5 Marshalling Boxes

A marshalling box (1000x600x300mm) shall be mounted on Centre phase structure with terminals to terminate all phase cores of a set of three single phase Ct. Self-shorting and isolating type terminals shall be provided for CT secondary circuits. These boxes shall be fabricated from steel sheet not less than MSG 2.5mm thick, seam welded at corners. However, in case of type tested rigid frame design, the thickness of steel sheets may be reduced but not below 2 mm according to manufacturer's standard design. At least 20% spare terminals shall be required. These boxes shall be designed for protection class IP55. Gland plates shall be provided for proper termination of cables.

Heaters with thermostat and humidistat shall be provided inside each marshalling box it required to eliminate condensation in the box. Lamps with door operated switch shall be provided for internal illumination. There shall be a single phase power socket inside each marshalling box. An MCB with auxiliary contact shall be provided for switching ON/OFF the



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AC power supply to the heating, illumination and power socket. The MCB shall also be equipped with sensitive earth fault protection for personnel safety.

Each star-point of the CT circuit shall be separately grounded through isolating type terminals to enable convenient verification of single point grounding of the interconnected CT circuits.

### 6.8.6 Terminal Marking

The terminal markings for the current transformers shall be in accordance with IEC Publication 61869-2 and shall clearly identify the secondary terminals corresponding to each specified current ratio.

### 6.8.7 Name Plates

The rating plate markings shall be of permanent nature and shall be in accordance with latest issue of IEC Publication 61869-2. In addition to the data mentioned in IEC, knee point e.m.f (Ek), magnetizing/exciting current at Ek and secondary winding resistance at 75˚C temperature of each core at each tap shall be engraved on the nameplate. Engraving shall be white on a black background.

### 6.8.8 Warning

A permanent legible warning shall be placed inside the current transformer terminal box carrying the wording "Caution: Transformer never to be energized with secondary circuit open".

### 6.8.9 Tests

#### 6.8.9.1 General

The current transformers shall be subjected to tests in the factory and at Site in the presence of the Employer for conformity to the requirements of the Specifications.

Six (6) certified copies of the tests made, and of the results thereof, shall be furnished by the Contractor to the Employer for approval after the tests are made. The results of these tests shall be in such form as to provide means of determining compliance with the applicable Specifications for the material tested. If any item of the plant is of a new design or if essential parts have been redesigned, additional test reports to verify this data shall be submitted for the Employer's approval.

#### 6.8.9.2 Type Tests

The following type tests shall be made on a single CT of each type in accordance with the latest issue of IEC Publications IEC 61869-2 and IEC 60060-1:

(1) Short time current tests.
(2) Temperature rise test.
(3) Lightning impulse tests on primary windings.
(4) Determination of errors and accuracy of protective and measuring cores including instrument security factor test for measuring core.
(5) Wet test for outdoor type transformers.
(6) Radio interference voltage measurement (RIV).

However, duly certified and complete test reports for tests carried out by an independent authority/laboratory on similar CT shall be acceptable in lieu of actual tests. Six (6) copies of the test reports shall be submitted for Employer’s review and approval.



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Independent laboratories are specified in Clause 6.3.13 of these Technical Specifications.

#### 6.8.9.3 Routine Tests

The Following Routine Tests Shall Be Made On All CTs in accordance with the latest issue of relevant IEC publications, for all ratios and at all taps:

(1) Verification of terminal markings.
(2) Power frequency withstand test on primary windings.
(3) Partial discharge measurement.
(4) Power frequency withstand test on secondary windings.
(5) Power frequency withstand test between sections.
(6) Inter-turn overvoltage tests.
(7) Determination of errors and accuracy of protective and measuring cores.
(8) Dissolved gas analysis and measurement of moisture content of oil.
(9) Magnetizing characteristics verifications at each tap of each core.
(10) Measurement of winding resistance at each tap of each core.

#### 6.8.9.4 Special Tests

The following tests shall be performed on a single CT in accordance with latest issue of the relevant IEC standard:

(1) Chopped lightning impulse test on primary winding.
(2) Measurement for capacitance and dielectric dissipation factor.
(3) Mechanical test.
(4) Measurement of transmitted over voltages.

However, duly certified and complete test reports for tests carried out by an independent authority/laboratory on similar CT shall be acceptable in lieu of actual tests. Independent laboratories are specified in Clause 6.3.13 of these Technical Specifications. Six (6) copies of the test reports shall be submitted for Employer review and approval.

### 6.8.10 Drawings, Technical and Descriptive Data

The Contractor shall furnish following information:

(1) Technical data as per the format of specific facilities data to Proposal provided in Employer Requirements.

(2) Drawings showing outline dimensions, construction and installation details of the current transformers.

(3) Manufacturer manuals for inspection, assembly, installation, testing, commissioning, oil sampling, dissolved gas analysis and measurement of moisture content of oil, maintenance.

(4) Reference data for moisture content and dissolved gases of oil.

(5) Current error and phase displacement data/ curves for variation of 5% to 120% in rated current for measuring cores.

(6) Composite error data/curves for current ranging from rated primary to rated accuracy limit primary current for protective cores.

(7) Excitation curves for each of the protective and measuring cores at each tap.



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(8) Resistance and leakage reactance of the secondary winding at each tap for protective and measuring cores.

(9) Type test reports from independent laboratory of similar current transformers.

#### 6.8.10.1 Approval of Drawings and Data

Drawings and data to be submitted for review and approval shall include those specified in test reports, instruction manuals, schematic and panel wiring diagrams, interconnection diagram, nameplates, drawings, and other relevant drawings/data required for proper installation, operation and maintenance of the current transformers. The contractor shall prepare and submit for Employer's review and approval detailed current transformer performance calculations at each tap of each core to establish that the CT design parameters and characteristics are suitable for the present and future requirements of protection and metering systems. Upward revision in any of the parameters found necessary from the results of the performance calculations shall be incorporated in the final design of the current transformers without any additional cost.

## 6.9 COUPLING CAPACITOR VOLTAGE TRANSFORMERS / CAPACITOR VOLTAGE TRANSFORMERS / VOLTAGE TRANSFORMERS

### 6.9.1 General

These specifications cover the requirements for design, manufacture works, testing, supply, installation, testing and commissioning of CCVTs/CVTs for 132kV switchyard of Attabad Lake HPP and 132kV T/L.

### 6.9.2 Equipment Description

#### 6.9.2.1 General

The CCVTs/CVTs shall be capable of withstanding the severe environmental conditions of outdoor operation experienced in tropical areas. The equipment shall be designed, manufactured and tested in accordance with latest issues of IEC 61869-5.

The CCVTs/CVTs shall be single phase units, oil-filled type. Each device shall be connected between the line and earth and shall be equipped with two secondary windings. Under no condition of operation shall a complex wave be generated which will interfere with proper operation of the relays. Each unit shall be furnished with ferro-resonance suppression devices.

The CCVTs shall be used for PLC signal coupling on transmission lines and shall be equipped with bushings for connection of PLC coupling equipment and, as required, with necessary carrier accessories. The carrier coupling accessories shall include the drain coil, the arresters or spark gap across the drain coil for over-voltage protection, external accessible earthing switch across the drain-coil and a fitting for carrier frequency cable.

The units shall consist of a capacitor divider unit and an electromagnetic unit properly designed and interconnected. A protective device shall be incorporated in the CCVT/CVT for the purpose of limiting over-voltage which may appear across one or more of its components, and to prevent sustained ferro-resonance (harmonic or sub-harmonic oscillation of the device or its associated burden).

Each CCVT/CVT shall be supplied complete with corona free clamp type HV terminal connectors, earthing terminals, secondary terminal boxes and supporting steel structures, as specified.



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### 6.9.2.2 Equipment Parameters

The CCVTs/CVTs shall be designed in accordance with the following ratings:

| | | 132 kV | SMS |
|---|---|---|---|
| (1) | Nominal system voltage, kV, rms: | 132 | 132 |
| (2) | Rated voltage for the equipment, kV, rms: | 145 | 145 |
| (3) | Rated frequency, Hz: | 50 | 50 |
| (4) | Rated voltage factor for Continuous operation: | 1.2 | 1.2 |
| (5) | Rated lightning impulse withstand voltage (1.2/50μs), kV, peak: | 650 | 650 |
| (6) | Rated switching impulse withstand voltage, kV, peak: | - | - |
| (7) | One minute power frequency withstand voltage, kV, rms: | 275 | 275 |
| (8) | Rated primary voltage, UPR, kV: | 145/ √ 3 | 145/ √ 3 |
| (9) | Rated secondary voltage of each winding, USR, V: | 110/ √ 3 | 110/ √ 3 |
| (10) | No. of secondary windings: | 2 | 1 |
| (11) | Rated output of each secondary winding, at a power factor of 0.8 lagging, VA: | 100 | 50 |
| (12) | Accuracy class requirement:<br>Sec. winding-1 (measurement and preferably 0.2S-protection) down to zero burden:<br>Sec. winding-2 (protection): | 0.2+3P | 3P |
| (13) | Total Simultaneous burden, VA: | 200 | 50 |
| (14) | One minute power frequency withstand voltage, applied between primary and secondary terminals, kV, rms: | 5 | 5 |
| (15) | One minute power frequency withstand voltage for:<br>a) Low voltage terminal:<br>b) Between Sections: | as per IEC 61869-5 | |
| (16) | Impulse withstands level of the coupling device: | According to IEC | |
| (17) | Coupling capacitance, pF: | ⩾6000 | ⩾6000 |
| (18) | Minimum Creepage distance: | 4495 | |



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| | | | |
|---|---|---|---|
| (19) | The R.I.V. at 1.1x Ur/ √ 3 kV and 1000 kHz maximum, microvolts: | 500 | 500 |

(20) Secondary terminals Connectors shall be suitable for 2.5 to 10 $mm^2$ stranded copper conductor.

(21) The temperature rise of a CCVT/CVT at the specified voltage, rated frequency, rated burden and at any power factor between 0.8 lagging and unity, shall not exceed 45 K above an ambient of 50°C.

(22) The total nominal stack capacitance of high voltage capacitors of CCVTs/CVTs/IVTs shall be greater than or equal to the value indicated in item 16, under the specified conditions with a tolerance of (+10%, -5%).

(23) When the CCVT/CVT/IVT is supplied at 120% of rated voltage and with a substantially zero burden, has its secondary terminals short-circuited, and the short-circuit is suddenly removed, the peak of the secondary voltage shall revert to a value which does not differ from its normal value by more than 10% after ten cycles of rated frequency.

(24) When the CCVT/CVT/IVT supplied at rated voltage and with a substantially zero burden, has its secondary terminals short-circuited, and the short-circuit is suddenly removed, ferro-resonance shall not be sustained for more than 2 seconds.

(25) Following a short-circuit of the supply at the primary and earth terminals, the secondary output voltage of the capacitor voltage transformer shall decay within one cycle of rated frequency, to a value of less than 10% of the peak value before short-circuit.

(26) Secondary winding-1 shall be used for metering as well as for protection functions. The specified accuracy shall, therefore, be maintained preferably down to zero burden.

(27) Insulation levels, creepage distance and other rating shall be adjusted as per IEC to make equipment suitable for installation at 2500m altitude from sea level.

### 6.9.3 Construction

#### 6.9.3.1 General

The CCVTs/CVTs/IVTs shall be constructed to provide adequate insulation for the insulation class specified and to withstand the mechanical and thermal stresses produced under short-circuit conditions.

The high voltage capacitor elements shall be made of high quality paper and aluminum foil and shall be properly assembled to minimize changes in capacitance with time and temperature. They shall be enclosed in an oil-filled porcelain chamber, hermetically sealed with oil-resistant and weather-proof gaskets. The chamber shall be equipped with a bellows or gas cushion expansion device. Necessary steps shall be taken to ensure free expansion of oil and gas in the temperature range specified.

A dust-proof and weather-proof base housing shall be provided at the base of the high voltage capacitor stack, containing the intermediate potential transformer, compensation devices, ferro-resonance suppression devices and protective devices.

#### 6.9.3.2 High Voltage (HV) Capacitors

The CCVTs/CVTs/IVTs shall be equipped with H.V. porcelain insulators, with insulator not less than that of the terminal to which they are connected and of creepage distance specified in Clause 6.9.2.2 item 18.

Each capacitor shall be equipped with a pressure indicator. Provisions shall be available in the electromagnetic unit for power factor testing and for this purpose a test terminal shall be provided at the base of the transformers. This terminal and the arrangement for earthing,



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thereof, shall be similar to the neutral bushing specified on the CCVT/CVT/IVTs. Oil level gauge shall be of a type which can be read with the equipment energized.

The insulators shall be manufactured from wet type porcelain and shall be suitable for continuous outdoor service. The porcelain shall be constructed so as to produce a uniform electrical stress distribution throughout and shall contain no voids, be leak-proof at all temperatures and shall be guaranteed to be within the specified RIV range.

The HF tap and the extra high rated intermediate voltage tap shall be brought out from the capacitor into the electromagnetic unit by means of porcelain bushings.

Intermediate voltage tap bushing insulation level shall be as under:

| | | |
|---|---|---|
| (1) | One minute power frequency withstand voltage : | Manufacturer to specify |
| (2) | Rated lightning impulse (1.2/50 µsec.) withstand voltage : | Manufacturer to specify |

#### 6.9.3.3 Neutral Bushings

The primary neutral connection shall be brought out through the welded steel plate tank wall or cover, with a dry polyurethane type bushing, capable of withstanding a 4 kV, 50 Hz test for connection to a neutral conductor.

#### 6.9.3.4 Primary Line Terminals

The CCVTs/CVTs/IVTs shall be supplied with corona free 4-bolt clamp type terminal connectors, plated for connecting aluminum bus as specified in Employer Requirements for 132kV CCVTs/CVTs respectively including hardware required to bolt the connectors to CCVTs/CVTs high voltage terminals.

#### 6.9.3.5 Secondary Terminals, Terminals and Marshalling Boxes

The secondary leads shall be brought out through the capacitive potential devices tank wall by means of multiple bushings, equipped with connectors for 2.5 to 10 mm2 stranded copper conductor and shall terminate in a low voltage weather-proof box mounted on the side of the tank. Secondary terminals shall be labeled with engraved stainless steel or escutcheon plate labels, to be approved by the Employer Mcbs with alarm contacts shall be provided for each core in the terminal box for protection against faults in the cable connections between the terminal box and the marshalling box. Protective characteristics of the Mcbs shall be coordinated with the rating of the CCVTs/CVTs as well as with the downstream protective devices.

The terminal box and the cabinets containing the PLC accessories and the PLC tuning units shall be located in such a manner that they will line up when the CCVTs are banked in line for three-phase operation.

The name plate shall be fixed at the outside of the terminal box to be visible with the box closed. Connection diagram shall be affixed inside the secondary terminal box so that it can be easily read while working in the box.

A marshalling box shall be erected on center phase supporting structure containing isolating type terminals to all secondary circuits, 2 mcbs (high speed CCVT/CVT protection switches compatible with speed of the distance relays, with alarm contacts), two mcbs for metering and one mcb with auxiliary contact for synchronizing circuits.

Proper cable glands shall be provided in the marshalling box at the cable entry.



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Humidistat controlled heaters shall be provided inside each marshalling box if required to eliminate the condensation from the box. Lamps with door operated switch shall be provided for internal illumination. There shall be a single phase power socket inside each marshalling box. An mcb with auxiliary contact shall be provided for switching ON/OFF the AC power supply to the heating, illumination and power socket. The mcb shall also be equipped with sensitive earth fault protection for personnel safety.

Each star-point of the CCVT/CVT circuits shall be separately grounded through isolating type terminals.

#### 6.9.3.6 Grounding Terminal

The Contractor shall provide copper grounding lugs complete with connectors suitable for 185 Sq.mm stranded copper cable for CCVTs/CVTs.

#### 6.9.3.7 Carrier Accessories

Coupling equipment accessories comprising drain coil, protective devices, carrier choke coil, and carrier earthing switch shall be provided either within the base housing or alternately in a separate housing mounted adjacent to the base housing. A low capacity connection shall be provided between the carrier coupling accessories and the coupling capacitor. The carrier earthing switch shall be able to effectively earth all carrier coupling components. The position of the carrier earthing switch shall not affect the performance of the CCVT. All connections which may be subjected to high potential rise during abnormal conditions shall be ground shielded.

#### 6.9.3.8 Cores and Windings

The core for the intermediate transformer shall be made of high quality non-aging grain-oriented silicon steel carefully selected, tested and annealed to provide the best magnetic characteristics.

The windings shall be properly insulated for the specified insulation class and shall be capable of withstanding the maximum temperature that may exist in the equipment during the expected life of the winding.

If an earthing switch for the intermediate transformer is provided, the earthing switch shall be lockable in the open position. The position of the earthing switch closed or open shall not affect the level of the carrier signals transmitted through the transmission line. Visual indication shall be provided for position of the ground switch.

#### 6.9.3.9 Tank

The tank shall be constructed of welded steel plate and shall be suitably reinforced to withstand handling and excessive pressures, under fault conditions, without distortion. Where welding is done, a sealed weld shall be used in every case so that no crack or pinhole is left where rusting could take place, or through which pickling solutions might attack the weld.

#### 6.9.3.10 Steel Structures

The CCVTs/CVTs shall be delivered complete with steel supporting structures. The Proposer shall provide complete details of the structures with the Proposal.



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#### 6.9.3.11 Name Plate

A weather-proof stainless steel name plate with engraved inscriptions shall be attached with each CCVT/CVT at a location easily accessible. Engraving shall be white on a black background.

The name plate shall contain all information as specified for rating plates and markings in the latest edition of IEC 61869-5

### 6.9.4 Tests

#### 6.9.4.1 General

The CCVTs/CVTs shall be subjected to tests in the factory and at site in the presence of the Employer for conformity to the requirements of the Specifications. All tests shall be performed with the actual electromagnetic unit. The tests shall be made in accordance with the latest issues of IEC 61869-5.

Six (6) certified copies of the tests made, and of the results thereof, after the tests are made shall be furnished by the Contractor to the Employer for approval. The results of these tests shall be in such a form so as to provide means of determining compliance with the applicable Specifications, for the material tested.

#### 6.9.4.2 Type Tests

The following type tests shall be made on a single coupling capacitor voltage transformer of each type in accordance with the latest issue of IEC Publications:

(1) Accuracy check (determination of errors).
(2) Temperature rise test.
(3) Capacitance and tan. δ measurement at power frequency
(4) Chopped impulse test.
(5) Radio interference voltage (RIV) tests.
(6) Short circuit withstand capability test.
(7) Lightning impulse test.
(8) Wet test for outdoor type transformers with AC voltage (for 132 kV CVTs/CVTs).
(9) Transient response test.
(10) Ferro resonance tests.
(11) Tightness of electromagnetic unit.
(12) Accuracy tests.
(13) Measurement of the transmission factor of high frequency over-voltages (special test)
(14) Mechanical strength test (special test).
(15) Determination of the temperature coefficient (special test).
(16) Tightness design test of capacitor unit (special test).
(17) High frequency capacitance and equivalent series resistance measurements in the range of the rated temperature category.
(18) Stray capacitance and stray conductance measurements of the low voltage terminal.
(19) Partial discharge test.

However, duly certified and complete test reports for tests carried out by an independent authority/laboratory on similar CCVTs/CVTs shall be acceptable in lieu of actual tests. Six (6)



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copies of the test reports shall be submitted for Employer review and approval. Independent laboratories are specified in Clause 6.3.13 of these Technical Specifications.

#### 6.9.4.3 Routine Tests

The following routine tests shall be performed on all CCVTs in accordance with the latest issue of relevant IEC publications:

(1) Tightness of capacitor voltage divider.
(2) Capacitance and tanδ measurement at power frequency.
(3) Power frequency withstand test.
(4) Partial discharge measurement.
(5) Verification of terminal markings.
(6) Power frequency withstand test on the electromagnetic unit.
(7) Power frequency withstand test on low voltage terminal.
(8) Power frequency withstand test on secondary windings.
(9) Ferro-resonance check.
(10) Accuracy check (determination of errors).
(11) Carrier drain coil impedance measurement and current carrying capacity test.
(12) Routine test for voltage limitation devices as per IEC 61869-5.

### 6.9.5 Drawings, Technical and Descriptive Data

The Proposer shall furnish the following information:

(1) Technical data as per the format of specific facilities data to Proposal provided in the Employer Requirements.
(2) Sketches showing outline dimensions and location of accessories. Descriptive data shall show main construction features of CCVT's/CVTs.
(3) A full description of the secondary network and transient suppression circuits.
(4) Accuracy curves for voltage error and phase angle error at rated frequency, at any voltage between 80% and 120% of the rated voltage and with burdens of between 25% and 100% of rated burden at power factor of 0.8 lagging.
(5) Type test reports from an independent laboratory/authority of similar type of CCVTs/CVTs.

#### 6.9.5.1 Approval of Drawings and Data

Drawings and data to be submitted for review and approval shall include, but not necessarily be limited to, the following:

(1) Detailed construction drawings.
(2) Schematic and wiring diagrams.
(3) Name plates.
(4) Drawings required for installation, operation and maintenance.

## 6.10 SURGE ARRESTERS

### 6.10.1 General

These Specifications cover the requirements for design, manufacture and factory testing of surge arresters for protection of the switchyard equipment.



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The Contractor shall furnish station type metal oxide surge arresters suitable for protection of equipment from over voltages produced by lightning and switching operations. The arresters shall be capable of withstanding multiple-stroke currents, long duration lightning discharges and switching surges. After dissipation of the surge of lightning discharge, with a 50 Hz voltage equal to the voltage rating of the arrester across its terminals shall interrupt the follow current at first zero value of the current.

The arresters, unless specified otherwise shall be in conformance with applicable provisions of the latest IEC Publication 60099-1 and latest issue of IEC Publication 60099-4.

The surge arresters shall have an established record of satisfactory tests and service performance under temperature range specified in these Specifications. The arresters shall be supplied complete with steel supporting structures, terminal connectors, grounding connectors, cable and surge counters. The arresters shall be single phase, single pole, and outdoor type, with protective characteristics.

**6.10.2 Ratings and Characteristics**

Main ratings of the surge arresters will be as following:

| | | |
|---|---|---|
| (1) | Nominal system voltage kV, rms. | 132 |
| (2) | Rated frequency, Hz. | 50 |
| (3) | Arrester rated voltage (Ur) kV, rms. | 120 |
| (4) | Maximum continuous operating voltage, kV, rms. | 96 |
| (5) | Rated discharge current kA, peak. | 10 |
| (6) | Classification | Station type metal oxide arresters |
| (7) | Maximum ambient air temperature | 40°C |
| (8) | Maximum residual voltages, at 20kA/10kA discharge currents of the following impulses kV, peak. | |
| (a) | Steep current Impulse (1x20 micro sec) | According to Table J.1 of IEC Publication 60099-4 |
| (b) | Lightning current Impulse (8x20 micro sec.) | According to Table J.1 of IEC Publication 60099-4 |
| (c) | Switching current Impulse (30x60 micro-sec) | According to Table J.1 of IEC Publication 60099-4 |
| (9) | Maximum external (RIV) at 1 MHz measured at 5% above maximum system voltage, including connectors, micro volts. | 500 |
| (10) | Energy dissipation capability kJ/kV. | 7 |
| (11) | External Insulations: | |
| (a) | Lightning impulse voltage withstand, kV, peak. | 650 |



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| | | |
|---|---|---|
| (b) | Switching impulse voltage withstand, kV, peak. | - |
| (c) | Power frequency withstand voltage, wet, kV, rms. | 275 |
| (d) | Creepage distance | 4495 |
| (12) | Line Discharge Class *: | 3 |
| (13) | Insulation levels, creepage distance and other rating shall be adjusted as per IEC to make equipment suitable for installation at 2500m altitude from sea level. | |

The Contractor shall submit calculations to prove that the specified line discharge class is sufficient for the longest line. In case the specified line discharge class is not adequate, the surge arrester of appropriate line discharge class shall be supplied.

### 6.10.3 Construction

#### 6.10.3.1 General

Each arrester shall be completely sealed against atmospheric influences, and a pressure-relief device shall be fitted to ease any excess pressures in the arrester preventing explosive shattering of the housing. The relief device shall be such that it will not operate under normal operating conditions.

The design of the arresters shall be such that a reasonably uniform potential drop will exist across each section of the arrester regardless of any distortion of the electrostatic field due to the presence of salty dust, fog, water or sleet on the arrester porcelain, or uneven drying of the surface of the porcelain. All arrester units shall be interchangeable with equally rated units of the same construction.

#### 6.10.3.2 Arresters Housing

The arrester housing units shall be composed of a suitable porcelain housing with metal end fittings enclosing the valve element. Housing shall, where possible, be single piece porcelain. The sealing arrangement at the end of each arrester unit shall consist of pre-stressed stainless steel sealing plates and rubber gaskets.

The porcelain shall be fabricated by the wet process, free from laminations, cavities or other flaws affecting their mechanical or dielectric strength and shall be well vitrified and nonporous. Seals shall be provided between the porcelain housing and metal end fittings and any materials used, so that it shall maintain their effectiveness over long periods. The metal end fittings shall be attached to the housing with solder or cement as appropriate for the construction used.

#### 6.10.3.3 Metal Oxide Discs

The disc units shall be composed of an inorganic compound of a ceramic nature and shall be mechanically strong. The discs shall have an insulation covering at the edges with suitable mechanical and electrical strength to protect the valve element material and to eliminate flashovers at the edges. The contact surfaces of the discs shall have a metallic or other approved treatment for improving the contact between the discs and with the end connections.

#### 6.10.3.4 Grading Rings

When required for proper performance, each arrester shall be provided with a metal grading ring assembly. The ring and ring support shall be of rugged design and construction to maintain the ring properly spaced under the wind loading specified in the Employer Requirements.



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#### 6.10.3.5 Connectors

All the necessary line and ground connectors shall be provided for the proper connection of the surge arresters.

The Contractor shall furnish all materials for connecting ground terminal to its discharge counter including insulated ground conductor, conductor supports with brackets, terminal lugs and all other accessories for complete installation.

### 6.10.4 Steel Structures

The surge arresters shall be supplied complete with galvanized steel supporting structure so as to bring the height of center line of H.T. terminals in accordance with the Employer Requirements. The associated discharge counters shall be mounted on the supporting structure at a suitable height so that they can be read by a person standing at ground level. The arrester units shall be insulated from their supports at their bases so as to assure efficient operation of the discharge counters. The Contractor will make proper arrangement for fixation of the discharge counter on the steel support structure of surge arrester.

### 6.10.5 Leakage Current Meter and Discharge Counters

Each single phase arrester shall be equipped with a leakage current meter and discharge counter. Leakage current meters and counters shall have weather-proof enclosures and shall be explosion proof for full short-circuit current. The leakage current meter shall be of the type which, in addition to continuous indication of the leakage current, shall permit measuring/monitoring/analyzing of leakage current with external equipment without having to disconnect/de-energize the surge arrester. The connector/socket for this purpose shall be of the type which can be used with leakage current analyzers. Counters shall have a high speed response and shall have minimum effect upon overall protection afforded by the surge arresters. Counters shall be sensitive enough to record the minimum discharge current likely to take place inside the arresters. Discharge counters shall be of a type that does not need any external power source and shall be equipped with spark gaps to protect the counter coils. Discharge counters shall be equipped with minimum 4 digit level read-out. Discharge counter shall be fitted with remote indicators to initiate visual and audible signal in the control room.

A portable leakage current analyzer with necessary auxiliaries will be provided to determine the changes of the leakage current.

### 6.10.6 Name Plates

Each single-pole arrester shall be provided with a name plate permanently attached to the arrester and in case the arrester is composed of a number of units, each unit shall also have an individual name plate. The main name plate shall be attached to the lower arrester unit or base so that it can be read by a person standing at ground level.

The main name plate shall include the following information:

(1) Continuous operating voltage.
(2) Rated voltage.
(3) Nominal discharge current.
(4) Rated short-time withstand current in kA, rms.
(5) Manufacturer's name and trade mark, type and identification of complete arrester.
(6) Identification of the assembling position of the unit.
(7) The year of the manufacture.



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(8) Serial number of the arrester.

(9) If sufficient space is available, the nameplate should also contain line discharge class of the arrester.

Name plates shall be of a corrosion-resistant metal.

### 6.10.7 Factory Tests

#### 6.10.7.1 General

The surge arresters shall be subjected to tests in the shop and at Site in the presence of the Employer for conformity to the requirements of the Specifications.

Six (6) certified copies of the tests made and of the results thereof, shall be furnished by the Contractor to the Employer for approval after the tests are made. The results of these tests shall be in such form as to provide means of determining compliance with the applicable Specifications for the material tests. If any item of the Plant is of a new design or if essential parts have been redesigned, additional test reports to verify the design shall be submitted for Employer approval.

#### 6.10.7.2 Type Tests

The following type tests shall be made for each type of surge arrester in accordance with the latest issue of IEC Publication 60099-4 and standards specified herein. However, duly certified and complete test reports for tests carried out by an independent authority/laboratory on similar surge arrester shall be acceptable in lieu of actual tests.

Independent laboratories are specified in these Technical Specifications. Six copies of the test reports shall be submitted for Employer review and approval.

(1) Insulation withstand tests on the arrester housing.

(2) Residual voltage tests (steep current impulse, lightning impulse and switching impulse residual voltage tests) to demonstrate protective levels of the arrester.

(3) Long duration current impulse withstand test to demonstrate the ability of the resistor element to withstand possible dielectric and energy stresses without puncture or flashover.

(4) Operating duty test to demonstrate the thermal stability of the arrester:
   a) High current impulse operating duty test
   b) Switching surge operating duty test

(5) Verification of power frequency voltage versus time curve.

(6) Short-circuit tests to demonstrate the ability of the arrester housing to withstand short circuit currents without violent shattering of the housing under specified test conditions.

(7) Artificial pollution test in accordance with latest IEC practices.

(8) Internal partial discharge test.

(9) Seal leak rate test.

(10) Current distribution test for multi-column arresters.

(11) Bending moment test.

(12) Environmental tests.



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#### 6.10.7.3 Routine Tests

The following routine tests shall be made on each arrester in accordance with the latest issue of IEC Publication 60099-4.

(1) Measurement of reference voltage.
(2) Residual voltage test.
(3) Internal partial discharge test.
(4) Leakage check for sealed housing.
(5) Current distribution test for multi-column arresters.

#### 6.10.7.4 Acceptance Tests

The following tests shall be made on the nearest whole number to the cube root of the number of arresters to be supplied:

(1) Measurement of power frequency voltage on the complete arrester at the reference current measured at the bottom of the arrester.
(2) Lightning impulse residual voltage on the complete arrester or arrester unit.
(3) Internal partial discharge test.
(4) Special thermal stability test.

### 6.10.8 Drawings, Technical and Descriptive Data

#### 6.10.8.1 General

Proposer shall supply following with the Proposal:

(1) Technical Data of Surge Arresters as per the format of Specific Facilities Data to Proposal provided in Employer Requirements.
(2) Detail catalogues and application guides for the proposed surge arresters.
(3) Dimension drawing and layout of the arrester.
(4) Catalogues of the accessories.

#### 6.10.8.2 Approval Drawings / Data / Documents

Technical Data/Specific Facilities Data of surge arresters and accessories, outline drawings showing dimensions of the arresters with all necessary details showing characteristics of the arresters shall be supplied. Calculation as required shall also be submitted.

Approval drawings shall show detailed physical arrangements and connections with other relevant technical details including maintenance and installation details.

## 6.11 LINE TRAPS

### 6.11.1 General

These specifications cover the requirements for the design, manufacture, work testing, supply, installation, site testing and commissioning of the line traps on the 132kV transmission line circuits at 132 kV Attabad Lake HPP switchyard and shall conform to the NGC/DISCOs requirements Scope of works for the line traps.



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### 6.11.2 Equipment Description

#### 6.11.2.1 General

Line traps (LTs) shall be designed for outdoor service and shall be capable of withstanding the severe atmospheric conditions experienced in tropical climates. The equipment shall be designed, manufactured and tested in accordance with the latest issue of IEC 60353 and particulars listed herein.

The units shall be of the wide-band tuned type (band to be selected later). 132kV LTs shall be pedestal mounted on top of the coupling capacitor voltage transformers.

Jumper clamps shall be included for connection of the overhead line with the line traps through down droppers. The clamps shall be suitable for fixing on line traps, the diameter of the conductor grooves on the clamp shall match that of the down droppers used.

The line trap shall comprise a main coil with a protective unit and a tuning device. The tuning unit shall be mounted inside the main coil such that it is easily accessible and can be changed without removing the line trap. Tuning device components shall be designed to withstand all relevant electrical and mechanical stresses.

The protective device shall use non-linear type arresters, according to IEC 60099-1. The nominal discharge current shall preferably be the same as that of the substation arresters, installed behind the line trap, but in no case shall be less than 5 kA.

The unit shall be capable of withstanding all relevant electrical and mechanical stresses.

#### 6.11.2.2 Equipment Parameters

The line traps shall perform according to, or better than the parameters specified hereunder:

**132kV Line Traps**

| | | | |
|---|---|---|---|
| (1) | Rated voltage | : | 145kV, rms |
| (2) | Rated power frequency | : | 50 Hz |
| (3) | Minimum inductance | : | 0.315mH |
| (4) | Accuracy of inductance value | : | 10% |
| (5) | Tuning pots frequency range | : | Wide band frequency range Covering at least 300 kHz band. Exact range shall be determined after frequency allocation. |
| (6) | Rated continuous current | : | 2000 A |
| (7) | Rated short-time current | : | 50 kA, rms |
| (8) | Dynamic short-time current | : | 125 kA |
| (9) | Rated duration of short-time current | : | 1 sec. |
| (10) | Rated blocking impedance (resistive component) | : | 1.41 times the characteristic impedance of transmission line (according to IEC 60353 standard) |
| (11) | Insertion loss | : | < 2.5 dB |
| (12) | Ambient temperature | : | -10 to 50°C |
| (13) | Mounting | : | Pedestal mounted on top of CCVTs |



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### 6.11.3 Construction

#### 6.11.3.1 General

The metallic parts shall be of non-ferrous galvanized or stainless steel material. The insulation shall have low moisture absorption, low dielectric loss, high tensile strength and high resistance to weather and chemical corrosion. Line traps shall have flat pad aluminum terminals. Post insulators and bird barriers shall be provided with the line traps. Corona shield shall be provided for 132 kV line.

#### 6.11.3.2 Name Plates

The main coil, the protective and tuning devices shall be provided with rating plates of weather-proof stainless steel material mounted on the outside surface, on a location easily accessible. The inscription on these shall be indelibly marked.

Duplicate nameplates shall also be installed at a convenient height where these could be read from the ground.

The nameplates shall include, as a minimum, all the information specified in the latest edition of IEC 60353.

### 6.11.4 Test

#### 6.11.4.1 General

The line traps shall be subjected to tests in the factory and at site in the presence of the Employer. The tests at Manufacturer's works shall require the line trap to be mounted in a condition similar to that in service.

The tests on the protective device shall be carried out in conformity with the recommendations of IEC 60099-1.

The Contractor shall furnish to the Employer for approval certified copies of the tests and the results thereof, after the tests have been conducted. The results of these tests shall take such a form, which provides means of determining compliance with the applicable Specifications for the material tested. If any item is newly designed or if main parts have been redesigned, additional test reports to verify this data shall be submitted for the Employer approval.

#### 6.11.4.2 Type Tests

The following type tests shall be made on each type of line traps in accordance with the latest issue of IEC 60353. However, duly certified and complete test reports for tests carried out by an independent authority/laboratory on similar line traps shall be acceptable in lieu of performing actual tests. Independent laboratories are specified in the Contract Document. Six copies of the test reports shall be submitted for Employer review and approval.

(1) Temperature rise test.
(2) Measurement of radio influence voltage.
(3) Insulation tests.
(4) Short-time current tests.
(5) Measurement of the rated inductance of the main coil.
(6) Measurement of power frequency inductance of the main coil.
(7) Measurement of blocking resistance and blocking impedance.
(8) Measurement of tapping loss and tapping loss based on the blocking resistance.



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The Proposer shall state the field tested reliability of the tuning device.

#### 6.11.4.3 Routine Tests

The following routine tests shall be performed in accordance with the latest addition of IEC 60353:

(1) Measurement of rated inductance of the main coil.
(2) Measurement of power frequency inductance of main coil.
(3) Measurement of blocking resistance and blocking impedance.
(4) Measurement of tapping loss and tapping loss based on the blocking resistance.

### 6.11.5 Drawings, Technical and Descriptive Data

#### 6.11.5.1 Proposal Drawings and Descriptive Data

The Proposer shall furnish the following information:

(1) Sketches showing outline dimensions, and location of accessories. Descriptive data shall show main construction and operating features of line traps.
(2) Sketches of the steel support structures for pedestal mounting of the line traps and layout showing the arrangement for line trap mounted on top of coupling capacitor for each type of unit.
(3) Type test reports of exactly similar type of line traps from an independent and internationally recognized laboratory will be accepted.

#### 6.11.5.2 Approval of Drawings and Data

The detail drawings, technical data and instructions to be submitted, shall include, but not necessarily be limited to, the following:

(1) Construction details, installation drawings and schematic diagrams.
(2) Tuning instructions.
(3) Name plate drawings.
(4) Drawings and instruction manuals for installation, operation and maintenance.

## 6.12 PROTECTION SYSTEM

### 6.12.1 General

These Specifications cover the requirements of design and construction of protection system that comprises protective relays, auxiliary relays and special purpose relays for 132kV AIS switchyard. The relays and protection system shall conform to the applicable requirements of IEC 60255 and IEC 61850 as well as to specifications described herein. Provision shall be provided in the protection relays to communicate with the Substation Automation System and Gilgit Baltistan/NPCC central control system through SCADA Gateway in accordance with the protocol specified in IEC 61850 and IEC60870-5-101/104 respectively.

The Contractor shall supply all necessary auxiliary relays, boards, wiring terminals etc., install the necessary equipment and commission it in accordance with requirements of these specifications.

The general philosophy for provision of protection scheme for the 132kV switchyard will be as following:



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(1) For 132kV transmission line, one set of distance cum differential protection shall be provided for the transmission lines along-with O/C & E/F relay (4 elements). Moreover, differential protection shall also be provided in case the line length is short. The distance relay shall comprise of multi features as specified.

(2) There shall be separately MCB protected DC and CVT circuits for each protection. Independent CT cores shall be provided for each protection. Duplicate trip coils of the circuit breakers shall be provided with DC supplies from separate batteries. Each protection, main and back-up shall trip both the trip coils.

(3) Over current and earth fault relays shall form back-up protection and shall ensure final tripping within the thermal short time rating of the primary equipment.

(4) For 132kV circuit breaker, breaker failure protection shall be provided to detect failure of a circuit breaker to trip on fault following a trip initiation from the protective relays and will trip the “next-in-line” local breakers and remote breaker(s).

(5) 132kV busbar protection relay shall be suitable for one & half breaker scheme.

(6) The circuits shall be designed for necessary interface with the protection signaling equipment (PSE) for coordinated operation of both line ends of the protection scheme.

(7) The protection shall be stable during system transients and it shall operate correctly during system faults within the protected zones for the range of fault levels and with the relevant fault current DC time constants.

(8) Each trip circuit, along-with each breaker trip coil shall be monitored by supervisory relays to give audible and visual alarms for open and short circuits. The trip circuits shall be supervised in both open and close conditions of the circuit breaker. Trip circuit supervision relay shall also give an alarm in case of partially or completely shorted winding of trip coils. An alarm shall be initiated if trip circuit supervision itself fails. Separate panel shall be provided to supervise all trip coils per bay.

(9) Each protection set shall have separately protected and continuously supervised DC supply circuit. The DC supply protection shall be properly coordinated for discriminate isolation of the faulty section.

(10) DC power supplies and trip output shall be routed through test blocks.

(11) Before taking up the schematic diagrams, the Contractor shall prepare trip and alarm logic tables and protection and metering single line diagrams with as much detail as possible for Employer review and approval.

(12) Reliability analysis for relays and their components shall be provided. The Contractor shall also provide mean time between failures (MTBF) for each type of relay.

(13) a) All necessary equipment to communicate with the numerical devices such as latest laptop and peripheral devices including printers shall be provided. Licensed working software for communicating with the devices shall be part of the supply. Software shall be suitable for windows environment.

b) Numerical relays shall have serial/fiber optic interfaces and standard protocols, compliant with IEC 60870-5-103/IEC 61850 to facilitate data communication with station control system/Gilgit Baltistan (GB) control system.

(14) It shall be possible to upgrade the operating software of the numerical devices as it is further developed by the manufacturer.

(15) The numerical devices offered under this contract shall be of latest version, of proven design, having minimum of Five (05) years' operating experience in a well reputed power utility power systems of voltage level 132kV and above.

However, the latest version of the same shall be offered/quoted along with valid type test reports for the relays, in accordance with the applicable IEC standards and the DISCO's type test policy. The relays shall be compatible with and meet the requirements for integration with the National Power Control Center.

(16) The devices to be supplied under this contract, including the numerical and static relays, shall have only industry class components.

Separate and independent relays shall be provided for each protection function except where it is specified that built-in function of a relay shall be used.

(17) LEDs and LCDs shall be used for targets showing visual indication of the protection status. Retrieval of fault Data/Alarms should be made available in numerical relays.

(18) In addition to built-in test blocks and sockets in the protective devices which may need special test plugs, external test blocks shall be provided in adequate numbers to enable testing the device with standard test plugs and test blocks and without affecting the other devices and protection functions. Moreover, test blocks shall be wired in such a manner that trip and alarm from the device and DC supplies to the device are interrupted upon insertion of the test plug. The CT and CVT circuits to each protective device shall be routed through the test blocks.

(19) The relay panels shall have front door with glass window. Rear doors shall be of double leaf type. Protection class of panel shall be not less than IP54.

Humidity control in the panels shall be affected by heaters controlled by humidistats and thermostats. Thermostat shall be set at 20˚C and humidistat at 60% relative humidity. However, it shall be possible to set thermos ate from 0 to 60˚C and hygrostat from 0-100% relative humidity ranges.

(20) All panels shall have door operated lamps for interior illumination. Three pin single phase, 230V AC receptacles shall be provided in each panel. There shall be separate MCBs for lighting and power receptacles. MCBs shall be equipped with auxiliary contacts and sensitive earth fault protection for personnel safety.

(22) The trip circuit supervision relays shall be such that in event of a fault in any one component, it shall not be possible to inadvertently trip the circuit breaker. The trip circuit supervision relays shall initiate a delayed alarm in the station. This alarm shall operate for loss of trip supply and for any interruption in the trip circuit wiring.

(23) Test blocks shall be provided to facilitate tests by secondary injection of all major fault measuring relays without disconnecting any wire or permanent connection. The test block shall permit direct injection of currents and voltages into the individual relays.

(24) Test blocks shall isolate the trip contacts of main protection relays on both side. Injection sockets shall be arranged so that it shall not possible to open circuit the current transformer secondary circuits when inserting test plugs.

The trip function, if not interrupted by a test switch, shall be blocked when inserting the test plugs.

(25) Three spare test plugs of each type shall be supplied.

(26) Selector switches should not be introduced in protection current transformers.



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(27) All tripping and inter tripping relays shall be of high speed, high burden, draw out and flush mounted type.

(28) Where with draw able type relays are used, there shall be designed so that when in the withdrawal position, associated current transformers shall be short circuited.

(29) The protection schemes shall include all hardware and software to remote setting/interrogation/fault evaluation.

(30) Current transformer requirements shall be determined to ensure high protection performance. The Proposer/contractor shall submit comprehensive technical report that includes the required CT burden and knee point voltage calculations. The report shall confirm that CTs will be designed to ensure a saturation free performance under both transient and steady fault conditions, taking due account of system X/R ratios, system fault levels and remanent flux conditions in the CT core.

(31) The design life of numerical protection relays shall be greater than 25 years.

(32) For overall letter integration via the communication facilities, the numerical protection relays shall support IEC 60870-5-103 and IEC 61850.

(33) Separate sets of MCBs with normally closed contact shall be provided for:

a) Each protection scheme

b) Fault recorder.

c) Metering.

d) Synchronizing.

(34) The arrangement and mounting of all indicating devices, control switches, relays and other apparatus shall be subject to the approval of the Employer and final approval from Employer.

(35) All possible precautions shall be taken to ensure that direct current operated relays which perform a tripping function are not liable to maloperation. For this reason, the following measures shall be taken:

a) The total capacitance to earth of all connections to the negative pole of the tripping battery shall not exceed 10 microfarad.

b) If the positive side of a relay coil is connected to wiring external to the relay cubicle, then the relay shall not operate if a capacitor of 10 microfarad charged to (110%) of rated voltage is discharged through the relay.

c) The current at operation shall be greater than 100 milliamps.

(36) The maximum A.C. fault voltage across any two points of a current circuit shall not exceed 3000 volt peak and nonlinear resistors shall be included if necessary to achieve this limitation.

(37) Each relay which initiates tripping shall be provided with a trip isolation facility which should be integral with the relay such that the tripping has to be isolated prior to withdrawal of the relay from its case.

(38) The Supplier/Contractor shall install only protection relays and equipment which are supported by guaranteed works, routine test certificates issued by the manufacturers.



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(39) The Supplier/Contractor shall provide electrical protection relay schedules to include manufacturer, type designation characteristic details and ranges and actual protection settings to be used, on a per circuit basis.

(40) All calculations to determine relay settings and adequacy of CT and CVT rating shall be submitted to the Employer for approval. In the event that the rating of the CVT or CT proposed is insufficient to accommodate the connected burden in accordance with this specification, the Contractor shall supply the CT and CVT with the necessary increased capacity at no extra cost.

(41) Microprocessor based relays wherever specified shall be of modular design and modular sub racks shall have standard width of 19 inches. The hardware design shall use latest state of art technology based on LSI/VLSI microprocessor technology and shall perform satisfactorily under highly noisy electrical environment. Microprocessor relays shall be complete with inbuilt self-monitoring/self-checking or auto testing features.

(42) Relays shall be of approved construction, flush mounted, draw out type, and shall be arranged so that adjustments, testing and replacement can be effected with the minimum of time and labor. Relays of the hand reset type shall be capable of being reset without opening the case.

(43) All devices shall be clearly labeled.

(44) Relay terminal arrangements shall be subject to the approval of the Employer Snap on type terminations will be accepted only if adequate termination locking features are available, which will prevent inadvertent/ accidental disconnection of terminations.

(45) Electrically reset tripping relays shall be provided where necessitated by the system of control.

(46) Unless otherwise specified, tripping shall always be directly from the relevant measuring relay and through the tripping relay operated from the respective main relays.

(47) Relays, where appropriate, shall be provided with flag indicators, phase identified where applicable. Flag indicators shall be of the hand reset pattern and shall be capable of being reset without opening the case. Where two or more phase elements are included in one case separate indicators shall be provided for each element.

(48) Relays which rely for their operation on an external D.C. supply shall have it monitored at the relay and an alarm provided in event of failure.

(49) Relays with provision for manual operation from outside the case, other than for resetting, will not be accepted and time delay relays shall not be of the dashpot type.

(50) Relays, whether mounted on panels or not, shall be provided with clearly inscribed labels describing their application and rating in addition to the general purpose labels. Demo type labels or similar will not be accepted.

(51) Attention is particularly drawn to the climatic conditions specified in Section 6.3 and relay designs should be entirely suitable for duty under these conditions. and at height of.

(52) To minimize the effect of electrolysis, relay coils operating on D.C. shall be so connected that the coils are not continuously energized from the positive pole of the battery.



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(53) Control and relay circuits, current and voltage transformer secondary circuits, battery and auxiliary power supply wiring, supervisory, alarm and communication circuits shall be protected against conductive, electrostatic and electromagnetic influences.

(54) Every panel shall have at the top left hand corner easily visible lamp to indicate that DC supply in the panel is off.

(55) The test terminals shall isolate the trip contacts of main protection relays on both the sides. Injection sockets shall be arranged so that it shall not possible to open the current transformer secondary circuits when inserting test plugs.

(56) All equipment as well as the terminals of the cubicles shall be easily accessible.

(57) All protections and associated equipment shall be of standard construction from experienced, reliable and well reputed manufacturers.

(58) Terminal blocks for CT connections shall have shorting, testing and disconnecting facilities which allow tests to be conducted with the circuit on load and which may be operated without disturbing the connected wiring. VT Terminal blocks shall have disconnected and testing facilities.

(59) All necessary additional devices, plug connections, conversional and short copper or fiber optic connection shall be part of supply.

(60) All protective relays shall be immune to D.C. failure. They shall never operate on loss of D.C.

(61) The following contacts and/or signals shall be provided, as minimum, in the output of relay sets:

i) Annunciation
ii) Sequence of events recorder alarm.
iii) SCADA functions.
iv) Station fault Recorder (Oscillographs fault trigger).
v) Reclose initiation.
vi) Reclose blocking.
vii) Breaker failure initiation.
viii) Optical fiber signaling and other communication signaling.

### 6.12.2 Operating Conditions

All relays shall be tropicalized and shall be suitable for satisfactory operation at an ambient air temperature having a maximum value of 40 degree C and 24 hours average value of 30 degree C and minimum temperature -10 degree C, and humidity reaching up to 95%.

### 6.12.3 Construction

#### 6.12.3.1 General

All relays shall be so designed and constructed that mechanical shock or external vibration does not operate or damage them.

#### 6.12.3.2 Relay Board

Panels dimensions shall not be less than 1000x1000 2000mm.

The static relays shall be designed in 19 inches rack-mounted modules.



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The relay board panels protection class shall not be less than IP54.

The construction detail of relay boards and panels shall comply with information given in Section 6.12, "Control and Recording Equipment". The relay panels shall have front door with glass window. Rear doors shall be of double leaf type.

All relay boards and panels shall be supplied factory wired and tested.

Relay panels at the switchyard shall have the following color scheme:

| | |
|---|---|
| Exterior: | Pebble Grey - RAL7032 - Semi Gloss |
| Interior: | Cream White - RAL9010 - Semi Gloss |
| Plinth: | As Exterior |

**6.12.3.3 Numerical Protective Relays**

(1) Relays shall be of approved types complying with IEC 60255 or other latest standard. (British Standard 142), shall have approved characteristics, be flush mounted in dust and moisture proof cases and shall comply with BS 2011 test Classification 20/40/04. The components of each relay shall be suitable for operation under ·the local climatic conditions.

(2) The relays should have been type tested in accordance with the latest IEC standards, with particular attention to the EMI immunity.

(3) All protection relays shall be of numerical type with communication facility with a protocol as per IEC 60870-5-103/IEC 61850. The protection schemes shall include all hardware and software to permit remote setting/interrogation/fault evaluation from the engineering work station of the control room. These relays are of a family of hardware known as Intelligent Electronic Devices (IED's). Auxiliary relays, repeat relays, trip relays and any other simple auxiliary or contact multiplication function may be based on standard attracted armature or other Electro-Mechanical techniques. Numerical relays should offer instrumentation, disturbance recording and event logging functions in addition to providing the principal protection function. Access to these functions shall be available locally at the relay as well as remotely as described below. Routine test requirements shall be limited to basic function testing through the provision 'of comprehensive, continuous self-monitoring alarm and diagnostic functions.

(4) In case protection relays of the numerical type (IED's) should be integrated to the PCMS. Numerical relays and schemes provided shall all be suitable for connection to a local communications network to allow the complete relay scheme to be interfaced to a central computer work station. The communications bus, necessary modems and interface units and all associated software should be provided as of the contract. With the resulting system it shall be possible to interrogate all numerical relays and schemes to monitor and extract recorded data (including settings, measurement parameters, and disturbance records). It shall also be possible to enable remote adjustment of relay settings if required.

(5) The numerical relays provided shall have following features:

i) Shall be based on digital signal processing and algorithmic based functions using multiple CPUs.

ii) Programmable scheme logic.



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iii) Measured quantities displayed.

iv) Shall be of compact design and modular software.

v) Shall have continuous self-monitoring and diagnostic features or shall have automatic relay and circuitry testing features.

vi) Shall have selection functions from protection software library and shall be complete with Menu-driven use interface program.

vii) Shall have serial interfaces (redundant ports) for on-line and off-line transmission of relay operation data, feeder load data, sequential, event and fault recording; remote setting etc.

viii) Time-tagged events/disturbance record shall have facility of historic fault information of at least five system faults and on demand shall display relay operations, fault recording, fault location, protection operating, times, feeder load data prior to fault etc. from each system disturbance.

ix) Shall have both front and rear serial-port for further data exploitation, equipment parameterization, retrieval of fault records, etc. A laptop PC and peripheral devices including printer, applicable software shall be supplied without an additional cost.

x) Shall be suitable for operation based on 110V D.C. auxiliary power sources for 132kV system as specified.

(6) The design of the numerical relays should be hardened against transient surge and over voltages caused by the CT/VT and DC circuits and associated field devices. The routing of cables shall be such as to limit interference to a minimum. Any auxiliary supplies necessary to power solid state circuits shall be derived from the main station battery and not from batteries built into the relay. Continuously energized relays including those with economy resistors will not be accepted for any application.

(7) Storage facility for fault information for at least five latest system faults, giving on demand operations, operating times, line load data etc.

(8) Numerical relays shall also be provided with local communication port to allow direct interfacing to a lap-top PC, to facilitate local interrogation, setting-up and recorded data extraction. Individual protection units shall be provided with an integral user interface to facilitate setting changes and observation of indications without the use of remote communications.

(9) Numeric/Static relays shall comply with the impulse withstand and high frequency disturbance tests specified in Appendix E of IEC Publication 60255-4, and type test reports covering these tests for all these relays shall be provided. Relays shall be CE marked in accordance with European Union requirements related to Electromagnetic Compatibility and Low Voltage Equipment safety. Equipment complying with other national standards may be accepted at Employer discretion and where the vendor provides copies of the relevant standards.

(10) Numeric/Static relays shall also remain stable under conditions of Radio Interference. Radio Interference tests acceptable to the Employer shall have been carried out by the Manufacturer and in this case RFI test reports shall be submitted for the Employer approval. If such tests have not been carried out, the Contractor shall carry out RFI tests to the satisfaction of the Employer and submit test report for approval.



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(11) Hardware and software shall be checked by software sub-routine continuously. Important components supervised shall include:

i) CPU's and associated Memory (ROM, RAM, EEPROM).
ii) Input signal validity (A/D converter).
iii) O.S. Software.
iv) Protection function software.
v) Watchdog and self-monitoring software.
vi) Output signal integrity.
vii) Algorithm execution / logic performance.
viii) Digital input conversion system.
ix) I/O logic points.
x) Power Supply Noise/Failure.
xi) Internal Clock.

(12) Functional elements in numeric relays shall have LED indicators on the front panels to enable identification of their operation, faulted phases, zones, hardware and software status etc.

(13) All numerical data communication shall comply with IEC-60870-5-103/IEC-61850 protocol.

(14) Operator Interface

All numerical protection systems shall be provided with an integral local user interface, to enable communication with the relay without the use of external equipment. Any facilities provided for connection to an external computer shall be an additional feature to the local user interface. No exceptions to this requirement shall be permitted.

(15) Relay serial communication facilities should allow all information which is available locally at the relay front panel to be accessed remotely. It should also be possible to carry out bulk transfer of settings and fault record information using appropriate licensed PC based software. The necessary software for communication with each relay type shall be provided as part of the contract.

(16) Identification.

Each protection relay shall have a unique identifier that is clearly visible. The software reference and issue level shall be identified. The marking of all relays shall comply with Clause 12 of IEC 60255-6(1988).

(17) Each protection relay shall be provided with LCD display facilities on which shall be shown:

The current transformer ratio (if applicable), including all ratios of multi ratio transformers and the ratio selected.

Voltage transformer ratio (if applicable).

(18) Settings.
Each protection relay shall provide a means by which the user can easily apply the required settings, which is also secure from inadvertent operation. A display of the selected settings shall be provided on the protection relay.



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### 6.12.4 Environmental Requirements

#### 6.12.4.1 Atmospheric Environment

a) Temperature

The standard nominal range of ambient temperature shall be -10°C to +40°C. The protection system shall operate satisfactorily when tested to the following requirements:

IEC 60068-2-1 with severity class -10°C, 96 hours.
IEC 60068-2-2 with severity class +55°C, 96 hours.

The protection system shall be able to withstand the temperature requirements for storage and transportation with severity class -25°C to 70°C, 96 hours.

b) Relative Humidity

The protection system shall operate correctly with relative humidity conditions prevailing at site of 93% - 95% and shall have been tested to IEC 60069-2-3 with severity class 56 days. The contractor shall demonstrate the suitability.

c) Enclosure

The protection relays shall meet the requirements of the tests detailed in IEC 60529 with classification IP 51 (dust protected) for housing and IP21 for terminals.

It shall be projected against vertically falling drops of water in 4 fixed positions of 15° tilt with flow rate of 3mrn / minute for 2.5 minutes.

#### 6.12.4.2 Mechanical Environment

a. Vibration (Sinusoidal)

Cross over frequency - 58 to 60 Hz.

The protection system shall meet the requirements of the tests detailed in IEC 60255-21-2 with severity class 1.

b. Shock and Bump

The protection system shall meet the requirement of the tests detailed in IEC 60255-21-2 with severity class-I.

| Type of Test | Severity Class | Peak Acceleration (gn) | Duration of Pulse (ms) | No. of Pulses in each Direction |
|---|---|---|---|---|
| Shock Response | 2 | 10 | 11 | 3 |
| Shock with Stand | 1 | 15 | 11 | 3 |
| Bump | 1 | 10 | 10 | 1000 |

c. Seismic

The protection System shall meet the requirements of the tests detailed in IEC 60255-21-3.

Cross over frequency = 8 to 9 Hz

X = horizontal axis, Y = vertical axis.



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| Severity Class 2 | Peak Displacement below Cross over frequency (mm) | | Peak Acceleration above Cross over frequency (gn) | | No. of Sweepey Class in each axis | Frequency Range |
|---|---|---|---|---|---|---|
| | X | Y | X | Y | | |
| 2 | 7.5 | 3.5 | 2.0 | 1.0 | 1 | 1.35 |

**6.12.4.3 A.C. Immunity**

a. AC/DC Auxiliary Energizing

The protection system shall be capable of being energized from a D.C auxiliary energizing voltage of 110V for 132kV system.

The protection system or its associated power supply for use in 110V (nominal) DC supply system shall operate correctly over a voltage range +20% and -15%.

The static protection system shall meet the requirements of IEC Standard 60255-11 with interruptions to dc auxiliary energizing quantity of 10m sec.

AC 100 Hz ripple on DC supply, the relays shall withstand 12% AC ripple on the DC supply.

Performance Criteria Class-A.

b. Frequency.

The standard frequency shall be 50 Hz. The nominal range of frequency shall be -5 percent to +5 percent.

**6.12.4.4 Insulation**

**a. Rated Insulation Voltage.**

The rated insulation of circuits connected to current transformers of high impedance relays shall be 1000 V. All other circuits shall have an insulation voltage of 250V. All open contacts of the protection system shall withstand a voltage of 1000 V.

**b. Dielectric Tests.**

The protection system shall comply with the dielectric test requirements of IEC 60255-5:

i. I 2.0 kV rms for one minute between all terminals and case earth.
ii. 2.0 kV rms for one minute between all terminals of each independent circuit grouped together, and all other terminals.
iii. 1.5 kV rms for one minute across dedicated normally open contacts of output relays.
iv. 1.0 kV rms for 1 minute' across normally open contacts of charge over and watch dog output relays.

**c. Impulse Withstand.**

The protection system shall comply with the impulse test requirements of IEC publication 60255-5 of 5 kV peak 1.2/50 µs, 0.5 j across.

i. Each independent circuit and the case with terminals of each independent circuit together.
ii. Independent circuits with the terminals of each independent circuit connected together.
iii. Terminals of the same circuit except normally open metallic contacts.

### 6.12.4.5 Electromagnetic Compatibility

The requirements of this section of the specification are applicable to electronic protection systems whether these are based on analogue, digital or numerical design techniques. These requirements may also be applied to electro-mechanical relays that radiate electromagnetic interference during their operation.

**High frequency Disturbance**

The protection system shall comply with the requirements of IEC publication 60255-221 with severity class-III.

1MHZ burst disturbance test.

2.5 kV Common Mode

Power supply, CTs, PTs, opto inputs, output contacts, terminal block, communication.

1kV differential Mode

Power supply, flied voltage, CTs, PTs, opto inputs and outputs contacts. Performance Criteria Class-A.

### 6.12.4.6 Fast Transients

The protection system shall comply with the requirements of IEC publication 60255-22-4 with severity level III and IV.

2kV, 5 kHZ (Class-III) and 4 kV 2.5 kHZ (Class-IV) Power Supply, field voltage, opto inputs, outputs contacts, CTs, VTs.

2kV, 5 kHZ (Class III) and 4 kV, 2.5 kHZ (Class-IV) Capacitive Coupling. Terminal Block communication connections.

### 6.12.4.7 Conducted / Radiated Emissions

#### 6.12.4.7.1 Conducted Emission

The protection system shall comply with the requirements of EN550II (Class A) and EN 52022 (Class B)

0.15 - 0.5 MHz, 79 dBJlV (quasipeak) 132 dBJlV (average)

0.5 - 30 MHz, 73 dBJlV (quasipeak) 60 dBJlV (average)

#### 6.12.4.7.2 Radiated Emission

The protection system shall comply with the requirements of EN 55011 (Class A) and EN 55022 (Class A).

30 - 230 MHz, 40 dBJlVlm at 10 m measurement distance.

230 -1000 MHz, 47 *dBJlV/m* at 10 m measurement distance.

**Electro static Discharge**

The protection system shall comply with the requirements of IEC publication 60255-22-3 with severity class-III and class-IV.

Class 4: 15 kV air discharge.



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Class 3: 6 kV contact discharge.

Test carried out both with and without cover fitted

#### 6.12.4.8 Conducted / Radiated Immunity

#### 6.12.4.8.1 Conducted Immunity

EN 61000 4...,.6 (level 3)

10 Vemf@ 1 kHZ 80% am, 150 kHZ to 80 MHZ

Spot tests at 27 MHZ, 68 MHZ.

#### 6.12.4.8.2 Radiated Immunity

The protection system shall comply with the requirements of IEC Publication 60255-22-3 with severity Class-III.

10VIm 80 MHZ - 10 HZ @ 1 kHZ 80% am.

Spot tests at 80 MHz, 160 MHz, 450 MHz and 900 MHz.

Performance Criteria Class A.

Radiated Immunity from digital radio telephones.

The protection system shall comply with the requirements of EN 50204

10VIm 900 MHZ ± 5 MHZ and 1.89 OHZ ± 5 MHZ,

200 HZ rep. Freq; 50% duty cycle, pulse modulated Performance Criteria Class A.

#### 6.12.4.8.3 Special Purpose Relays

Special purpose relays shall be semi flush draw-out type as far as possible for front of panel mounting and generally constructed as indicated in these Specifications. These relays include, but are not limited to reclosing, synchronizing and carrier signaling relays.

#### 6.12.4.9 Auxiliary Relays

Auxiliary relays shall be of rugged construction and shall have a high degree of reliability even when they have been idle for long periods of time. All auxiliary relay coils and contacts shall be suitable for continuous operation at 110 V DC for 132kV system with a tolerance of +10% and -15%. The relay coils shall be so designed that their consumption is kept to a minimum and yet sufficient contact pressure is ensured when the relay operates to make contacts. Rating of the contacts and make rating shall not be less than 5A at 110V DC and shall have a good margin on contacts break ratings of resistive and inductive loads involved.

Auxiliary relays shall be of instantaneous type or time delayed as required. The time delay provided in the relays shall not be affected by changing temperature or humidity.

Auxiliary and contact multiplier relays in the tripping circuits shall be of high speed type or better than class-I relays as defined in IEC-60255.

Manual reset auxiliary relays shall be high speed, multi-contact type with operation indicator.

Auxiliary tripping relays shall be self-reset with operating time not exceeding 5 milliseconds, front-connected type suitable for rear-of-panel mounting.



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#### 6.12.4.10 Settings

All setting adjustments shall be inaccessible until the case or the cover is removed. The settings shall be clearly marked and shall be visible when the relay case is closed.

If the relay is intended for setting adjustment on load i.e. the adjustment being directly in a current transformer secondary circuit, means shall be provided to ensure that the current transformer is not open circuited during adjustment.

#### 6.12.4.11 Coils

The current coils of the relays shall withstand the thermal and mechanical stresses of at least 35 times the continuous current rating of the coil for one half second or 20 times the continuous rating of the coil for 3 seconds without damage to the coil or associated mechanical or electronic components. The continuous rating shall be twice the rated current, with the specified temperature rise.

Voltage coils shall withstand thermal stresses due to continuous energization at voltage 25 percent in excess of the rated voltage at all settings of the relay.

#### 6.12.4.12 Contacts

The operating contacts shall have a liberal rating so that there is no contact damage or mal-operation. Where necessary a sealing device which shall be released when the desired function is completed.

### 6.12.5 Ratings

(1) System frequency is 50Hz.

(2) The control voltage shall be 110V DC for 132kV, subject to tolerances as specified below. All control and indicating devices, relays and instruments operating on 110V DC shall have a minimum tolerance of +10% and - 5% for variation in voltage.

The continuous contact rating of protective relays for tripping of the breakers shall not be less than 5A at 110V DC and continuous rating of contacts for alarms shall not be less than 4A at 110V DC.

(The temperature rise of coils when tested at continuous rating shall not exceed the values given below. The values shall be determined by resistance method at rated frequency and at rated current or voltage or the setting current or voltage whichever is lower.

| Insulation Class | Max. Value of Air Temperature (°C) | Max. Temperature Rise at Ambient Air Temperature (≤40°C) |
|---|---|---|
| A | 105 | 65 |
| B | 130 | 90 |
| C | 180 | 140 |

The classification of insulating materials is according to IEC standards. Temperature rise for this Project shall be corrected for the specified ambient temperature of 50˚C.

(5) Tripping contacts shall be capable of making and carrying 30 A for at least 2000 operations in a duty cycle specified in IEC Standards.

(6) Relays shall be capable of withstanding for one minute a low frequency test of the following values:

| | | |
|---|---|---|
| (a) | Insulation to ground and | Minimum 1500 volts, rms. |
| | | between circuits: |
| (b) | Across normally open | Minimum 1500 volts, rms. |
| | | contacts: |

(7) The accuracy class of all relays shall conform to the applicable requirements of approved international standards.

### 6.12.6 Operating Characteristics

#### 6.12.6.1 Numerical Line Distance Relay - Protection

The transmission line protection relay shall be numerical, high-speed, non-switched, fully micro-processor based, distance type relay suitable for single and multipole tripping of long, and heavily loaded lines as well as short lines.

Final selection of the relay shall be subjected to approval of the Employer

The numerical distance relay shall include the following features:

a) Sensitive directional and directional comparison earth fault protection.
b) Mutual compensation for parallel lines.
c) Fault location.
d) Sequence of events recording.
e) Fault recording event recording and disturbance recorder.
f) Stub protection.
g) Weak end infeed trip.
h) CVT fuse failure supervision
i) Detection broken conductor.
j) Power swing detection/blocking.
k) Under voltage/over voltage features.
l) Adjustable characteristic angle.
m) High Resistance fault detection.
n) Variable residual compensation for all zones.
o) Delta directional comparison.
p) CT supervision/PT supervision.
q) CVT transient detection.
r) Breaker contact wear monitor.
s) Residual voltage protection.
t) GPS time synchronizing.
u) Switch on-to-fault facility.
v) Easy setting mode.
w) Programmable LEDs.

The distance relays shall have provision for operating in any of the following modes of operation via power line carrier communication system:

1) Permissive under-reach transfer tripping.
2) Permissive over-reach transfer tripping.
3) Stage acceleration.
4) Directional comparison blocking and un-blocking schemes.



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High resistance earth faults are difficult to detect by using distance relays if they were set to operate for such fault, there would be danger of operation due to load currents for this reason the distance protection shall incorporate or be associated with facilities for detection of such faults using sensitive directional earth fault elements.

Directional comparison earth fault scheme shall be integrated with the distance protection and capable of using the same power line carrier protection signaling command as the associated distance protection. The scheme shall be in-operative during the single pole auto-reclose dead time.

When permissive over-reach signaling is selected the distance protection and direction comparison earth fault protection shall include a signal echo scheme which re-transmits the received signal if the line isolator or both circuit breakers are open.

It shall be possible to extend the first zone step to 120% of the basic length of the protected section during protection signaling system (PLC) failure or when charging a dead line. During the auto reclose dead time the first step shall automatically be set back to normal first zone setting of the line impedance.

The characteristics of measuring elements for all types of faults shall be directional impedance and shall have Mho type, quadrilateral/lenticular features to best suit various fault conditions under phase-to ground and interphase faults. Measures shall be taken to avoid undesired tripping due to current reversals during switching operations. Phase and ground fault compensation features shall be incorporated to ensure accurate distance measurement for all types of faults.

The scheme shall be suitable for operation when connected with capacitor voltage transformers.

The scheme shall be capable of functioning in conjunction with auto-reclosing relays and shall be capable of actuating single and three phase tripping of the faulted phase(s). Moreover, provisions shall be made to initiate three pole tripping if either single phase tripping order is given after time delay or another phase of the protected line becomes faulted after one pole has been tripped. Provision shall also be made to ensure three phase tripping when breaker at either end of the line is closed manually onto fault on the protected line with the line previously de-energized. In this case the auto-recloser shall be blocked.

The relays shall operate with correct directional sense for zero voltage three phase faults, based on the normal voltage existing at the relay terminals prior to the faults by a memory unit/module. Provision shall be made to prevent false operation of the unit and to give annunciation for loss of voltage due to fault on the secondary side of the CVTs. The blocking of false operation shall be faster than minimum first zone operating time of the relay.

Power swing blocking function shall be included in the distance protection scheme with a convenient arrangement to render it out of service if necessary. Indication of power swing blocking will be provided.

The power swing blocking shall be provided with selection feature to select any of the following mode:

i) Blocking of all zones
ii) Blocking of zone 3
iii) Blocking of zone 2, zone 3
iv) Blocking of zone 1 only

v) Unblocking of any selected mode

In addition to feeding the system parameter and desired relay settings with a PC, it shall also be possible to make all relay settings manually, through man machine interface unit provided at the front of the relay.

The relay shall be immune to electromagnetic disturbances. The relay shall not generate, conduct or radiate noise which could interfere with other equipment in the switchyard.

There shall be complete galvanic separation between internal processing units and the external connections.

A signaling unit shall be provided with the scheme to indicate the particular phase or phases etc. and zones involved even if the relay picks up and no tripping command results. External remote reset of these indications shall be possible. The scheme shall be provided with sufficient contacts for wiring to the remote Annunciator and SDER.

The scheme shall be insensitive to the specified range of frequency changes and to the DC component in the fault current. The scheme shall provide at least four zone directional detection of all inter phase faults and ground faults and fourth zone for· reverse direction. The first zone of the relay shall normally be set to cover 85% of the line length and shall operate well within one cycle for all phase and ground faults respectively, within the first zone setting. Individually adjustable timing relays shall be provided for second and third zone time delayed tripping.

To protect the zone between the single line circuit breakers and the line disconnectors, while the-line isolator is open, signal to the distance relay shall be provided through auxiliary switch contacts of the disconnectors to activate stub protection. Also zone 3 timer shall be by-passed under this condition.

The reach of each zone shall be individually and independently adjustable. The Contractor shall furnish necessary evidence to show that each step of operating time is sufficiently independent of the magnitude of fault current.

Provisions shall be made for detection of broken transmission conductors not involving ground.

The Contractor shall submit sufficient evidence supported by relay setting calculations and relay characteristics on R-X diagrams, based on the line surge impedance loading (SIL) and line length to show that the offered relays have the required reach on each transmission line section where it shall be applied without load encroachment. Means shall be applied for the protection to function correctly during low fault currents.

The DC-DC converters provided with the relays shall be conservatively rated and shall be of robust design so as to provide the required operating voltage and isolation of high frequency transients at the full range of battery operating voltage with the relay room ambient temperature specified.

Serial interfaces for on-line and off-line transmission of relay operation data, line load data, fault recording, remote setting and remote test initiation be provided.

Relay shall be able to store at least 50 events and 10 disturbance records and shall be able to download locally and remotely from engineering workstation and NPCC/RCC (Gilgit) through the Switchyard Control System gateways.



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Serial connection facility to a PC with printer/plotter for further data exploitation with the required software.

#### 6.12.6.2 Transmission Line Fault Locator

A built-in fault locator shall be provided with distance numerical protection. The built-in fault locator shall provide readout of the distance to fault in kilometers, ohms or as a percentage of line length. It shall be possible to start the fault locator by fault detection, trip command from the distance relay and by external command from any other protective device. Means for remote indication for fault location shall be available.

The fault locator shall be based on impedance to fault measurements as against measurement of wave propagation time.

The fault locator shall have a high setting range to cover long line section. The measuring time shall not exceed 30 msec, with minimum measuring accuracy of ±2% on 2 digit, display or equivalent accuracy on 3 digit display. The measurement shall not be impaired in case of double end infeed or with fault resistance. The fault locator shall be suitable to, function in ambient temperature up to 50 deg. C and under severe environmental disturbances resulting in H.F. transients and shall conform to the transient tests specified in latest issue of relevant IEC and ANSI standards. Means shall also be provided to enable it to function correctly in case of zero sequence mutual compensation.

#### 6.12.6.3 Line Differential Protection

On short lines, line differential protection shall be provided. Line differential protection shall be numerical high speed, suitable for operating with fiber optics connection as applicable for various lines.

They shall be sensitive enough to detect the minimum fault (phase or earth fault) expected in the system or 1.2xIn, whichever is lowest.

Inter-phase and earth fault protection shall remain stable in the event of through fault current up to the peak short circuit level.

The protection shall be capable of high speed operation with maximum operating time not exceeding 20 ms at five times the settings.

The differential protection shall fully discriminate between internal and external faults and shall be capable of identifying the faulty phases.

Starting elements, if of over current type, shall be provided with filter for the second and third harmonics for primary operating values in the range of 20-100% rated current for earth fault and 50-300% for phase fault. Alternatively, the starting elements shall be of the under impedance type.

Comparison or measurement of the protection shall preferably be done over the complete cycle providing fast operating time.

#### 6.12.6.4 Over Current and Earth Fault Protection

The relay shall have non-directional three phase over current elements and one earth fault element.

The relay shall have the facility of selection of following characteristics according to IEC 60255 and BS-142.



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(a) Standard inverse.
(b) Very inverse.
(c) Long time inverse.
(d) Extremely inverse.
(e) Definite time over current.

Relay shall have adjustable settings for both operating current and time, the design of the relay being such that the setting can be carried out without taking relay out of service. The range of current settings for phase fault shall cover at least 5-200 percent of rated current with tapings a minimum of 5-percent intervals and time setting adjustment shall be 0 to 3 seconds at ten times the setting current. Time setting for both over current and earth fault elements shall be adjustable over a range of at least 0.05 to 1.0 times in steps not exceeding 0.025 times. Earth fault element shall have a minimum range of setting from 5% to 80% with tapping of 5% interval.

The high set element shall have a setting range of 200 percent to 3000% of nominal current the tripping time of high set elements should have within 20 ms.

Each protection element shall have separate trip and alarm contacts and separate trip indicators.

Relays shall be supplied with front and rear ports equipped with communication software for local/remote access of data and parameter down load.

HMI - Keypad facilities shall be provided for local access to setting, monitoring and disturbance data shall also be provided.

The relays shall be thermally rated such the operating time of the relay at the highest practical current levels on combination of current and time multiplier settings shall not exceed the time thermal with stand time of the relay.

The actual relay pick-up current shall not exceed 1.1 times the relay setting and reset value shall not be less of 90% of pick-up current.

### 6.12.6.5 Reclosing Relays

Built in auto-reclosure within distance relay shall be used for 132kV system.

### 6.12.6.6 Synchronism Check Relays

The synchronism verifier relay shall check the conditions of synchronism existing between two system voltages at the two terminals of each circuit breaker and close the respective circuit breaker when the voltages are within the set limits in phase and frequency. Also included shall be the feature that the relay will allow circuit breaker closure when one of the sources is de-energized. If the two systems are not in synchronism, then closing of the circuit breaker shall be blocked.

The manual Mimic synchro-check scheme shall be implemented with one relay per voltage level.

Status (On, Off) of the relevant disconnectors and circuit breakers shall be taken into account in the selection of the voltage transformers to be connected to the synchronism check relays and the synchronizing instruments so that the applied voltages to these devices will correspond to the system voltages that are actually present at the two terminals of the circuit



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breaker which is to be closed. The scheme shall ensure that the voltage transformers will not be paralleled at the secondary side.

The operating time of the relay shall be adjustable in the range 0 to 100 seconds. The relay shall have phase angle setting range of 5 to 80 degrees.

Synchronism-check relay shall have provision for the following conveniently selectable modes and combinations thereof:

- Incoming system live, running system dead (live line, dead bus)
- Incoming system live, running system live (live line, live bus)
- Incoming system dead, running system live (dead line, live bus)
- Incoming system dead, running system dead (dead line, dead bus)

A three position synchronism selector switch, marked with positions Auto-Off-Manual, shall be provided adjacent to each discrepancy type circuit breaker control switch on the remote control panel in the control room. Besides selecting the appropriate voltages and applying these to the synchronism check relay of the respective circuit breaker and the common synchronizing instruments, the selector switch shall activate the synchronism check scheme as follows:

**Switch in Off position**

No voltage applied to the respective synchronism check relay. No voltage applied to the common synchronizing instruments. Closing command to the circuit breaker is blocked.

**Switch in Auto position**

Voltages applied to the respective synchronism check relay and the common synchronizing instruments. Upon turning the circuit breaker control switch to command position, synchro-check scheme is activated. Circuit breaker control switch is released but the synchro check scheme remains activated. The scheme remains activated until the circuit breaker closes and/or the selector switch is turned to Off position. If synchronism check is unsuccessful within an adjustable preset time an alarm is activated.

**Switch in Manual position**

The Contractor shall design the synchronism check scheme accordingly and submit to the Employer for approval.

### 6.12.6.7 Breaker Failure Protection

The breaker failure relays shall be numerical type back-up protection for circuit breaker failure. The breaker failure relay shall be four element relay three for phase and one earth element. In case of non-availability of earth fault element in the standard relay separate relay may be used as earth fault element. It shall be possible to make separate setting for phase and earth faults. The relay range shall be at least 0.1 In to 2. In for overcurrent and 0.02 In to 1 In steps of 0.01 for earth fault. Protection shall provide two stage tripping with an initial trip to its own breaker and time staged tripping to the adjacent breakers. The relay shall be capable of carrying continuously not less than double the rated current on all taps. The measuring relays shall be fast operate - fast reset with drop-off to pick up ratio nearly 96%. The timers shall be of fast pickup and fast reset static/digital design. The time range shall cover 0-500 msec for stage-1 time and 50 to 500 msec for stage-2 in a suitable scale for as precise setting as possible. In the breaker failure, provision shall be made for direct transfer tripping of remote end breaker in case of failure of local circuit breaker. The direct transfer trip shall be provided



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as coded signal. Provisions shall also be made to prevent the scheme operating incorrectly on unbalanced load current when one pole is open during single pole auto-reclose cycle.

For the protection equipment which function is not necessarily dependent on a certain level of current (e.g. Buchholz) or the relays for which level operation is usually less than the level of the BFR, the starting of the breaker failure will be performed by logical circuit instead of the usual overcurrent starting.

When circuit breaker opening is blocked due to loss of pressure or spring not charged etc. breaker failure protection should issue stage-2 trip without unnecessary time delay.

The breaker failure relay shall be provided for each individual breaker at 132kV level.

#### 6.12.6.8 Bus Differential Relays Protection

Bus differential protection shall be low impedance centralized type. The bus differential relays shall be high speed and of the low impedance type connected for protection of both phase and ground faults. There will be two busbar protection relays. One will protect busbar-I, while other will protect busbar-II. The bus-bar protection scheme shall also look into faults taking place between C.Ts. and circuit breakers. The protection shall be insensitive to C.T saturation, and shall have high through fault stability even for nearby faults. The protection shall be insensitive to transients and harmonics. The scheme shall work satisfactorily on C.T's which may not have identical transformation characteristics on the same tap. The speed of operation shall be less than one cycle if the symmetrical fault current exceeds a value twice the pick-up level. The overall time shall be less than 0.1 sec. It shall be capable of picking up under the minimum bus-bar fault current conditions.

Suitable number of auxiliary contacts shall be provided for remote indications and alarms such as for annunciators, and events recorders, SCADA functions etc.

#### 6.12.6.9 Stub Protection

For generator transformer connection two over-current relays shall be provided for stub protection. The relays shall be as specified in Clause 6.12.6.4.

#### 6.12.6.10 Lockout Relays

Lockout relays, shall be Electro-Mechanical, draw-out, high burden, hand and electrically reset, high speed and of multi-contact construction.

The relay coil shall be designed for continuous operation on 110V with tolerance of +20% and -15%. The operating time shall not be greater than 10ms at rated voltage. The high burden relays shall be immune to AC and capacitance discharge current.

Lockout relays shall have at least five (5) year field proven experience and shall be designed, tested and manufactured in accordance with IEC standards. The contact arrangement shall consist of 7 NO and 2 NC contacts. Number of relays shall commensurate with the requirement of the protection scheme. The contact rating shall not be less than the following:



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| Contract Rating | Make and Carry Continuously | Make and Carry for 3 seconds | Break |
|---|---|---|---|
| AC | 1250 VA with maxima of 15A and 660V | 7500VA with maxima of 30A and 660V | 1250VA with maxima of 5A and 660V |
| DC | 1250 W with maxima of 5A and 600V | 7500W with maxima of 30 A and 660V | 100W resistive 50W inductive with maxima of 5A and 660V |

The relays shall be suitable for flush or semi-flush mounting on the front of the cubicle with connection made at the rear of the case or for internal surface panel mounting. If the unit does not have an integral indicating target or if it is mounted at the rear of the panel a separate and reset push button shall be provided on the front of the panel.

The mechanical durability shall be 10,000 operation (minimum) with load contact.

Standard lockout relay shall be Alstom make, type MVAJ 21 or approved equivalent

**6.12.6.11 High Speed Tripping Relays**

(1) Tripping relays shall be Electro-Mechanical, draw out, high burden, self-reset, high speed and of multi-contact construction with indication target to be reset manually.

The relay coil shall be designed for continuous operation on 110VDC with tolerance of +20% and -15%. The operating time shall not be greater than 10ms at rated voltage. The high burden relays shall be immune to AC and capacitance discharge current.

Tripping relays shall have at least Five (05) years filed proven experience and shall be designed, tested and manufactured in accordance with IEC standards. The contact arrangement shall consist of 7NO and 2 NC contacts. Numbers of relays shall commensurate with the requirement of the protection scheme. The contact rating shall not be less than the following:

| Contract Rating | Make and Carry Continuously | Make and Carry for 3 seconds | Break |
|---|---|---|---|
| AC | 1250 VA with maxima of 15A and 660V | 7500VA with maxima of 30A and 660V | 1250VA with maxima of 5A and 660V |
| DC | 1250 W with maxima of 5A and 600V | 7500W with maxima of 30 A and 660V | 100W resistive 50W inductive with maxima of 5A and 660V |

The mechanical durability shall be 10,000 operations (minimum) with loaded contact. Standard tripping relay shall be Alstom make, type MAVJ21 or approved equivalent.

(2) The CB fail inter trip direct transfer trip receive relay, and the CB fail inter trip direct transfer trip· transmit relay, shall be self-reset type, with manually reset targets, high burden, high speed tripping relays of multi-contact construction suitable for flush or semi- flush mounting on the front of the cubicle with connections made at the rear of the case. Alternative rear of panel mounted relays may be used but a separate front panel hand reset target relay shall also be provided.



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### 6.12.7 Phase Arrangement

The standard phase arrangement on all relay boards when facing the front-of-the panels shall be R-Y-B, from left to right, from top to bottom, and from front-to-back. All relays, instruments, other devices, buses and equipment involving three-phase circuits shall be arranged and connected in accordance with the standard phase arrangement. Similar devices shall be wired alike. Positive terminals shall be located at the top, left and front position, relative to the corresponding negative terminals, as viewed from the front-of panels.

### 6.12.8 Connections

The line, power transformer and bus bar protection relays shall be connected as indicated in Conceptual Drawings included in Volume-II Part-III of these Specifications. The 110 V DC system circuits shall be separate for each control function and for each protection.

### 6.12.9 Factory Tests

All equipment furnished by the Contractor under these Specifications shall be subjected to tests in the shop in the presence of Employer for conformity with the requirements of the Specifications. Certified type test reports on identical units shall be provided. Type test shall not be repeated if manufacturer can present satisfactory test reports from an independent laboratory. Independent laboratories are specified in the Employer Requirements. Two copies of the type test reports and six copies of the routine test reports shall be submitted to the Employer for review. The tests shall be in accordance with relevant IEC Standards and include, but not necessarily be limited to the following:

#### 6.12.9.1 Factory Design Tests (Type Test)

1) Limits error test.
2) Temperature rise test.
3) Overload test.
4) Mechanical durability test.
5) Temperature test/heat cycle test.
6) Surge withstand capability test.
7) Test for operation at minimum and maximum voltage.
8) Make and carry current rating test for tripping contacts.
9) Dielectric tests across open contacts.
10) Sensitivity tests for the following faults:
    - Phase to earth.
    - Phase to phase.
    - Three phase.
11) Operating time under transient conditions.
12) Stability tests.

#### 6.12.9.2 Factory Production (Routine) Tests

1) Limits error test.
2) Resetting values test.
3) Dielectric tests between circuits and relay frame.
4) Operating test.



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### 6.12.10 Relay Panels

The panel layout and equipment arrangement on the relay panels shall be based, as far as possible, on the relevant Specification Drawings.

#### 6.12.10.1 Protection Panels for 132kV Lines

**Panels for 132kV Lines**

a) Distance protection tripping and auxiliary relays as specified.
or Numerical Line distance cum differential protection (87L) and auxiliary relays as specified (For short lines only).
b) Four element over current and earth fault relays for line protection as specified.

#### 6.12.10.2 Bus Bar Protection Panel

(1) Low impedance centralized bus bar differential relays.
(2) Lock out relays as specified in Section.

#### 6.12.10.3 Breaker Failure Protection Panels

(1) Breaker failure relays as specified.
(2) Lockout and trip relays as specified.

In addition to relays described above, the relay board shall accommodate, synchro-check relays, all other auxiliary relays and devices required for complete protection scheme for the switchyard. Independent relays in accordance with protection single line diagram of contract Volume-II, Part-III shall be provided.

### 6.12.11 Drawings and Descriptive Data

Data to be furnished with the Proposal shall include outline drawings, catalogues and descriptive internal details for the type of relays to be supplied. Data supplied with protective relays shall include engineering application and all necessary operating characteristic curves for each type of relay.

#### 6.12.11.1 Approval Drawings

Approval drawings and data shall include all the data requested above plus single line diagrams, three line diagrams, panel connection diagrams, interconnection diagrams, switch board outline and equipment arrangement drawings, equipment data, protective relaying system computations. Relay settings, instruction and maintenance manuals, all wiring and schematic diagrams, circuit diagrams with their functional description in detail.

The Contractor shall submit sufficient evidence supported by relay setting calculations based on line surge impedance loading (SIL), line parameters, load flows and fault levels to show that the offered starting relays have the required reach on each transmission line section where it shall be applied without load encroachment. The Contractor shall furnish appropriate evidence to show that the time setting range(s) and current setting range(s) of the offered overcurrent relays and breaker failure relays have been selected in order to coordinate the proposed relays with the existing protection schemes on adjacent lines.

(1) For distance relays the following curves shall be submitted:

(a) Operating characteristic curves of measuring units in the form of R-X diagram including curves of starter units.



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(b) Curves for operating time against fault impedance (percentage relay setting) for constant voltages.

(c) Constant operating time characteristic curves for various times up to the limit of operation showing relay setting against system impedance ratio. These curves shall be for single phase as well as for three phase faults.

(2) Time current characteristics for overcurrent relays.

(3) Operating characteristics of other relays.

(4) Curves showing the variation in the errors of the relays with changes in ambient temperature, frequency and auxiliary D.C. Voltage.

## 6.13 SUBSTATION AUTOMATION SYSTEM

### 6.13.1 General

This section covers the design, supply, installation, testing and commissioning of Substation Automation System (SAS) for 132 kV Attabad Lake HPP Switchyard. Substation Automation System (SAS) for 132kV Switchyard shall include control, monitoring, fault recording, events recording and supervision functions complete with equipment interfaces for the entire substation including but not limited to:

- Control of substation equipment including circuit breakers, disconnectors and earthing switches.
- Interfacing with protection relays
- Measurements of voltages, currents, frequency, watts, and VARs through transducers.
- Measurement of status indications.
- Alarm annunciations.
- Interface with secured energy metering system.
- Interfacing with station voltage regulation equipment for indication and control.
- Event logging and fault recording functions based on inputs from relays and other substation devices/equipment and BCUs.
- All SCADA functions including communication interface with National Power Control Centre (NPCC)/Regional Control Centre (RCC).

The SAS shall be modern computerized (microprocessor-based) flexible and freely extendable open architecture control and monitoring system consisting of programmable controller(s) and shall be designed, manufactured, installed, tested and commissioned for the safe and reliable operation of the substation.

The SAS shall be offered from a manufacturer who shall have designed, manufactured, type tested, installed and commissioned Substation Automation System (SAS) that shall be in satisfactory operation on 132 kV. Only those manufacturers having adequate Project and Client references and proven SAS shall be considered. Proof of experience in 132kV or above outdoor substations shall be submitted. SAS hardware shall have at least Three (03) years of operating experience at similar substation Projects.



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### 6.13.2 System Design

#### 6.13.2.1 General Design Requirements

The system shall be state of the art based on IEC 61850 and suitable for operation under electrical environment present in MV substations, follow the latest engineering practice, and ensure long-term compatibility requirements and continuity of equipment supply and the safety of the operating staff.

BCUs shall be installed in the SAS and shall be modular in design based on open architecture and shall interface to field devise or instrumentation.

The system shall incorporate the control, recording, monitoring and protection functions, self-monitoring, signalling and testing facilities, measuring as well as memory functions, event recording and evaluation of disturbance records as specified.

All components shall be of approved and reliable design. The highest degree of uniformity and plug and play interchangeability shall be attained. The design shall facilitate easy maintenance, fault diagnosis and repair of the components. Maintenance, modification or extension of components may not cause a shutdown of the whole SAS. Self-monitoring of components, modules and communication shall be incorporated to increase the availability and the reliability of the equipment and minimize maintenance.

The equipment shall be completely assembled as far as possible at the Manufacturer's premises prior to shipment to site.

All components shall be suitable for the local climate, and the cubicles and panels shall be dust and moisture-proof to withstand prevailing climatic conditions. The specified maximum ambient temperature shall be taken into consideration in closed rooms, as the perfect operation of the air-conditioning system in the rooms shall be assumed as not guaranteed. The Contractor shall design the systems and select equipment accordingly.

All instrumentation and control equipment shall be capable of continuous satisfactory operation within the specified variation in supply voltage and frequency.

No batteries shall be used in the storage of configurations within electronic devices, as this would necessitate changing of batteries within the equipment over its useful service life. All memory storage shall be based on flash memory or non-volatile storage.

It shall be possible to carry-out all modification works off-line with appropriate provisions to verify/validate the changes for correctness before implementation. Such activities shall be bump-less.

All the central and the common units and input/output/analogue modules shall be provided with a 30% spare capacity after completing the Scope of Work in accordance with this specification. However, for main computers (database servers), the equipment shall be supplied with adequate memory of the required task with 100% spare capacity for future use. The hard disk capacity should be adequate to satisfy the requirements of the operating system support and diagnostic and application software with 100% spare capacity.

The Substation Automation System (SAS) have provision for remote monitoring and control from NPCC/RCC via SCADA gateways.

The system shall be designed such that personnel without any background knowledge in microprocessor-based technology are able to operate the system. The operator interface shall

be intuitive such that operating personnel shall be able to operate the system easily after having received some basic training.

Future extensions shall be possible by the simple addition of hardware at bay level and configuration of database at station level. The SAS design and performance shall include all the necessary provisions for signal allocation, display mimic etc. for possible future extensions.

All required hardware and software shall be provided, including all wiring, panels and necessary auxiliaries, even though not every item may be specified in detail herein.

The future availability of equipment spares for at least Fifteen (15) years from the date of commissioning shall be guaranteed.

The Data Points / Tele Information Points for exchange of information between NPCC/RCC and SAS shall be sent in the form of Application Service Data Units with Information Object Address (IOA) should be prepared for each bay to enable the NPCC/RCC to extend their database for networking the SAS. All engineering, including Factory Acceptance Tests (FAT) and Site Acceptance Tests (SAT) shall be carried out by the manufacturer. The SAT shall include end-to-end test with NPCC/RCC for all information points (signal, tele-measurement, command etc.). The Data Points/ Tele information Points list and grouping shall be prepared according to NTDC Standards and the Contractor shall obtain explicit approval of these documents.

The following capabilities shall be supported by all BCUs unless specific exceptions are noted:

- BCUs shall support IEC 61850 communication standards.
- BCUs shall be open architecture based. They shall support time synchronization over the SCADA network.
- Each BCUs shall maintain version control for its software/firmware and configuration files

The range limits for measurement values shall be applied as follows:

- ‘Normal’ Operating Region: The ‘high’ and ‘low’ limits shall be used to define this region. Values for power system variables are expected to fall within this region.
- ‘Warning’ Operating Region: The ‘high-high’ and ‘low-low’ limits shall be used to define this region. Values in this region indicate that some kind of operational correction is required.
- ‘Emergency’ Operating Region: The ‘min’ and ‘max’ limits shall be used to define this region. Values in this region indicate exceptional conditions requiring immediate attention.
- Out-of-Range: ‘Min’ and ‘Max’ represent the boundaries for measurements within process limits. Data outside these limits is questionable and may indicate equipment failure. Accordingly, data quality shall be marked ‘questionable’ and ‘out-of-range’. When an analog data value transitions into an out-of-range region, the last reasonable value shall be retained in the Repository. It shall not be updated again until the value leaves the out-of-range region.

All events shall be time-tagged at the time of occurrence, as detected/determined by the monitoring/processing source (e.g., BCU or other IED). Time-tagging resolution shall be a maximum of 1 ms, relative to the internal clock of the monitoring/processing source.

Contact inputs: Changes in signal state shall be time-tagged at the time of transition, although such changes shall be validated before they can be accepted, processed, and reported. Validation shall be achieved by applying digital filtering to ensure changes persist for at least a user-defined period of time before they are accepted as genuine.

BCUs / IEDs shall be able to detect a quick sequence of multiple changes in status for the same point and ensure that all those changes are reported. This assumes that individual status transitions persist sufficiently long to qualify for validation.

#### 6.13.2.2 System Architecture

The SAS shall be based on open system architecture. The main process information of the station shall be stored in distributed databases. Historical data shall be automatically archived/backed-up and stored into hard disks.

The system architecture shall be structured in the following levels:

- NPCC/RCC level - System shall have the necessary equipment to connect with this level for monitoring and control purpose.
- Station level - Operator Workstation in the Substation Control Room; to view data and perform switching and other control actions locally.
- Bay level - Bay Control Cubicles installed in the switchyard control room.

For 132kV substation, BCUs shall provide all functions regarding control, monitoring and protection, inputs for status indication and outputs for commands. The process data (voltages, currents, frequency, power factor, MW, MVAR etc.) from circuit breakers and their associated disconnectors, line disconnectors, earthing switches and instrument transformers shall be acquired through transducers and fed to the BCU.

The BCUs along with the SCADA Interface Cabinet (SIC) shall be installed in the substation control room. The protection relay panels will be installed in the relay room.

The data exchange between the electronic devices on bay and station level shall take place via the communication infrastructure. This shall be realized using duplicated fiber-optic cables, thereby guaranteeing disturbance free communication. Data exchange is to be realized using IEC 61850 protocol with a redundant managed switched Ethernet communication infrastructure using duplicated LAN. The communication shall be made in fault tolerant ring in redundant mode such that failure of one set of optical fiber shall not affect the normal operation of the SAS. However, failure of optical fiber cable shall be alarmed in SAS.

The BCUs shall be interfaced with operator workstation that shall enable substation personnel to view data and perform switching and other control actions locally. The operator workstation shall be able to display real-time (live) substation data (current, voltage, active and reactive power, etc.) in a variety of formats, including tabular format and graphical format. It shall be possible to superimpose real time data on a static background, such as a substation mimic. Abnormal data shall be highlighted using special colors or symbols to report each condition. Gateway devices shall be used for remote monitoring and control at NPCC/RCC via DPLC and Fiber Optic links.

At station level, the entire station shall be controlled and supervised from the station HMI. It shall be possible to control and monitor the bay from the bay level equipment, in the event that the communication link fails. The station-wide interlocking shall also be available when the Central Control Unit fails.

To provide highest reliability, the operator workstation and the gateways shall work completely independently. Additionally, the gateway and the operator workstation shall be configured fully redundant to ensure full functionality in case of single point of failure.

Clear control priorities shall prevent operation of a single switch at the same time from more than one of the various control levels i.e., operator workstation, or apparatus level (LCC). The priority shall always be on the lowest enabled control level.

A dedicated redundant master clock for the synchronization of the entire system shall be provided. This master clock shall synchronize all devices in the system.

Operator workstation, monitor, printers and other peripheral devices shall remain operational in the event of station AC supply failure, drawing auxiliary power from a redundant sinewave UPS connected to a dual input supply from both the 110V station batteries via their respective DC distribution board buses and an incoming AC supply.

The following equipment, as a minimum, shall be designed, supplied, installed, integrated, tested and commissioned as part of SAS:

- Bay Control Unit
- Redundant Operator Workstation complete with key board, redundant video display units or LCDs, mouse etc.
- Engineering Workstation complete with keyboard, video display unit or LCD, mouse etc.
- Redundant GPS Master Clock complete with antenna and interface ports
- Alarm and Events Printer and Hard Copy laser jet printer
- Local Area Network (LAN) comprising switched Ethernet or fiber communication infrastructure Control room furniture including desks and chairs for Operator Workstation.
- Redundant Gateways for remote control via industrial grade hardware (to NPCC/RCC) through IEC60870-5-101/104 protocol.

Panels housing BCUs and SIC shall be provided as part of the respective equipment/system as specified elsewhere in these Technical Specifications. However, interfacing of the relay and control panels with the BCU and all other adaptation works shall be included in the scope of work of SAS.

The conceptual SAS Configuration is shown in the Specifications-Drawings.

### 6.13.3 Functional Requirements

#### 6.13.3.1 Overall Control Philosophy

The substation equipment shall operate from any one of the following locations:

- National Power Control Center (NPCC) Islamabad/Regional Control Center (RCC) via SCADA system.
- Operator's Workstation in the switchyard Control Room.
- Bay Control Units (Bay Control IED along with Bay Mimic Panel/Devices) in the switchyard Control Room.
- Bay Local Control Cubicles (LCCs) installed in the switchyard and control panels installed on/or adjacent to the respective equipment.

A selector switch shall be available for selection between operator workstation or to control from bay mimic control panels so that operation of the equipment is possible from only one control level. The priority shall always be on the lowest enabled control level. The data transmittal from the substation to NPCC/RCC shall continue irrespective of the position of this selector switch.

The Substation shall normally be controlled and monitored from the operator workstation associated with the BCU panel. In case of failure of BCU, the control of the respective equipment shall be possible from its related bay mimic control panel. The operation from the Bay Control Cubicles is limited to testing and maintenance purposes.

The operation shall always depend on the conditions of other functions, such as interlocking, synchro check, etc. For security reasons the command is always to be given in two stages: selection of the object and command for operation under all modes of operation. Final execution shall take place only when selection and command are actuated.

SAS shall be equipped with capability to generate dynamic and static graphic displays to assist the operator to easily control and monitor the entire substation. The graphics shall also include dynamic replica of the synchro scope function, there shall be a dedicated graphic display comprising voltage and frequency measurements and synchro scope for synchronizing.

All the circuit breaker, disconnector and earthing switch interlocking should be hardwired and shall be implemented to the maximum extent possible in the respective Bay Control Cubicles of the substation. The hardwired interlocking is to be provided to ensure that inadvertent incorrect operation of switchgear causing damage and accidents in case of failure of BCU does not take place.

It shall be possible to start, load, operate, unload and stop the Emergency Diesel Generator (EDG) from the Operator's Workstation / Station HMI. The main parameters of the EDG including speed, voltage, frequency, power, currents etc. shall be monitored at the operator workstation. The faults in the EDG system shall also be alarmed at the Operator Workstation.

**a) Position indication and interlocking scheme for operation from Bay Mimic Panel**

The position indication scheme shall be as follows for the bay mimic panel:

This scheme consists of indication of the operational status of power circuit breakers, disconnectors and earthing switches.

The status of circuit breakers, disconnectors and earthing switches shall be indicated by the indicating lamps of the discrepancy type control switch having Off Command-OFF-ON-On command positions. An OFF status of control switch lamp indicates that position of both the control switch and respective circuit breaker are in agreement with each other. A disagreement in their position's initiates flickering of control switch lamp/LEDs.

Circuit breakers, disconnectors and earthing switches shall be interlocked with each other and with the relevant control and protection functions for safety of equipment and personnel and to prevent inadvertent operation. The interlocking scheme shall include but not be limited to the following:

Electro-Mechanical interlocking shall be supplied with each breaker. Electro-Mechanical interlocking shall be provided to prevent operations of the associated disconnectors when circuit breaker is closed. It shall not be possible to operate a bay with outer breakers open and centre breaker closed. However, a key operated switch shall be provided on the control board for each Bay breaker to bypass this interlock whenever required.



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Necessary Electro-Mechanical interlocks shall be furnished for disconnectors for lines and circuit breakers.

The Electro-Mechanical interlocks shall perform the following functions:

1) Prevent operation of each circuit breaker disconnectors when associated circuit breaker is closed.
2) Prevent operation of line disconnector when associated breaker (s) is (are) closed.
3) Prevent remote/local operation of disconnectors when associated circuit breaker is being maintained (whether open or closed).
4) Prevent closing of earthing switch when line disconnector is closed.
5) Prevent closing of line disconnector when earthing switch is closed.
6) The arrangement shall be made to ensure that the disconnector cannot be operated mechanically with manual operating handle when the associated circuit breaker(s) is (are) in closed position.
7) Arrangement shall be made to ensure that the line earthing switch cannot be closed when line is energized from the remote end.

#### 6.13.3.2 Bay Level Functions

The following functions shall be allocated at bay level:

- Bay control functions
- Bay protection functions
- Data collection functionality

The main functions at bay level are:

**a) Control mode selection (Local- Bay Mimic)**

As soon as the operator receives the operation access of the substation, the operation is normally performed via the operator workstation. During normal operation the operator workstation allows the safe operation of all switching devices via the Bay Controller Units (BCUs)/IED. The control mode selection switch shall be placed in “Local” position to perform any operation from the operator workstation.

In the event that the BCU fails, the operator shall be able to operate the respective bay circuit breakers, disconnectors and earthing switches from the adjacent Bay mimic panel by placing the Local-Mimic-Remote in the “Bay Mimic” position.

**b) Control of circuit breakers, disconnectors and earthing switches**

All the substation circuit breakers and associated isolators, disconnector and earthing switches shall be able to be controlled from the BCU as well as from the related Bay mimic control panel.

**c) Select-before-execute principle**

For security reasons, the command is always to be given in two stages: selection of the object and command for operation under all modes. Final execution shall take place only when selection and command are actuated.

**d) Command supervision**

Software Interlocking is to be provided to ensure that inadvertent incorrect operation of switchgear causing damage and accidents in case of false operation does not take place. In addition to software interlocking hardwired interlocking is to be provided as specified above.



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**e) Synchro-check, voltage selection**

The synchronism and energizing check functions shall be bay-oriented. These features are:

- Settable voltage, phase angle, and frequency difference
- Energizing for dead line-live bus, live line-dead bus or dead line- dead bus with no synchro-check function
- Synchronizing between live line and live bus with synchro-check function

The voltages relevant for the Synchronism check functions are dependent on the station topology, i.e., on the positions of the circuit breakers and/or the relevant disconnectors. The correct voltage for synchronism and energizing is derived from the auxiliary switches of the circuit breakers and the disconnecting switches, and shall be selected automatically by the BCU and operator workstation.

**f) Transformer tap changer control**

Raise and lower operation of OLTC taps of transformer shall be facilitated through BCU.

**g) Circuit breaker, Disconnector and earthing switch position indications**

The open / close status of each pole of circuit breaker, disconnector and earthing switch shall be monitored and displayed on the operator workstation associated with the BCU. The open/close status of each circuit breaker, disconnector and earthing switch shall also be indicated on the associated bay mimic panel.

**h) Alarm annunciation**

All substation related alarms shall be annunciated on the operator workstation interfaced with the BCU.

**i) Measurement display**

Analogue inputs for voltage and current measurements shall be connected to the voltage transformers (VT) and the current transformers (CT) through intermediate transducers. The values of active power (W), reactive power (VAR), frequency (Hz), power factor and the rms values for voltage (U) and current (I) shall be calculated in the BCU. All the measurements related to substation components shall be displayed at the operator workstation of the BCU.

**j) Local HMI**

Each BCU shall have its Local HMI. It shall be possible to control and monitor the complete bay from here. The Local HMI shall display the bay mimic/single line diagram and shall dynamically display the equipment status and all its related measurements and alarms.

**i) Interface to the station HMI**

The BCU shall communicate with the central control units utilizing IEC 61850 protocol

**ii) Data storage for at least 200 events**

Each BCU shall have a data storage capability of at least 200 events.

### 6.13.3.3 Station Level Functions

**a) Status supervision**

The position of each switchgear including circuit breaker, disconnector, earthing switch, transformer tap changer etc., shall be supervised continuously. Every detected change of position shall be immediately displayed in the single-line diagram on the station HMI/Operator workstation screen, recorded in the event list and a hard copy printout shall be produced. Alarms shall be initiated in the case of spontaneous position changes. The switchgear positions shall be indicated by two auxiliary switches, normally closed (NC) and normally open



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(NO), which shall give ambivalent signals. An alarm shall be initiated if these position indications are inconsistent or if the time required for operating mechanism to change position exceeds a predefined limit. The SAS shall also monitor the status of sub-station auxiliaries. The status and control of auxiliaries including emergency diesel generator shall be done through separate I/O module/card of BCU and all alarm and analogue values shall be monitored and recorded through this module.

**b) Measurements**

The analogue values acquired/calculated in bay control/protection unit shall be displayed locally on the operator workstation and selected values shall be communicated to Remote end substation. The abnormal values shall be discarded. The analogue values shall be updated every two (2) seconds. Threshold limit values shall be selectable for alarm indications.

**c) Event and alarm handling**

Events and alarms are generated either by the switchgear, control and protection devices or by the BCU. They shall be recorded in an event list in the operator workstation. Alarms shall be recorded in a separate alarm list and appear on the screen. All, or a freely selectable group of events and alarms shall also be printed out on an event printer.

**d) Operator Workstation Monitor**

**1) Substation HMI Operation**

On the operator workstation monitor the object has to be selected first. In case of blocking conditions or if interlocking conditions are not met, the selection shall not be possible and an appropriate alarm annunciation shall occur. If a selection is valid the appropriate control execution button shall be pressed in order to close or open the corresponding object. Control operation from other places shall not be possible in this operating mode.

**2) Presentation and Dialogues**

The operator workstation shall be redundant with hot standby and shall provide basic functions for supervision and control of the substation. The operator shall give commands to the switchgear on the screen via mouse clicks. The operator workstation shall give the operator access to alarms and events displayed on the screen. Aside from these lists on the screen, there shall be a printout of alarms or events in an event log. An acoustic alarm shall indicate abnormalities, and all unacknowledged alarms shall be accessible from any screen selected by the operator. The following standard display graphics shall be available from the operator workstation:

- Single-line diagram showing the switchgear status and measured values
- Control dialogues with interlocking or blocking information details (This control dialogue shall tell the operator whether the device operation is permitted or blocked.)
- Measurement dialogues
- Alarm list, station/bay-oriented
- Event list, station/bay-oriented
- System status

**3) Operator Workstation Software Design Principles**

Consistent design principles shall be adopted with the operator workstation software concerning labels, colors, dialogues and fonts. Non-valid selections shall be dimmed out. The object status shall be indicated using different status colors for:



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- Selected object under command
- Selected on the screen
- Not updated, obsolete values, not in use or not sampled
- Alarm or faulty state
- Warning or blocked
- Update blocked or manually updated
- Control blocked
- Normal state

**4) Process Status Displays and Command Procedures**

The process status of the substation in terms of actual values of currents, voltages, frequency, active and reactive powers as well as the positions of circuit breakers, disconnector, earthing switches and transformer tap-changers shall be displayed in the station single-line diagram. In order to ensure a high degree of security against undesired operation, a "select-before-execute" command procedure shall be provided. After the "selection" of a switch, the operator shall be able to recognize the selected device on the screen, and all other switchgear shall be blocked.

As communication between Operator's Workstation and device to be controlled is established, the operator shall be prompted to confirm the control action and only then final execute command shall be accepted. After the "execution" of the command the operated switching symbol shall flash until the switch has reached its new position. The operator shall be in a position to execute a command only, if the switch is not blocked and if no interlocking condition is going to be violated. The interlocking statements shall be checked by the interlocking scheme implemented at bay and station level. After command execution the operator shall receive a confirmation that the new switching position has been reached or an indication that the switching procedure was unsuccessful with the indication of the reason for non-functioning.

**5) System Supervision and Display**

The SAS shall be comprehensively self-monitored such that faults are immediately indicated to the operator, possibly before they develop into serious situations. Such faults are recorded as a faulty status in a system supervision display. This display shall cover the status of the entire substation including all switchgear, BCUs, communication infrastructure and communication links, etc.

**6) Event List**

The event list shall contain events that are important for the control and monitoring of the substation. The operator shall be able to call up the chronological event list on the monitor at any time for the whole substation or sections of it. A printout of each display shall be possible on the hard copy printer. The events shall be registered in a chronological event list in which the type of event and its time of occurrence are specified. It shall be possible to store all events in the computer for at least one month. The information shall be obtainable also from a printed event log.

The chronological event list shall contain:

- Position changes of circuit breakers, disconnectors and earthing devices
- Indication of protective relay operations
- Fault signals from the switchgear



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- Indication when analogue measured values exceed upper and lower limits. Suitable provision shall be made in the system to define two level of alarm on either side of the value or which shall be user defined for each measure and
- Loss of communication
- Filters for selection of a certain type or group of events shall be available. The filters shall be designed to enable viewing of events grouped per:
- Date and time
- Bay
- Device
- Function e.g. trips, protection operations etc.
- Alarm class

**7) Alarm List**

Faults and errors occurring in the substation shall be listed in an alarm list and shall be immediately transmitted to the Operator's workstation. The alarm list shall substitute a conventional alarm tableau, and shall constitute an evaluation of all station alarms. It shall contain unacknowledged alarms and persisting faults. The date and time of occurrence shall be indicated.

The alarm list shall consist of a summary display of the present alarm situation. Each alarm shall be reported on one line that contains:

- The date and time of the alarm
- The name of the alarming object
- A descriptive text
- The acknowledgement state

Whenever an alarm condition occurs, the alarm condition shall be shown on the alarm list and shall be displayed in a flashing state along with an audible alarm. After acknowledgement of the alarm, it should appear in a steady (i.e., not flashing) state and the audible alarm shall stop. The alarm should disappear only if the alarm condition has physically cleared and the Operator has reset the alarm with a reset command. The state of the alarms shall be shown in the alarm list (Unacknowledged and persistent, Unacknowledged and cleared, Acknowledged and persistent).

Filters for selection of a certain type or group of alarms shall be available as for events.

**8) Object Picture**

When selecting an object such as a circuit breaker, disconnector, earthing switch, on-load tap changer etc. in the single-line diagram graphic, and the associated bay picture shall be presented first. In the selected object picture, all attributes like

- Type of blocking
- Authority
- Bay Mimic control
- Errors etc., shall be displayed



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**9) Control Dialogues**

The operator shall give commands to the system by means of mouse click located on the single-line diagram graphic. Data entry is performed with the keyboard. Dedicated control dialogues for controlling at least the following devices shall be available:

- Breaker, disconnector and earthing switch
- Transformer tap-changer

**10) User-Authority Levels**

It shall be possible to restrict activation of the process graphics of each object (bays, apparatus) within a certain user authorization group. Each user shall then be given access rights to each group of objects, e.g.:

- Display only
- Normal operation (e.g. open/close of switchgear)
- Restricted operation (e.g. by-passed interlocking)
- System administrator

For maintenance and engineering purposes, the following authorization levels shall be available at the Engineering Workstation:

- No engineering allowed
- Engineering/configuration allowed
- Entire system management allowed

The access rights shall be defined by passwords assigned during the log-in procedure. Only the system administrator shall be able to add/remove users and change access rights.

**11) Reports**

The reports shall provide time-related follow-ups of measured and calculated values. The data displayed shall comprise:

**i) Trend reports:**

- Day (mean, peak)
- Month (mean, peak)
- Semi-annual (mean, peak)
- Year (mean, peak)

**ii) Historical reports of selected analogue values:**

- Day (at 15 minutes interval)
- Week
- Month
- Year

It shall be possible to select displayed values from the database in the process display on-line. Scrolling between e.g., days shall be possible. It shall be possible to select the time period for which the specific data are kept in the memory.



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Following printouts shall be available from the printer and shall be printed on demand:

- Daily voltage and frequency curves depicting time on X-axis and the appropriate parameters on the Y-axis. The time duration of the curve is 24 hours.
- Weekly trend curves for real and derived analogue values.
- Printouts of the maximum and minimum values and frequency of occurrence and duration of maximum and minimum values for each analogue parameter for each circuit in 24 hr. period.
- Provision shall be made for logging information about switchgear (breaker, disconnector and earthing switch etc.) status like number of operations with date and time indications along with the current value it interrupts (in both conditions i.e., manual opening and fault tripping)
- Equipment operation details shift wise and during 24 hours.
- Printout on adjustable time period as well as on demand for MW, MVAR, Current, Voltage on each feeder and transformer as well as Tap Positions, temperature and status of pumps and fans for transformers.
- Printout on adjustable time period as well as on demand system frequency and average frequency.

Format of all the Reports shall be acceptable to the Employer.

**12) Trend Display (Historical Data)**

It shall be possible to illustrate all types of process data as trends–input and output data, binary and analogue data. The trends shall be displayed in graphical form as column or curve diagrams with a maximum of 10 trends per screen. Adjustable time span and scaling ranges shall be provided. It shall be possible to change the type of value logging (direct, mean, sum, or difference) on-line in the window. It shall also be possible to change the update intervals on-line in the graphic display as well as the selection of threshold values for alarming purposes.

### 6.13.3.4 NPCC / Regional Control Center (RCC) Gateway

The SAS shall have the capability to support simultaneous communications with remote NPCC/ RCC for which it shall have two ports.

The communication interface shall allow scanning and control of defined points within the SAS. The SAS shall simultaneously respond to independent scans and commands from remote centre. The Gateway shall use industrial grade hardware and IEC 60870-5-101/104 protocol for communication with remote centre.

The gateway shall be able to send to the remote NPCC/RCC centre:

- Single point indication with time
- Double point indication with time
- Transformer tap-position with time
- Measurement value with time
- Integrated total (counters)
- Disturbance record files

The gateway shall be able to receive from NPCC/ RCC:

- Single control, either direct or as a select / execute sequence



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- Double control, either direct or as a select / execute sequence
- Clock synchronization
- Counter freeze

For further details, refer to section on SCADA in “Telecommunication and SCADA System”.

#### 6.13.3.5 System Hardware

The Contractor shall provide redundant operator workstation/HMI in hot-standby mode. The servers used in these workstations shall be of industrial grade. It shall be capable to perform all functions for entire substation including future requirements as indicated in the Single Line Diagram. It shall use industrial grade components. Processor and RAM shall be selected in such a manner that during normal operation not more than 30% capacity of processing and memory are used. Supplier shall demonstrate these features. The capacity of hard disk shall be selected such that the following requirement should occupy less than 50% of disk space:

- Storage of all analogue data (at 15 minutes interval) and digital data including alarm, event and trend data for thirty (30) days,
- Storage of all necessary software,
- 1TB space for Employer’s use.

Supplier shall demonstrate that the capacity of hard disk is sufficient to meet the above requirement.

**a) Operator Workstation Visual Display Units (VDUs)**

The VDU shall show overview diagrams (Single Line Diagrams) of the switchgear with a color display. All event and alarm annunciation shall be selectable in the form of lists. Operation shall be by a user-friendly function keyboard and a cursor positioning device. The user interface shall be based on WINDOWS concepts with graphics and facility for panning, scrolling, zooming etc.

The display units shall have high resolution and reflection protected graphics screen. High stability of the picture geometry shall be ensured. The screen shall be at least 27" diagonally in size and capable of color graphic displays. The display shall accommodate resolution of 1920 x 1280 pixels.

**b) Printer**

It shall be robust and suitable for operation with a minimum of 220 characters per line. The printing operation shall be quiet with a noise level of less than 45dB suitable for location in the Attabad Lake HPP substation control room. Printer shall accept and print all ASCII characters.

The printer shall have in-built testing facility. Failure of the printer shall be indicated in the operator workstation. The printer shall have an off-line mode selector switch to enable safe maintenance. The maintenance should be simple with provisions for ease of change of print head, ribbon changing, paper insertion etc.

All reports and graphics prints shall be printed on laser printer. One dot matrix printer shall be exclusively used for hourly log printing. All printers shall be continuously online.

**c) Mass storage unit**

The mass storage unit shall be built-in into the operator workstation. All operational measured values and indications shall be stored in a mass-storage unit in form of DVD RW. The unit



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should support at least Read (48X), Write (24X), and Re-Write (10X) operations, with Multi-Session capability. It should support formatting and use under the operating system provided for operator workstation. The monthly back-up of data shall be taken on disc. The facility of back-up of data shall be inherent in the software.

**d) Substation LAN**

Redundant substation LANs shall provide the principal means for data exchange among station components at the substation. Each LAN shall consist of Ethernet or Fiber network segments, switches and TCP/IP communications software.

**e) Bay Level Unit**

The bay level unit shall be of industrial grade. The unit, based on microprocessor technology, shall use numerical techniques for the calculation and evaluation of externally input analogue signals. They shall incorporate select-before-operate control principles as safety measures for operation via the operator workstation. They shall perform all bay related functions, such as control commands, bay interlocking, data acquisition, data storage, event and disturbance recording and shall provide inputs for status indication and outputs for commands. They shall be connected to the switchgear via transducers. The BCU shall acquire and process all data from the substation components (equipment status, fault indications, measured values, protection/alarm signals etc.) and not only display these on the associated operator workstation but also transmit them to NPCC/ RCC via redundant DPLC and Fiber Optic links. In addition, this shall receive the operation commands from operator workstation. The BCU shall have the capability to store all the data for at least 24 hours. **Each BCU of 132kV substation bays shall cater for one (01) circuit breaker at 132kV level and their associated disconnectors, line disconnectors, earthing switches and instrument transformers and reactors, as applicable.** The BCU shall be equipped with analogue and binary inputs/outputs for handling the control, status monitoring and analogue measurement functions. All bay level interlocks shall be hardwired and shall be implemented to the maximum extent possible in the Bay Control Cubicles so as to permit control from the bay mimic panel, with all bay interlocks in place, during maintenance and commissioning or in case of contingencies when the Station HMI is out of service.

The BCU along with the SCADA Interface Cabinet (SIC) shall be installed in the control room of Attabad Lake HPP substation control building.

The BCU shall meet the requirements for withstanding electromagnetic interference. Failure of any single component within the equipment shall neither cause unwanted operation nor lead to a complete system breakdown.

The I/O modules shall form a part of the BCU and shall provide coupling to the substation equipment. The I/O modules shall acquire all switchgear information (i.e., data coming directly from the switchgear or from switchgear interlocking devices) and transmit commands for operation of the switchgear. The measured values of voltage and current shall be from the secondary of instrument transformers.

Field connection circuits for I/O points, communications, and power require special consideration to protect equipment against damage and to protect I/O processes against corrupting influences. This is important for maintaining reliability and operational integrity. These issues are addressed by three standards listed under the Specific Relevant Standards clause: IEEE C37.1-1994, IEC 60870-2-1, and IEC 60870-2-2. System and circuit design related to field connection circuits shall comply with these standards. Where they overlap, the more stringent clause shall prevail.



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The BCU shall meet the requirements for withstanding electromagnetic interference according to relevant provisions of IEC 61850. All IEDs including BCUs shall have parallel redundant Ethernet two (02) nos. multimode fibre optic ports + multimode IRIG-B compliant with IEC-61850 to facilitate data communication. Failure of any single component within the equipment shall neither cause unwanted operation nor lead to a complete system breakdown.

In summary, I/O interfaces shall provide high integrity for the detection and measurement of acquired signals. They shall also prevent damage, maintain safe conditions for personnel, and prevent bad data caused by the secondary effects of lightning, operation of power switchgear, abnormal electrical power behaviour, and so on. Under no circumstances shall these effects cause an unintended control action.

Bay Control Unit shall provide at least two serial data server port for gathering I/O data from other sources within the station or from satellite facilities.

**f) Extendibility in future**

The SAS shall be suitable for extension in future for additional bays. During such requirement, all the drawings and configurations, alarm/event list etc. displayed shall be designed in such a manner that its extension shall be easily performed by the Employer. During such event, normal operation of the existing parts/systems of substation shall be unaffected and system shall not require a shutdown. The contractor shall provide all necessary software tools along with source codes to perform addition of bays in future and complete integration with SAS by the Employer. These software tools shall be able to configure BCUs, add additional analogue variable, alarm list, event list, and modify interlocking logics etc. for additional bays/equipment which shall be added in future.

### 6.13.3.6 Software Structure

The software package shall be structured according to the SAS architecture and strictly divided in various levels. Necessary firewall shall be provided at suitable points in software to protect the system. An extension of the station shall be possible with lowest possible efforts. Maintenance, modification or an extension of components of any feeder may not force a shut-down of the parts of the system which are not affected by the system adaptation.

The Contractor shall provide each software in two copies in DVD to load into the system.

**a) Station Level Software**

**1. Human-machine interface (HMI)**

The base HMI software package for the Operator Workstation shall include the main SAS functions and it shall be independent of Project specific hardware version and operating system.

The software for Engineering Workstation shall include tools for graphics editing, engineering and system configuration. The system shall be easy to use, to maintain, and to adapt according to specific user requirements. Systems shall contain a library with standard functions and applications. The fault/ disturbance analysis and evaluation software shall also be included as part of Engineering Workstation.

IEC 61850-based configuration control, using the SCL tools shall be provided by the contractor for off-line operation.



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## 2. Network Management System (NMS):

The Contractor shall provide network management system (NMS) software for following management functions:

(a) Configuration Management
(b) Fault Management
(c) Performance Monitoring

This system shall be used for management of communication devices and other IEDs in the system. This NMS can be loaded in Engineering Workstation and shall be easy to use, user friendly and menu based. The NMS shall monitor all the devices in the SAS and report if there is any fault in the monitored devices. The NMS shall:

(a) Maintain performance, resource usage, and error statistics for all managed links and devices and present this information via displays, periodic reports and on demand reports.
(b) Maintain a graphical display of SAS connectivity and device status.
(c) Issue alarms when error conditions occur
(d) Provide facility to add and delete addresses and links

## 3. Disturbance & Fault and Events Recording Software:

The software shall be supplied to allow access to the disturbance and events recording functions via Engineering Workstation. The software shall as a minimum include the following features

- Event recording
- Trending
- Continuous oscillography
- Continuous monitoring of frequency, phase and RMS/peak parameter value
- Time tagging of discrete events
- Display events in the order of occurrence
- Configurations including input and editing of event identification text/ messages.

Software shall be compliant with IEEE standard C37.111. It shall adhere to a common format for data files and an exchange medium used for the interchange of various types of fault, test, or simulation data for electrical power systems. The sources of transient data such as digital protective relays, the sampling rates, filters, and sample rate conversions for the transient data being exchanged shall be as per COMTRADE. (Common Format for Transient Data).

## 4. Central Control Unit Multiple Roles:

The central control units shall have multiple roles described below:

**Principal Station Client:** The Central Control Unit being the principal station client shall be responsible for collecting and maintaining the various data and files that comprise the station information base. BCUs, Bay Protection Units, and other IEDs are expected to report a large amount of their data through use of IEC 61850 report services. The central control units will need to poll for any remaining data, using IEC 61850 services, or calculate it from other available data, using local automation applications.



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**5. Local Repository / Compatibility with IEC 61850:**

The central control units provide a Local Repository for the storage of station data. This is directly related to its role as principal station client. The information stored in the Repository shall include real-time data and closely related support data (e.g. operational parameters, configuration parameters, text-based descriptions), as provided by the IEC 61850 information models. Repository data may include diagnostic and maintenance data if it is included in the IEC 61850 information models. IEC 61850 provides information models for most of the available system data, and those models can be extended to include new components. The results produced by automation application functions shall be stored in the Repository if other clients subscribe them. The Local Repository shall have interfaces that are interoperable with all other system devices (i.e. servers and clients) using IEC 61850 communication services, information models, and object references. The central control units shall implement all of IEC 61850's ASCI service models. The Repository shall be maintained in a replaceable flash memory module. Battery power is an unacceptable approach to maintaining non-volatile data memory.

**6. Proxy Server:**

The central control units play both client and server roles in the station system. They act as a client to populate the Repository with data from other server IEDs (e.g. Bay Control Units). In turn, they act as a 'proxy' server by satisfying client requests with data directly from the Repository. They shall prevent access contention and congestion that may potentially disrupt the operation of field IEDs, simplify access mechanisms, and provide accountability (i.e. an audit trail) for past operations.

**7. Control Command Processing**:

The central control units are responsible for coordinating the execution of all control commands initiated by system clients. This shall ensure that the Local Repository and system logs are kept up to date for system clients.

Only one control command at a time shall be executed. All attempted control operations, whether successful or not, shall be entered into the Command Log. IEC 61850 enables all control operations to be tracked to the initiating party; this information shall be made part of each Command Log entry.

**b) Bay Level Software**

**1. System software**

The system software shall be structured in various levels. This software shall be placed in a non-volatile memory. The lowest level shall assure system performance and contain basic functions, which shall not be accessible by the application and maintenance engineer for modifications. The system shall support the generation of typical control macros and a process database for user specific data storage. In case of restoration of links after failure, the software along with hardware shall be capable of automatically synchronizing with the remaining system without any manual interface. This shall be demonstrated by the Contractor during integrated system test.

**2. Application software**

In order to ensure robust quality and reliable software functions, the main part of the application software shall consist of standard software modules built as functional block elements. The functional blocks shall be documented and thoroughly tested. They form part



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of a library. The application software within the control/protection devices shall be programmed in a functional block language.

### 3. IEC 61850 Support

Bay Control Units and Bay Protection Units shall represent all data as IEC 61850 object references, using Logical Nodes and Common Data Classes that are appropriate to the specific data sources.

Parallel Redundancy Protocol (PRP) shall be followed in compliance with IEC 62439-3 Standard for Industrial Communication Networks. PRP and High Availability Seamless Redundancy (HSR) is required to achieve zero/seamless switchover time, avoid loss of frames, seamless failover against failure of any component, zero time recovery and provision to check redundancy continuously in order to avoid failures. Moreover, all the protection relays, Bay Control Units (BCUs) and IEDs etc. shall be compatible with PRP in compliance to IEC 62439-3.

Simple Network Time Protocol (PTP) interface for GPS time synchronization shall be provided in order to achieve network clock synchronization accuracy in the sub-microsecond range. Moreover, all the relays, bay control units (BCU) and intelligent devices (IEDs) etc. shall be compatible with SNTP.

All of IEC61850's ACSI service models shall be implemented and ready for use. In particular, it is expected that Bay Control Units and Bay Protection Units will use Report Control Blocks to send data subscribed by central control units and Operator Interface [HMI]. Report Control Blocks will be absolutely necessary for the transmittal of SOE data. Operator Interface [HMI] will exchange data with IEDs only for maintenance, equipment mode control, and diagnostic purposes.

Bay Control Units and Bay Protection Units shall need to transmit and receive GOOSE messages in support of the heartbeat application

Each data component shall be accompanied by its associated data quality, as defined by the IEC 61850 Common Data Classes. All constituent bits of data quality shall be used and supported (as appropriate) by the Bay Control Units and Bay Protection Units.

Each BCU and Bay Protection Unit shall provide an IED Capabilities Description (ICD) file that describes the IEC 61850 information models, service models, and related communications capabilities supported by the device. It shall also fully support the SCL process described under the heading titled System Configuration. As the result of that process, a downloadable CID file shall be created for each BCU.

Bay Control Units and Bay Protection Units ports shall support IEC 61850 object references in the object base.

Bay Control Units, Bay Protection Units, and other IEDs are expected to report a large amount of their data through use of IEC 61850 report services. The central control units will need to poll for any remaining data, using IEC 61850 services, or calculate it from other available data, using local automation applications. Data shall be acquired and stored according to the System Performance Requirements.

The BCUs and Protection Relays shall have been submitted/passed a test to certificate compliance with the IEC 61850 part 10 Conformance Testing such as the following:

- Basic Exchange



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- Data Set Definition
- Unbuffered Report
- GOOSE Publish
- GOOSE Subscribe
- Time Synchronization
- File Transfer

The tests to certificate compliance with IEC 61850 Part 10 have to be certified by international accredited testing laboratories which are independent of the Proposer and Supplier.

#### 6.13.3.7 System Performance

The key performance requirements to be met for the SAS are:

- The Sequence of events shall have 1 ms resolution
- Each graphic screen shall be completely generated (and all data fields filled in with current data) within 1 second from the time it is called.
- All active data on a screen shall be updated at least once every second
- The total time from the instant an open/close command is executed and the instant when verification of its execution at the breaker is indicated on the graphic display shall not exceed 1.5 seconds.
- The time period between the operator entering an open/close command and the breaker closing/opening shall not exceed 1 second.
- The change of status of any event shall be indicated on the appropriate display within a maximum of 1 second of its occurrence.
- Peer-to peer data-exchange through IEC 61850 protocol shall be less than 30ms, i.e., between the changing input on one bay and an output execution on any other bay
- Measurement accuracy for EHV / HV bays shall be 0.2% for RMS current and voltage values up to 15% and 0.5% harmonic for active and reactive powers. For MV feeder the accuracy of the RMS current shall be 0.5%

#### 6.13.3.8 Reliability and Availability

The SAS shall be designed so that the failure of any single component, processor, or device shall not render the system unavailable. The SAS shall be designed to satisfy the very high demands for reliability and availability concerning:

- Mechanical and electrical design
- Security against electrical interference (EMI)
- High quality components and boards
- Modular, well-tested hardware
- Thoroughly developed and tested modular software
- Easy-to-understand programming language for application programming
- Detailed graphical documentation and application software
- Built-in supervision and diagnostic functions
- Security
  - Experience of security requirements
  - Process know-how
  - Select before execute at operation
  - Process status representation as double indications



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- Distributed solution
- Back-up functions
- Panel design appropriate for the harsh electrical environment and ambient conditions
- Panel grounding immune against transient ground potential rise

The SAS shall provide a high MTBF (mean time between failures) and a low MTTR (mean time to repair) rate, the values to be indicated by the Proposer. The Proposer shall clearly define how the offered architecture meets the availability requirements. A system block diagram shall therefore be submitted with the offer.

#### 6.13.3.9 Power Supply

The 110VDC, 230VAC Normal and 230VAC Essential power supplies for various panels and equipment of the SAS shall be taken from the respective boards as follows:

**a) DC power supply**

Two 110VDC feeders, one each from buses A and B of the 110VDC Distribution Board shall be taken for the SAS. Internal distribution to various BCUs and other equipment shall also be Contractor's responsibility for which DC distribution sub panel(s), cabling, DC/DC Converters shall be supplied.

Two 110VDC feeders, one each from the buses A and B of the 110 VDC Distribution Board shall be taken for each Bay Control Cubicle located in the bays within substations.

Two 110VDC feeders, one each from the buses A and B of the 110VDC Distribution Board shall be used for each Bay Mimic Panel to be provided as part of SAS and located adjacent to the respective BCU compartment.

**b) 230VAC essential power supply**

Two 230VAC feeders from the Essential Distribution Board fed from the Inverters and Essential AC Sub-distribution Board shall be taken for the SAS. Internal distribution to various equipment such as Operator Workstation, Printers, and other equipment of the SAS requiring 230VAC supply shall be provided for which distribution sub panel(s), cabling etc. shall be supplied.

**c) 230VAC power supply**

230VAC supplies for heating and lighting within the Bay Control Cubicles, BCUs and other panels of the SAS shall be supplied from AC Station Service System.

#### 6.13.3.10 Bay Controller Unit (BCU) Panels

Each BCU and Bay Mimic (BM) and their associated wiring and terminal blocks (SIC) shall be installed in either separate panels or in one panel divided in two compartment, one each for BCU and BM. The dimensions and appearance of the two panels shall be the same.

The Panels shall be vertical, indoor type, free standing with rear access, suitable for floor mounting and shall provide for bottom entry of cables via vermin proof plate. The panels design shall conform to IEC 60529, protection class IP51. Each Panel shall be constructed of sheet steel not less than 2.5mm unless otherwise approved by the Employer. The panels shall have a front Plexiglas door closed by key and a swing frame. There shall be unobstructed direct access to any component.

The panels shall remain rigid and retain their structural integrity under all operating and services conditions with and without the doors closed. The panels shall be grounded with



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16mm² conductors. The BCU shall be housed in 19" rack. The panels shall be equipped with hygro-statically and thermostatically controlled anti-condensation heaters.

All panels shall have door operated strip light for interior illumination. Three pin single phase, 230V AC receptacles shall be provided in each panel. There shall be separate MCBs for lighting and power receptacles. MCBs shall be equipped with normally closed contact for alarm

The arrangement and mounting of all indicating devices, control switches, relays and other equipment in the BCU and SIC panels and exterior finish and color shall be subject to the approval of the Employer.

The synchronism-check relays and voltage detecting relays shall also be provided for the manual closing of the breaker and for the remote closing by the remote supervisory system.

#### 6.13.3.11 Disturbance and Fault Recording and Sequence of Event Recording Functions

**a) Disturbance and fault recording functions**

The software shall be supplied to allow access to the disturbance and events recording functions via Engineering Workstation. The software shall as a minimum include the following features:

- Event recording
- Trending
- Continuous oscillography
- Continuous monitoring of frequency, phase and RMS/peak parameter value
- Time tagging of discrete events
- Display events in the order of occurrence
- Configurations including input and editing of event identification text/messages.

Software shall be compliant with IEEE standard C37.111. It shall adhere to a common format for data files and an exchange medium used for the interchange of various types of faults, test, or simulation data for electrical power systems. The sources of transient data such as digital protective relays, the sampling rates, filters, and sample rate conversions for the transient data being exchanged shall be as per COMTRADE (Common Format for Transient Data)

System shall have a disturbance recording function with a minimum of 10 seconds recording time for at least ten (10) disturbances and shall provide the user with time-tagged disturbance records. The pre-fault and fault currents and voltages shall be recorded for each disturbance and be made available for further evaluation purposes.

The substation monitoring system shall provide all relevant information for fault-finding, analysis, and troubleshooting. Suitable and user-friendly fault evaluation software shall be included in the scope of supply, providing short fault summaries and automatic printouts of the fault history and fault location. These functions should be available at the Engineering Workstation.

The broad category of disturbance recording functions shall include:

- Recording and display of Transient Fault Records (Oscillography)
- Recording and display of Sequence of Event Records
- Recording and display of Disturbances (Triggered Data Logs).



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The disturbance recording shall be based on acquiring inputs across the substation. Station Operators shall be able to use this to retrieve and archive operational data (currents, voltages and frequency) acquired from substation appurtenances including relays, transformers and other equipment to help analyse the system, identify potential equipment failures for preventative maintenance planning. At the least, the following substation parameters shall be monitored and recorded:

- Frequency and waveforms including magnitude of power swings and amplitude surges for the three voltages and four currents as well as neutral current of each autotransformer and shunt reactor before and during the fault
- The operation of protection relays, trip relays and status of each circuit breaker

The disturbance recording function shall be able to establish and display the chronological correlation between occurrence of faults and operation of protective relays and opening of circuit breaker (s).

**b) Sequence of events recording functions**

BCU should contain an event recording function capable of storing at least 512 time-tagged events extendable up to 1000 events. Events shall be generated either by the switchgear, by the control and protection devices, or by the station level unit. They shall be recorded in an event list in the station HMI. All, or a freely selectable group of events, shall also be printed out on an event printer.

The event list shall contain events that are important for the control and monitoring of the substation. The time has to be displayed for each event. The operator shall be able to call up the chronological event list on the monitor at any time for the whole substation or sections of it.

A printout of each display shall be possible on the hard copy printer.

The events shall be registered in a chronological event list in which the type of event and its time of occurrence are specified. The information shall be obtainable also from a printed event log.

The chronological event list shall contain:

- Position changes of circuit breakers, disconnectors and earthing devices.
- Indication of protective relay operations
- Fault signals from the switchgear
- Indication when analogue measured values outside upper and lower limits
- Loss of communication.

Filters for selection of a certain type or group of events shall be available. The filters shall be designed to enable viewing of events grouped per:

- Date and time
- Bay
- Device
- Function

The sequence of events recording function shall include the following capabilities:

- Perform events sorting and search (multiple-criteria) by specific signals, priority levels, alarm class as well as current status



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- Ability to sort and search data by specifying date/time range (Start date/time - End date/time).
- Ability to import/export data for use with standard Microsoft applications for further manipulation or presentation.
- Ability to maintain an Alarm Summary Record that provides listing of all Current Alarms.
- Stations point description Database shall be capable of import/export from a Microsoft Excel format file.

The software shall be supplied to allow access to the disturbance and events recording functions via Engineering Workstation as described under Station level Software.

#### 6.13.3.12 Alarm Annunciations

Alarms shall be generated either by the switchgear, by the control and relay panels, or by the BCU. Alarms shall be recorded in a separate alarm list and appear on the screen. All, or a freely selectable group of alarms, shall also be printed out on an event printer. Faults and errors occurring in the substation shall be listed in an alarm list. The alarm list shall substitute a conventional alarm tableau, and shall constitute an evaluation of all station alarms. It shall contain unacknowledged alarms and persisting faults. The date and time of occurrence shall be indicated.

The alarm list shall consist of a summary display of the present alarm situation. Each alarm shall be reported on one line that contains:

- Date and time of the alarm
- Name of the alarming object
- Descriptive text
- Acknowledgement state.

The operator shall be able to acknowledge alarms, which shall be audible and displayed on Operator's Workstation. Acknowledged alarms shall be marked in the list.

Filters for selection of a certain type or group of alarms shall be available as for events.

Minimum number of alarms required for each function has been listed below. The final alarm list shall however be subject to approval of the Employer:

**A) Circuit breaker**

1) Circuit breaker trip
2) Trip circuit faulty/DC failure
3) AC supply fail
4) DC supply fail
5) Control supply fail

**B) Breaker Failure Protection**

6) Bus breaker failure protection trip
7) DC supply off
8) AC supply off



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**C) Line Protection**

9) Distance protection pick-up
10) Distance protection red phase trip
11) Distance protection yellow phase trip
12) Distance protection blue phase trip
13) PLC faulty
14) CCVT MCB trip
15) Line over current and earth fault protection trip
16) Auto reclosure out of order
17) Over voltage protection trip

**D) Transformer Protection**

18) Differential protection operated.
19) Transformer overall protection operated.
20) Overcurrent protection operated.
21) Neutral overcurrent protection operated (auto-transformers).
22) REF protection operated (auto-transformers).
23) Overload protection operated (auto-transformers).
24) Tertiary protection operated (auto-transformers).
25) Over flux/overvoltage protection operated (auto-transformers).

**E) Busbar Protection**

1) Busbar protection trip
2) Busbar CT open

**F) Common Alarms**

1) Annunciator supply fail
2) Control board DC MCB trip
3) Control board AC MCB trip
4) Metering board AC supply fail
5) 110V DC distribution incoming
6) AC distribution incoming
7) Earth fault DC system
8) 110V Battery discharged
9) Protection Panel AC MCB Trip
10) AC distribution incoming fail
11) Telecom equipment failure

10% spare annunciator windows shall be provided for future alarms

The standard legends for annunciations shall be as required below by the use of the following colors:

For trip -- red
For alarm -- amber
For indication -- white

The lamp test facilities shall also be provided to check the lamp failure.



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### 6.13.4 Construction

#### 6.13.4.1 General

The Panels shall be of the vertical type of construction as defined in relevant IEC Standards.

The Panels shall be fabricated from sheet steel not less than MSG 2.5mm thick seam welded at corners and ground smooth. However, in case of type tested rigid frame design, the thickness of the steel sheets may be reduced according to manufacturer's standard design. The panels shall have front door with glass window.

Panels shall be bolted at the bottom to suitable steel channel sills with which necessary framing shall form a self-supporting dead-front type of structure. Suitable grouting and anchor bolt holes shall be provided in the channel sills.

All screws and bolts used for assembling panels shall be provided with lock washers or other locking devices.

Flat surfaces on the face of any panel shall not deviate more than 1.5mm from a true plane. To prevent warping of panels, all heavy devices shall be adequately supported by means of rear mounted brackets or straps. The panels trim doors and frames shall match and shall present a neat appearance when assembled. Electrical clearance shall conform to the applicable standards and shall be provided without cutting away to adjacent steel frame-work. The Panels shall be adequately ventilated.

The Panels shall have fixed panels on the front and hinged doors on the rear.

#### 6.13.4.2 Equipment Arrangement and Device Marking

The arrangement of equipment and the design of panels shall be such that adequate space is provided for inspection and maintenance of wiring, terminals and equipment. Equipment on the rear of the panels shall be accessible without removing any device.

The name and IEC standard device number shall be marked on the rear of the panels near the corresponding device. Wire numbers of wires connected to each stud of each device shall also be marked near the stud, on the device case or on the rear of the panel. Terminal markings shall not be obstructed by wires. Each terminal designation shall be printed legibly with permanent marking fluid that shall form a contrast with the panel finish. Each stud terminal of the device shall be marked with a permanent identifying character.

The installation of equipment shall start from the top of the panels, such that any unused areas shall be at the bottom of the panel. Any unused areas of panels shall be kept free of wiring to permit the installation of possible future components. No equipment shall be mounted less than 300mm above the floor.

#### 6.13.4.3 Door Hardware

The hinges for all panels' doors shall be of the fully concealed type and shall allow the doors to swing through not less than 120° from the closed position.

Stops or restraining chains shall be provided where required. Each door shall be provided with a handle and a three-point latch with lock.

#### 6.13.4.4 Lighting and Receptacles

Fluorescent lamp fixtures shall be provided in panels for interior lighting. A door operated switch shall be provided with each door. A three pin single phase, 230V AC service



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receptacles shall be provided in each panel. The lighting and receptacle circuits shall be completely wired in conduits and terminated in suitable junction boxes near one end of the panels, with provision for future extension.

#### 6.13.4.5 Grounding

A ground bus of copper bar not less than 7mm by 25mm shall be provided along the back of panels. The ground buses shall be bolted to the frame of each panel in such a way as to make good electrical contact with the panel. Solder less type connectors shall be provided at both ends of board for connection of the panel ground buses to 95mm$^2$cable.

#### 6.13.4.6 Finish

All metal surfaces shall be painted with one coat of metal primer and two coats of finishing paint. The interior finish of all panels shall be matt white. A quart of paint shall be supplied for "on-site" touch up work.

#### 6.13.4.7 Wiring

##### 6.13.4.7.1 Component Wiring

All internal wiring shall be made in accordance with IEC Standards, with annealed copper conductor, thermoplastic insulated with an overall flame-retardant insulation. Wiring for current transformer circuits shall not be smaller than 2.5mm$^2$. Wiring associated with potential transformer and protection circuit shall be done with 2.5mm$^2$ wire. Wiring associated with electronic circuitry shall not be less than 1.5mm$^2$.

The Proposer shall check the voltage drop before finalizing the size of all internal CT/PT and Electronic Circuitry Wires.

Wiring between terminals of various devices shall be point to point (no splicing or 'T' connection shall be allowed). All internal wiring shall be neatly truncated in wiring troughs bound and anchored. Sufficient slack shall be left at component terminals to permit rearrangement of connections between the terminals of any particular component. Wiring troughs shall terminate not lower than 300mm above the floor of the panels.

Groups of exposed wires shall be run straight, horizontally or vertically with short radius right angle bends. Each wire shall be properly protected where it leaves a channel or duct.

Outgoing wiring shall be connected to terminal blocks suitable for connection to multi-conductor twisted pair cables. Generally, one wire but not more than two wires shall be connected to any device terminal or terminal block.

All wires shall be identified at both ends according to the wiring diagrams.

Wherever wiring is routed to components which are not installed at the time of manufacture, sufficient length of wire shall be provided to ensure that any wire can be terminated on any point of the component.

##### 6.13.4.7.2 Terminal Blocks and Terminals

Terminal blocks shall be designed according to adequate rating requirements and IEC Standards.

Terminal blocks shall be arranged with sufficient room for each connection of incoming cables. Parallel rows of terminal blocks shall be spaced at least 200mm apart.

Blocks shall be mounted in vertical columns along the sides of cubicles or on vertical panels specially provided for terminal blocks. Not less than 25% spare terminals shall be provided on each block or group of blocks.

Cabling for indicating instruments using transducers outputs shall be by means of individually shielded wires and one (1) extra stud shall be provided per pair of terminals for grounding of the shield.

Provisions shall be made to terminate and ground the overall copper shields of all incoming cables.

White marking strips shall be provided for circuit designation. Each connected terminal of each block shall have the circuit designation or wire number printed on the marking strip with permanent contrasting marking fluid. Marking strip shall be strong enough to last up to life of equipment and marking shall not fade. Spare marking strips shall be furnished with each block.

#### 6.13.4.7.3 Test Blocks

Test blocks and test plugs shall be provided for testing instruments and protective devices, while in service, without causing any undesired tripping.

The test blocks shall be of the back connected, semi flush mounted, switchboard type with removable covers.

All test blocks shall be provided with suitable circuit identification. The cases shall be dust tight and shall have a black finish.

Test blocks shall be rated not less than 250V, 10A and shall be capable of withstanding a dielectric test of 1500V, 50 Hz for one minute.

All test blocks shall be arranged to isolate completely the instruments from the instrument transformers and other external circuits so that no other device will be affected, and means shall be provided for testing either from an external source of energy or from the instrument transformers by means of multi pole test plugs.

#### 6.13.4.7.4 Miniature Circuit Breakers (MCBs)

All MCBs shall be provided with auxiliary contacts wired to annunciation system to indicate breaker tripping. The breaker shall be designed for continuous duty and shall carry the rated current continuously without exceeding the specified temperature rise.

### 6.13.5 Bay Mimic Panel Devices

#### 6.13.5.1 General

The Bay Mimic (BM) Panels or compartments in BCU panels shall contain all the equipment necessary to control and monitor the working of the respective substation bay. Provision shall be made for future extension. All components of the BM panel/compartment shall be suitable for continuous operation at 110V DC in the range of +10%and-15%.

The front of BM panel/compartment shall contain but not be limited to the mimic diagram, control switches for circuit breakers, disconnectors and earthing switches and status indication lights. Synchronism-check selector switches shall also be provided.



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### 6.13.5.2 Mimic Buses and Equipment Symbols

Mimic buses and equipment symbols shall show the single line diagrams of the circuits. Mimic buses and symbols shall be made of anodized Aluminium or other non-ferrous metal finished in chip and stain- resistant colored lacquer.

### 6.13.5.3 Control and Instrument Switches

Contacts of all switches shall be self-aligning and shall operate with a wiping action.

Control switches shall be spring return to neutral or maintained contact type, and instrument switches shall be maintained contact type, both with handles. Compression springs shall not carry current. Synchronism-check switch and kirk key interlock switches shall be provided with removable keys.

All switches shall have 10A, 440V continuous rating and shall be capable of withstanding a life test of a least 10,000 operations with rated current flowing in the switch contact. The temperature rise at rated current should not exceed 30°C.

Control switches for circuit breaker, disconnectors and earthing switches shall be discrepancy type.

Each switch shall be clearly marked to show each operating position. Identification shall be engraved on separate name plates.

### 6.13.5.4 Indicating Lamp Assemblies

Indicating lamp assemblies shall be of the switch board type, rated for 1.5A, 110V DC with appropriate colored caps. Lamp shall be replaced from the front of the panels and any special tools required for lamp replacement shall be furnished.

Lamp test facilities shall be provided so that all indicating lamps on each panel can be tested simultaneously by operation of a common push button.

The lamp fittings shall allow adequate ventilation and shall not incorporate materials subject to deterioration under high ambient temperatures. The lamps shall be higher rated voltage and long life type.

### 6.13.5.5 Indicating instruments

**A) General**

All indicating instruments shall be transducer-fed unless otherwise specified. The instruments shall be designed, constructed, supplied and tested in accordance with latest edition of IEC Publication 60051 and the requirements listed herein. All instruments shall be tropicalized.

The analog type indicating instruments shall be flush mounted, dust-proof, switchboard type, having a removable transparent dust-tight window cover with a dull black finish. The instruments shall have 240° circular scale and accuracy of one percent of full scale value except frequency meter whose accuracy shall be 0.05Hz. The scale plates shall have permanent white finish with black graduations and numerals. The meter shall have scale appropriate for the CT/CVT to which they are connected. The true range of input signal shall be indicated on scale. The zero adjustment knob shall be provided.

For the multiple ratios CT, scale plate corresponding to each ratio shall be provided.



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AC instrument potential coils shall be designed for continuous operation at 1.2 times rated voltage and withstanding 2 times rated voltage for 10 minutes. AC instrument current coils shall be capable of continuous operation at 1.5 times rated current and withstanding 35 times rated current for one half second or 20 times the continuous additional rating of the coil for 3 seconds without damage to the coil.

**B) Ammeters and voltmeters**

The AC ammeters shall have full scale range corresponding to 150% of the rated current which is required to be measured.

The voltmeters shall have full scale values corresponding to 150% of the rated voltage which is required to be measured.

Separate ammeters shall be provided for each phase current. Single ammeter with phase selector switch will not be accepted. Ammeters for R and Y phases shall be of the analog type. Digital ammeter shall be provided for the Y-phase.

**C) Wattmeters and varmeters**

The Wattmeters and varmeters shall have a full scale range corresponding to about 125% of the rated power that will be required to measure. This rated power shall be based upon the rated primary current of the current transformers. The full scale range shall be chosen from the preferred values specified in relevant IEC Publication.

The Wattmeters and Varmeters shall have a centre zero scale. Power flowing into the bus shall be shown on the left hand side of the scale and this scale shall be marked "IN". Similarly, the power flowing out of the bus shall be shown on the right hand side and marked "OUT". The Varmeter shall show lagging VARs on left hand and leading VARs on right hand side. Each part of the scale shall be marked with the full range.

**D) Frequency meters**

Frequency meters shall be self- contained. Frequency meter shall be connected directly to the source without transducer. The instruments shall be of digital type with four digit display. The digit height shall be 2.5cm minimum. The frequency meter shall have accuracy of 0.05Hz.

**E) Transducers**

Transducer fed indicating instruments shall be used instead of simple analog meters for measurement of voltages, currents, frequency watts, and vars. Transducers shall convert secondary quantities from instrument transformers to proportional DC-milli ampere. The DC milli ampere generated shall be 10mA for rated input AC quantities. Transducer output for unidirectional quantities shall be 0/20mA and for bi-directional quantities shall be -10/0/10mA. Output shall be linear throughout the input.

The burden imposed on the instrument transformers shall not exceed 3VA per element. Transducers shall be powered from 110V DC supply. Transducers shall be of modern solid state design for maintenance free operation and protected against surge voltages on inputs and outputs. Accuracy shall be within 1%. Current, watt, and VAR transducers shall be capable of withstanding overcurrent of up to 40x normal rated current for not more than 1 second.

Screw or stud type barrier terminal blocks shall be provided for input side terminals and separate terminal blocks for the output circuits together with a means to ground the screen of the output cable and the transducer shall be provided.



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### 6.13.5.6 Panel Devices

The panels shall include, but not be limited to the equipment shown on Conceptual Drawings in given documents. Given in Volume-II Part-III of these Documents.

### 6.13.5.7 Watt-Hour and VAR-Hour Meters / Energy Boards

Energy meters shall be of digital design and shall fulfil the requirements laid down in IEC standard 60687 and other applicable IEC standards. The meters shall be flush mounted, back connected, switchboard type with built-in test facilities. The meter cases shall be dust-tight with removable covers and transparent windows. The meters shall be of protection Class IP54. They shall be suitable for connection to secondary of potential devices and secondary of current transformers.

The draw out feature shall permit the meters to be withdrawn from the cases without opening current transformer secondary circuits, disturbing service or requiring disconnection of leads or the voltage measuring circuit terminal with cubicle shall have opening facilities and current measuring circuit terminal shall have shorting facilities. The built- in test facilities shall permit the meters to be tested in place without requiring other switchboard mounted test devices.

Energy meter shall be capable of recording active and reactive energy imported and exported.

The meter shall have a test output device accessible from the front and capable of being monitored with suitable testing equipment. Energy meter shall be indelibly marked with a diagram of connections. The diagrams shall also show the phase sequence for which the meter in intended. Marking of the meter terminals shall appear on the drawing.

The relation between the test output and the indication in display shall comply with the marked meter constant on the name plate of the meter.

Watt-hour (Wh) and Volt-ampere-reactive hour (VARh)- meters shall be of accuracy class 0.2S. The meters shall have an electronic display with minimum retention time of four months. In case of multiple values presented by a single display it shall be possible to display the content of all relevant memories. When displaying the memories, the identification of each tariff applied shall be possible. The active tariff shall be indicated. The principal unit for the measured values shall be the kilowatt-hour (KWH) or the megawatt-hour (MWH).

Means of communication with the meter for programming, retrieval of data etc., shall be provided. The meters shall have password and telemetering facilities.

### 6.13.5.8 Outdoor Local Control Cubicles

#### 6.13.5.8.1 General

Each breaker will have marshalling kiosk/local control cubicle. Each local control cubicle shall have mimic pertaining to complete bay (it is intended for) or respective bay as applicable with control switches of circuit breakers, disconnectors/earthing switches, local/remote selector switches, ON/OFF push buttons all necessary relays, contactor, MCBs etc. The detail of mimic equipment to be installed in each cubicle is shown in Volume-II Part-III of Employer Requirements.

These panels shall be installed on foundations and so positioned that the face of the operator should be towards the equipment for which that cubicle is meant.



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#### 6.13.5.8.2 Construction

Each panel shall be duplex type i.e., it shall be accessible on both sides. Front side shall show mimic diagrams and control switches whereas the rear side shall contain terminal blocks. The cables shall be entered from the bottom of the panels. The panels shall be designed for protection class IP55.

The panels shall be fabricated from sheet steel not less than MSG 2.5 mm thick. However, in case of type tested rigid frame design, the thickness of steel sheets may be reduced, but not below 2mm, according to manufacturer's standard design. The paint on the outer surface shall withstand the temperature variations. It should be vermin proof, dustproof and waterproof.

#### 6.13.5.8.3 Lighting and Receptacles

Fluorescent lamps fixtures shall be provided in each outdoor local control cubicle, one on each side. These lamps shall be door-operated type.

A three pin single phase 230VAC service receptacle shall be provided in each cubicle. The lighting and receptacle circuits shall be completely wired.

Separate MCBs shall be provided in each panel for lighting and power sockets. MCBs shall have earth leakage device.

#### 6.13.5.8.4 Space Heaters

Each compartment of each cubicle shall be provided with space heaters of adequate sizes, controlled with thermostats and humidistats. These heating circuits shall be completely wired. Separate MCB shall be provided for the heating circuit. MCBs shall have sensitive earth fault protection for personnel safety.

#### 6.13.5.8.5 Sockets

Each outdoor local control cubicle shall be provided with telephone socket, completely wired and connected to closed circuit telephone system of the substation.

#### 6.13.5.8.6 Name Plates

Each item of equipment mounted on the panels shall be provided with an engraved name plate.

Name plates shall be made on laminated sheet plastic 1.6mm thick or of anodized aluminium 0.8mm thick engraved to provide white letters on a black background. Name plates forming a part of the mimic bus layout shall be of the same thickness as the mimic bus. The name plates shall be fastened to the panels at proper positions with black finished round head screws.

Samples of engraved nameplates shall be submitted for the approval of the Employer. Manufacturer's trademarks or nameplates shall be subject to approval and shall not be mounted on the front of any panel. A nameplate list and detail drawing shall be furnished to indicate the size of each type, number of characters per line and number of lines for each size.

### 6.13.6 Tests

All equipment furnished by the Contractor under the specifications shall be subjected to tests in the Shop in the presence of the Employer for conformity to the requirements of these specifications. The tests shall be in accordance with the applicable standards and include but not necessarily limited to the following:

a) Functional tests of all control circuits.



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b) Component wiring checks.
c) Mechanical tests.
d) Dielectric tests.
e) Other tests as specified herein

The test requirement for all equipment furnished shall be proved by certified test reports of actual tests performed previously on equipment of the same design. The test data shall be complete and clearly indicate the date of performance of the tests.

The SAS offered by the Proposer shall be subjected to following tests for 132kV Substation equipment installed in the outdoor substation and specified ambient conditions:

#### 6.13.6.1 Generic System Tests

The manufacturer shall, on demand, be able to show the tests plan and tests result executed on the system architecture similar to the one needed in the Project.

#### 6.13.6.2 Type Test Certificates and Reports

Type test certificates demonstrating successful results for the control devices and communication equipment shall be furnished at the time of Proposal submittal. Type test reports shall be submitted during detail design review stage for approval by the Employer.

#### 6.13.6.3 Factory Acceptance Tests

The supplier shall submit a test procedure for factory acceptance test (FAT) of the SAS for approval. For the individual bay level devices applicable type test certificates shall be submitted. The manufacturing and configuration phase of the SAS shall be concluded by the FAT. The purpose is to ensure that the Contractor has interpreted the specified requirements correctly. The general philosophy shall be to deliver a system to site only after it has been thoroughly tested and its specified performance has been verified, as far as site conditions can be simulated in a test lab. During FAT the entire SAS including complete control and protection system to be supplied under present scope shall be tested for complete functionality and configuration in factory itself. The extensive testing shall be carried out during FAT. The purpose of Factory Acceptance Testing is to ensure trouble free installation at site. No major configuration should be carried out at site. At least three (03) representative of the Employer/ Employer's representatives will inspect/witness the manufacturing and factory testing at manufacturer's shop for a period of approximately seven (07) days each trip.

### 6.13.7 Spares

All spare parts shall be new, strictly interchangeable with the parts by which they are intended to be replaced and shall conform to the relevant Specifications.

For each separate piece of equipment, the Contractor shall provide a spare parts book. This spare parts book shall contain an assembly drawing of the equipment which shall show all parts of the equipment marked and designated.

The spare parts shall be treated and packed for storage for a long time in the climatic conditions specified. Each spare part shall be clearly marked or labelled on the outside of its packing with its description and purpose. When more than one spare part is packed in a single case or container, a general description of its contents shall be shown on the outside of such case or container and detailed list enclosed.

The Contractor shall supply commissioning spares as necessary.



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The Contractor shall furnish a detailed list based on the list of mandatory spares with itemized prices at the time of submission of his Proposal. In addition to mandatory spares as listed below, the Proposer shall furnish a list of recommended spare parts with itemized prices for three years of substation operation

#### 6.13.7.1 List of Mandatory Spares

- Bay Controller Unit /BCU Modules
- Operator Workstation /Modules
- SCADA Gateway Cards/Modules/Routers
- GPS Mater Clock
- Monitors/VDUs
- Keyboard and mouse
- Laser Jet Printer
- Hardcopy Unit
- Hard disc drive
- Ethernet/LAN Switches
- Electrical power supply units /
- DC to DC Converters:
- Auxiliary and control relays
- Control and selector switches, etc.
- Indicating lamps

### 6.13.8 Drawings and Descriptive Data

#### 6.13.8.1 Proposal Drawings

- Complete filled-in Specific Facilities Data in the format included in Employer Requirements.
- Type test reports for the components and devices included in SAS
- Client's certificates and reference list of Projects on which the proposed SAS has been commissioned and operating satisfactorily.
- Block schematic showing the SAS configuration.
- Manufacturer's detailed technical description/brochures for each component and device included in the Substation Automation System.

#### 6.13.8.2 Approval Drawings / Documents

Complete panel wiring diagrams, overall schematics and technical data and manufacturers' detailed information on operation, testing, commissioning and maintenance of each component and device used in the SAS, shall be provided by the Contractor for review and approval of the Employer.

The following documents shall be submitted, as a minimum, for Employer approval during detailed engineering stage:



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- List of Drawings
- Block Diagrams
- System Architecture Drawing
- Hardware Specification
- Functional Design Document
- Clear procedure describing how to add Device/bay/diameter in future.
- Guaranteed technical parameters
- Guaranteed availability and reliability calculations
- Calculation for power supply sizing
- I/O Signal lists
- Cable schedule
- Schematic diagrams
- Interconnection and wiring diagrams
- List of equipment
- List of labels
- Logic diagram (hardware and software)
- Panel layout drawings
- Control room layout
- Test procedures/protocol for Factory Acceptance Test (FAT)
- Test procedures/protocol for Site Acceptance Test (SAT)
- List of spare parts.
- Product manuals
- Assembly drawings
- Operation and Maintenance Manual
- Complete documentation of implemented protocols between various elements
- List of software and loadable in CD ROM
- Other documents as may be required during detailed engineering

Two (2) sets of hard copy and four (4) sets of CDS ROM containing all the above documents and as built documents/drawings shall be provided.

#### 6.13.8.3 Consumables

All consumables such as paper, cartridges shall be supplied by the Contractor till the Substation Automation System is taken over by the Employer.

### 6.13.9 Training

#### 6.13.9.1 General

Training shall be imparted by the Manufacturer's experts to Employer's Design Engineers, Field Engineers and also to Field Operation staff. Contractor personnel who are experienced instructors and who speak understandable English shall conduct training.

The Contractor shall provide all necessary training material including presentations, manuals, and practical guides. Each trainee shall receive individual copies of all technical manuals and all other documents used for training. These materials shall be sent to Employer at least two (2) months before the scheduled commencement of the particular training course. Class



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materials, including the documents sent before the training courses as well as class handouts, shall become the property of Employer.

#### 6.13.9.2 Computer System Hardware Course

A computer system hardware course shall be offered. The training course shall be designed to give Employer's hardware personnel sufficient knowledge of the overall design and operation of the system so that they can correct obvious problems, configure the hardware, perform preventive maintenance and run diagnostic programs. The following subjects shall be covered:

(a) System Hardware Overview: Configuration of the system hardware.

(b) Equipment Maintenance: Basic theory of operation, maintenance techniques and diagnostic procedures for each element of the Bay Control, Workstations, Communication Equipment and Protocols, LANs, router and printers.

(c) System Expansion: Techniques and procedures to expand and add equipment

(d) System Maintenance: Theory of operation and maintenance of the redundant hardware configuration, failover hardware, configuration control panels, and failover switches. Maintenance of protective devices and power supplies.

(e) Subsystem Maintenance: Theory of design and operation, maintenance techniques and practices, diagnostic procedures, and (where applicable) expansion techniques and procedures. Classes shall include hands-on training for the specific subsystems that are part of Employer's equipment or part of similarly designed and configured subsystems. All interfaces to the computing equipment shall be taught in detail.

(f) Operational Training: Practical training on preventive and corrective maintenance of all equipment, including use of special tools and instruments. This training shall be provided on Employer's equipment, or on similarly configured systems.

#### 6.13.9.3 Computer System Software Course

The Contractor shall provide a computer system software course that covers the following subjects:

(a) System Programming: Including all applicable programming languages and all stand-alone service and utility packages provided with the system. An introduction to software architecture, effects of tuning parameters (OS software, Network software, Database software etc.) on the performance of the system.

(b) Operating System: Including the user aspects of the operating system, such as program loading and integrating procedures; scheduling, management, service, and utility functions; and system expansion techniques and procedures

(c) System Initialization and Failover: Including design, theory of operation, and practice.

(d) Diagnostics: Including the execution of diagnostic procedures and the interpretation of diagnostic outputs,

(e) Software Documentation: Orientation in the organization and use of system software documentation.

#### 6.13.9.4 Application Software Course

The Contractor shall provide a comprehensive application software course covering all applications including the database and display building course. The training shall include:



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(a) Overview: Block diagrams of the application software and data flows. Programming standards and program interface conventions.

(b) Application Functions: Functional capabilities, design and major algorithms, associated maintenance and expansion techniques.

(c) Software Development: Techniques and conventions to be used for the preparation and integration of new software functions.

(d) Software Documentation: Orientation in the organization and use of functional and detailed design documentation and of programmer and user manuals

## 6.14 TELECOMMUNICATION AND SCADA SYSTEM

### 6.14.1 General

This section includes the works for the Telecommunication (Telecom) and SCADA systems required in connection with Design, Supply, Installation, Testing and Commissioning of Plant for 132 kV Attabad Lake HPP Substation Project.

The design shall also consider the equipment required for speech and data communication from 132 kV Attabad Lake HPP substation to remote substations including National Power Control Centre (NPCC) / Regional Control Centre (RCC) and the provision of protection signalling over the 132kV overhead transmission line circuits emanating from 132kV Attabad Lake HPP substation.

### 6.14.2 Scope of Work

The Contractor shall be responsible for the design, manufacture, works testing, supply, storage at Site, installation, site testing, commissioning, guarantee and making good defects of fully functional Telecommunication and SCADA systems, required to fulfil the speech, data and protection signalling requirements. The main works shall include:

Establishment of redundant data communication links between 132 kV Attabad Lake HPP substation and remote end substations, which primarily comprises of establishment of end-to-end Digital Power Line Carrier (DPLC) and digital protection signalling equipment (DPSE) and Fiber optic System. The Contractor shall carry out the survey of the existing facilities and connecting sub-stations to determine the required interface works for the design of SCADA & Telecom necessary for 132 kV Attabad Lake HPP substation, and shall supply all such equipment to establish end-to-end digital power line carrier (DPLC) and digital protection signalling equipment (DPSE) and Fiber Optic System for 132 kV Attabad Lake HPP substation and all connecting sub-stations to implement SCADA & Telecom connection to NPCC/RCC.

The scope of work shall include the following:

a. Power line coupling equipment for coupling the DPLC equipment to the overhead transmission lines, and the adjacent substations for complete integration with NPCC/RCC.

b. Operational telephone (PAX) system at 132 kV Attabad Lake HPP substation including interconnecting and interface equipment required at 132 kV Attabad Lake HPP substation and the peripheral substations for complete integration with NPCC/RCC telephone network.

c. Substation Automation System (SAS) for remote monitoring and control of Attabad Lake HPP 132kV substation from NPCC/RCC.



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d. Interconnection of SCADA equipment, telephone PAX and protection relays to the DPLC & Fiber Optic terminal equipment.

e. New 48V DC power system at 132 kV Attabad Lake HPP substation and connection to existing 48V DC systems at peripheral stations for powering the telecom/SCADA equipment.

f. Survey shall be carried out by the Contractor of the existing facilities or adjacent sub-stations to determine the required interface works for the design of SCADA & Telecom. In case of award, Contractor shall carry out detailed survey and submit the Report within six weeks of Contract Award.

g. Engineering, design and supply of any devices required for proper interface and working of fully functional telecommunication and SCADA systems even if not specifically mentioned in Scope of Work/Price Schedules.

h. Co-ordination with other contractor(s) shall also be deemed to be included in Contractor's scope of work.

i. Scope of work is further elaborated in Volume-II, Part III (Conceptual drawings).

### 6.14.3 Detailed Requirements

#### 6.14.3.1 Protection Signaling

For the 132kV transmission line circuits, provision of duplicated coded channels for transmission of at least two (2) commands on DPLC and Fibre Optic links.

#### 6.14.3.2 Telephony

a. Speech communication for operational traffic and integration with the remote end substations and NPCC/RCC shall be provided.

b. The Contractor shall carry out survey of the existing status of the network during the detailed engineering phase of the Contract. Direct speech communication shall be provided between control room and other locations within 132 kV Attabad Lake HPP substation premises.

#### 6.14.3.3 Data Communication

Data channels shall be provided between 132 kV Attabad Lake HPP substation and NPCC on new DPLC and Fibre Optic Links to be established under this contract, after carrying out the survey of the existing status of the links. The exact data routes shall be finalized in consultation with NGC (Telecom) during design stage.

### 6.14.4 Equipment Requirements at 132 kV Attabad Lake HPP Substation

#### 6.14.4.1 Digital Power Line Carrier and Protection Signaling Equipment

**6.14.4.1.1 Attabad Lake HPP Substation – 132/66 kV Aliabad Substation (Double Circuit)**

a. For each circuit separately: Redundant (two units) digital power line carrier (DPLC) terminal (≥ 40W) and digital protection signaling equipment (DPSE) installed in swing rack cabinet at 132 kV Attabad Lake HPP substation.

b. Two sets (each set comprising two units) of Line Traps for phase-phase coupling.



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c. Two sets (each set comprising two units) of LMUs for phase-phase coupling with coupling filters, hybrid transformer, protection circuits, interface for through connection of existing PLC channels and all materials required for a complete installation.

d. One length of coaxial cable to connect LMU with associated DPLC terminals and between both LMUs.

e. Tele protection interconnection cables between DPSE and the relay panels and terminated at both ends.

f. All other ancillary material comprising cables, connectors, MDF modules, jumpers, harnesses, mounting frames, fuses, relays, nuts, bolts etc. required for complete installation and fully functional DPLC and PSE links.

**6.14.4.1.2 Attabad Lake HPP Substation – 132kV Sost Substation**

a. Redundant (two units) Digital Power Line Carrier (DPLC) terminal (≥ 40W) and Digital Protection Signaling equipment (DPSE) installed in Swing Rack Cabinet at 132 kV Attabad Lake HPP Substation.

b. One Set (each set comprising two units) of Line Traps for Phase-Phase Coupling.

c. One Set (each set comprising two units) of LMUs for Phase-Phase Coupling with Coupling Filters, Hybrid Transformer, Protection Circuits, interface for through connection of existing PLC Channels and all Materials required for a complete installation.

d. One Length of Coaxial Cable to connect LMU with associated DPLC terminals and between both LMUs.

e. Teleprotection Interconnection Cables between DPSE and the Relay Panels and terminated at both ends.

f. All other Ancillary Material comprising Cables, Connectors, MDF Modules, Jumpers, Harnesses, Mounting Frames, Fuses, Relays, Nuts, Bolts etc. required for complete Installation and fully Functional DPLC and PSE Links.

**6.14.4.2 Optical Fiber Terminal Equipment**

**6.14.4.2.1 Attabad Lake HPP Substation – 132/66 kV Aliabad Substation**

a. OLTE equipment in (1+1) configuration with equipment rack and installed in a swing rack cabinet.

b. Digital Access Multiplexer ((DAM) & CC/Add-Drop Multiplexer ADM) equipped with specified user interfaces and installed in OLTE cabinet.

c. DPSE for transmission over OLTE and installed in OLTE/separate swing rack cabinet for tele-protection.

d. One length approach fiber optic cable (FOC) with 24 fibers.

e. Optical distribution frame (ODF) for termination of 48 fibers.

f. Tele protection interconnection cables between DPSE and the relay panels and terminated at each end.

g. Amplifies/ Repeater (if required).

h. All other ancillary material comprising cables, connectors, MDF modules, jumpers, harnesses, mounting frames, fuses, relays, nuts, bolts etc. required for complete installation and fully functional fiber optic link.

#### 6.14.4.2.2 Attabad Lake HPP Substation - 132kV Sost Substation

a) OLTE Equipment in (1+1) configuration with Equipment rack and installed in a Swing Rack Cabinet.

b) Digital Access Multiplexer ((DAM) & CC/Add-Drop Multiplexer ADM) equipped with Specified User Interfaces and installed in OLTE Cabinet.

c) DPSE for Transmission over OLTE and installed in OLTE/Separate Swing Rack Cabinet for Tele-protection.

d) One Length approach Fiber Optic Cable (FOC) with 24 Fibers.

e) Optical Distribution Frame (ODF) for Termination of 48 Fibers.

f) Teleprotection Interconnection Cables between DPSE and the Relay Panels and terminated at each end.

g) Amplifies/Repeater (if required)

All other Ancillary Material comprising Cables, Connectors, MDF Modules, Jumpers, Harnesses, Mounting Frames, Fuses, Relays, Nuts, Bolts etc. required for complete Installation and fully Functional Fiber Optic Link.

### 6.14.4.3 PAX Equipment

a. One lot of digital telephone exchange (PAX) to fully integrate with the NPCC/RCC telephone network and equipped with at least:

i. 08 No. analogue trunks and 32 No. analogue subscribers.

ii. 2 x 2 Mbps digital trunks with Q Sig/4 No. digital subscribers.

iii. 02 No. long line extensions.

iv. 05 No. desk mounted telephone sets.

v. 05 No. executive telephone sets.

vi. 01 No. Industrial Router to establish link for remote maintenance of 132 kV Attabad Lake HPP substation's PAX from NPCC/RCC.

vii. Standard subscriber cables for all users.

viii. Swing rack cubicle, equipment rack and ancillary equipment required for a complete installation and fully functional telephone system.

b. One Main Distribution Frame (MDF) cabinets, floor mounted equipped with MDF frames, Krone quick-connect modules and protection equipment (for external circuits) to terminate 600 pairs with an expansion capability of 50% for additional internal and external circuits.

### 6.14.4.4 SCADA System

a. Interfacing of Gateways with DPLC and Fiber Optic terminals. Availability of SCADA signals and programming in Gateways shall be done by the Contractor.

b. Redundant Time synchronizing system comprising GPS receiver and necessary interface equipment for synchronizing the clock systems at NPCC/RCC and 132 kV Attabad Lake HPP substation.

c. Testing of SCADA functions of 132 kV Attabad Lake HPP substation with NPCC/RCC. This includes end to end verification of all SCADA Signals at remote end substations.



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d. Establishing end to end DPLC data links between 132 kV Attabad Lake HPP substation and NPCC/RCC.

e. Establishing end to end Fiber Optic communication links between 132 kV Attabad Lake HPP substation and NPCC/RCC.

f. Ancillary equipment not specifically mentioned herein but required for equipment interface and a fully functional SCADA system.

#### 6.14.4.5 48V DC Power System

a. Two lead acid Plante type battery banks,

b. Two battery chargers in (1+1) configuration,

c. Instrumentation and DC distribution with MCBs,

d. All other ancillary equipment required for a complete installation and fully functional 48V DC power system.

#### 6.14.4.6 Spare Parts

All modules with finite MTBF shall be provided as essential (mandatory) spare parts. Essential Spare Parts shall be supplied in accordance with the following:

a. Two (2) number of each module/sub-assembly for DLPC/DPSE

b. Two (2) number of each module/sub-assembly for OLTE/MUX, DPSE/PSE.

c. One (1) number each module/assembly for PAX equipment including 1 No. of each type of telephone sets (Desk, Wall, Executive).

d. One (1) number of each module/sub-assembly for SCADA and 48V DC Power Supply equipment including lead acid battery cells.

e. One (1) number each of LMU set, ODF, router, transducer (each type) and telephone sets (each type).

f. Ten percent (10%) of interface cables, connectors, circuit breakers, fuses, indication lamps, MDF Krone quick-connect modules.

g. 500m of approach fiber optic cable.

h. Ten percent (10%) spares for adaptation equipment.

Unit price of each item and complete lists of Essential Spare Parts covering the above shall be provided for telecommunication, SCADA and 48V DC power equipment.

Additionally, a list of Recommended Spare Parts for Five (05) years operation shall also be included.

#### 6.14.4.7 Erection and Testing Equipment and Maintenance Tools

Special equipment required for service, test and maintenance shall be offered and listed in detail. The mandatory Erection and testing equipment and maintenance tools shall include:

a. Equipment for configuration and testing/commissioning of DPLC, OLTE/MUX, DPSE/PSE and PAX comprising 2x Laptop PCs (no less than core i5) loaded with system and application software with backup DVDs.

b. Equipment for PLC link measurements i.e. signal generator (50Hz–2MHz) and selective level meter (50Hz-2MHz).

c. Equipment for generation and measurement of trip commands i.e. Tele protection test box.

d. Equipment for testing of end-to-end data communication links i.e. Data link tester.

e. Equipment for transducer measurements.
f. Equipment for testing of battery chargers.
g. Equipment for measuring the battery capacity while in service and accessories provided with the batteries.
h. Engineer's Optical service toolkit.
i. Engineer's Maintenance service toolkit.

A complete list of Mandatory Erection and Testing Equipment and Maintenance Tools stating the make and model number of each item shall be included in the Proposal.

Additionally, a list of Recommended Erection and Testing Equipment and Maintenance Tools shall also be provided.

### 6.14.5 Telecom System Specifications

#### 6.14.5.1 Digital Power Line Carrier (DPLC)

##### 6.14.5.1.1 General

Digital Power line carrier (DPLC) communication shall be established via the overhead power transmission lines.

The DPLC equipment shall consist of:

a. DPLC terminals with interfaces for connecting to voice, data and protection signaling equipment.
b. Line traps, coupling capacitor voltage transformers, line matching units and coaxial cable for coupling the carrier signal to the overhead transmission lines.

The equipment shall be suitable for operation in the frequency band of 40-1000 kHz. Swing frame cubicles of 19" rack design shall be used to house the DPLC terminal racks. The cubicle shall be designed as per the specifications given in Specific Facilities Data.

##### 6.14.5.1.2 Frequency Allocation Plan

In order to avoid frequency congestion, the Contractor shall, after award of contract, survey the existing installation and submit a carrier frequency allocation plan (FAP) for the new DPLC links. The Contractor shall obtain from the concerned authorities the latest frequency allocation plan for the sites included in the Contract and of those sites that are located at a distance that meets the under-mentioned criteria. The concerned authorities shall approve the proposed frequencies. The criteria to be used in frequency planning shall be:

a. Two-line sections separation at the same voltage level.
b. One line section and transformer section separation at different voltage levels.
c. While proposing the frequencies it shall be ensured that no interference is caused with the communication services of other administrations. Frequencies shall be allocated such that cross-talk due to coupling through the substation bus bars or due to the links operating over parallel overhead lines is kept to a minimum as per IEC standards.

The frequency setting of a link shall be programmable in the field.

##### 6.14.5.1.3 Signal to Noise Requirements

The DPLC shall automatically adapt its data transmission rates to ensure minimum BER under adverse weather conditions keeping the Tele protection signals at the highest priority.



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For voice communication, signal to noise ratio of not less than 25dB in the speech band under adverse weather conditions and not less than 35dB in normal operating conditions. The Contractor shall provide calculations in line with IEC 60663– “Planning of (single sideband) power line carrier systems" detailing coupling equipment, line attenuation and any other losses. Relevant assumptions on the transmission lines noises and on the VF levels adjustments shall be stated clearly.

Signal to noise calculations shall be provided by the Contractor during detailed design. Any assumptions made in the calculations shall be clearly stated.

#### 6.14.5.1.4 DPLC Equipment Features

The design and performance of the DPLC unit shall guarantee the reliable operation of the equipment under all common operation conditions encountered on the EHV power network and shall conform to the latest revision of IEC 60495 - "Single Sideband Power Line Carrier Terminals". The equipment shall be used for the transmission of the following types of information:

a. Speech for voice communication.
b. Telephone signaling.
c. Data communication.
d. Tele-protection signals.

The offered equipment shall have been type tested, field-proven and working successfully in telecom network operated by power utilities for at least three years and installed on minimum three Projects. Evidence in this regard shall be submitted with the Proposal in the form of reference lists, client’s certificates and type test reports.

The DPLC equipment shall have following features:

a. Field-programmable carrier frequency selection in increments of 4 kHz from 40 kHz to 1000 kHz, including filters.
b. Power amplifiers available in a range of power output ratings suitable for selection to match link transmission loss. HF power increments shall be 40 and 80 watts.
c. Automatic gain control (AGC) to prevent transmitter overload and receiver AGC from pilot signal. Receiver AGC to limit voice frequency output level to ±1.0dB or better over a 40dB dynamic range of input carrier level.
d. Provision in the receiver for equalization of line frequency attenuation distortion.
e. Transit filters, if required, for pass-through connection to equipment.
f. Provision for selectable matching balanced or unbalanced cables at the transmission frequency interfaces to impedances of 75 and 150 ohms. Impedance matching to 125, 150, and 250 ohm terminations will also be required. The nominal PLC output impedances shall be 75 ohms for unbalanced grounded circuits and 150 ohms for balanced ungrounded circuits.
g. Provision for input and output connections for voice, for telephony signaling and decoupled individually adjustable data channels as well as protection signaling in each channel unit.
h. Programmable to provide speech, tele-protection and 4800bps data services or any combination of these services e.g. 2xspeech+data+tele-protection, 3xspeech+tele-protection, 1xspeech+2xdata etc. The Proposer shall give details of all possibilities



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available in the equipment. Also, the supplied equipment shall have no restriction on the use of full range of its services by the Employer in future.

i. Interface ports to provide universal connection to existing telephone systems with 2-wire FXO, 2-wire FXS, 4-wire, and 4-wire/E&M terminations (irrespective of existing type and country of manufacture).

j. Provision of an internal tone generator for inserting and measuring test tones.

k. Test jacks and/or test points for diagnosing trouble. Important metering points, control elements and visual indicators shall be on the front of the modules or front panel.

l. Alarms shall provide dry relay contacts for forwarding alarms. Self-loop back features shall be provided.

m. Equipment operation from a nominal 48V (-15%, +20%) positive earthed DC battery supply, connected to a battery charger with internal regulation.

n. Provision in each cabinet for service telephone, with audible and visible calling annunciators.

o. Carrier oscillators accurate within ±20 Hz. The maximum allowable frequency difference between transmit and receive on any link over the specified environmental range shall not exceed ±2 Hz with suppressed carrier. With reduced carrier, the aforesaid frequency difference shall be zero. RF stability requirement shall be better than 1 Hz within the specified temperature range.

p. Equipment operation within the specified environmental conditions.

q. Provision of a self-diagnostic (loop back) to be controlled both locally and remote.

r. Software programmable without physical change of equipment modules or strapping.

s. Interface to transmit data on both 101 and 104 links.

t. Alarm monitoring provided through LEDs and dry alarm contacts.

u. Capable of easy integration into digital networks, LAN/IP connectivity, remote management and compatibility with legacy systems.

#### 6.14.5.1.5 DPLC Equipment Architecture

The equipment shall be of the single sideband, suppressed carrier type being considered on a modular basis, with the modules plugging into 19" (480 mm) shelves. The equipment shall utilize solid state integrated devices with a minimum of discrete components. Each channel shall have a bandwidth of 4/8 kHz, allowing simultaneous bilateral transmission of mixed type information (telephone, signal and data).

The information type to be accommodated on a channel shall be programmable to include any combination of speech, data and tele-protection signals.

Routine testing and fault location of the equipment shall be facilitated by means of built-in testing equipment and LEDs etc. The functions to be controlled by the equipment shall be stated by the Proposer.

The basic architecture of DPLC equipment shall include the following three parts:

a. Input/output interfaces of varying types.

b. Multiplexer and digital signal processor.

c. RF power amplifier.

#### 6.14.5.1.6 Input / Output Interfaces

Each DPLC link shall be configured for the particular application on that link. As a minimum, each unit shall be equipped with:

a. 1 x 2/4 wire speech interface.
b. 1 x 2-wire remote subscriber (FXS/FXO) interface.
c. 1 x LAN interface.
d. 4x RS 232 V.24/V.28 interface.
e. 1 No. integrated DPSE for connection to protection relays.
f. 1 No. service interface for service tool (Laptop PC) connection.
g. 1 No. service telephone interface plus telephone for testing and maintenance.
h. 1 No. set of status and alarm indication LEDs.
i. 1 No. interface for power supply, 48V DC and 220V AC.
j. 1 No. interface for time synchronization.
k. Interface to transmit data on both 101 and 104 links

#### 6.14.5.1.7 RF Power Amplifier

The RF power amplifier shall be modular and easily replaceable. It shall be possible to add stages of identical power amplifiers to obtain RF PEP power output of 40 W, 80 W or higher wattage.

Selection of the required power output for each link shall be made by the Proposer after considering the transmission line parameters. However, it shall not be less than 40W.

The RF power amplifier section shall receive RF signal from the digital signal processor which is fed to a voltage controlled amplifier to obtain the desired RF output.

Switching operations in the high-voltage network, in addition to climatic conditions, can lead to an alteration of the impedance in the high-voltage line. This affects the output current and the output voltage of the amplifier adapted to the line. The RF power amplifier shall thus be dynamically controlled for its power output.

In order to prevent overdriving when the amplifier is driven to full output, the RF power amplifier shall be controlled through a feedback control loop.

Similarly monitoring circuits shall be provided to prevent failure of any component due to exceeding of design limits.

For supervision of the equipment, alarm contacts shall be available along with LEDs on the front panel indicating status and alarms.

The RF power amplifier section shall also house necessary filters and hybrids for:

a. Separating the transmitted RF signal from the received signal.
b. Allowing connection of additional stages of amplification.
c. Matching the output to the coupling filters connected to the transmission line.

#### 6.14.5.1.8 Multiplexer and Digital Signal Processor

The input signals of all interfaces shall be multiplexed and digitally processed to form an SSB modulated signal of the desired RF band. For this purpose, the analogue input signals shall be first converted into a digital signal (a serial sequence of bits) by an analogue to digital



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converter. The digital input signals shall be processed by digital signal processor (DSP) circuits using suitable software algorithms, so as to get another digital data stream. The data streams thus obtained shall be converted through suitable modulation techniques to give an SSB modulated RF signal.

Reverse procedure shall be employed for demodulation. The entire signal processing technique shall be aimed at achieving user flexibility. Thus, by changing few software parameters settings of carrier frequencies, pilot frequencies, orientation of the spectrum etc. shall be possible to change.

Each asynchronous digital interface shall be adjustable in the range of 1200 to 9600 bit/s. The synchronous digital shall be able to be parameterized as clock master (DCE) or clock slave (DTE). The bit rate shall be adjustable from 9.6 to 64 kbps.

#### 6.14.5.1.9 Digital Protection Signaling Equipment

Digital protection signalling equipment shall be provided for secure and dependable transmission of protection trip signals over the DPLC. The equipment shall be designed in accordance with the following:

a. Coded commands for trip signals to prevent inadvertent signal transmission.

b. Possibility for transmission of four bi-directional trip commands.

c. Selectable and programmable security, dependability and transmission speeds.

d. 1+1 path protection available as a standard feature. A switch-over of the protection signal command shall be guaranteed in less than 5 ms.

e. Possible to drop and insert commands, transfer commands at a transit station and have AND- and OR- connections between commands. The equipment shall be able to support T-node configurations.

f. Signals adjustable from 24 to 250V DC by means of software. All inputs and outputs shall be isolated and with EMC immunity for harsh environment.

g. Provided with an integrated non-volatile event-recorder that can be synchronized internally and by Global Positioning System (GPS) and a command counter for recording trip commands.

h. Provision of individual command counters external to the equipment and manually resettable for each trip command. The equipment shall include at least the following counters:

    I. Command counter at transmitter input for memorizing the input trip command.

    II. Command counter for memorizing the trip command at the receiver.

Provisions shall also be available for remote signalling of the received and transmitted commands.

### 6.14.5.2 Power Line Coupling Equipment

#### 6.14.5.2.1 Method of Coupling

In order to connect the DPLC terminal to the transmission line, coupling equipment comprising line traps, coupling capacitor voltage transformers, line matching units and coaxial cable shall be provided.



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Coupling of the power line carrier signals to the transmission circuits shall be by means of line matching units, coupling capacitor voltage transformers and line traps. The method of coupling used shall be phase to phase (centre-outer).

#### 6.14.5.2.2 Line Traps

The minimum inductance of the line traps shall be 0.315 mH. Detailed specifications are included in Section 6.11 of these Technical Specifications.

#### 6.14.5.2.3 Capacitor Voltage Transformers

Detailed specifications are included in the Technical Specifications / Contract Document.

#### 6.14.5.2.4 Line Matching Unit (LMU)

The LMU shall couple and decouple the high-frequency signals of the power line carrier unit from and to the transmission system. The LMU shall work like a high-pass filter for coupling to the overhead transmission lines.

Broad-band units shall be provided for each phase. The tuning range of the LMUs shall cover transmit and receive frequencies of the new DPLC links and shall be field programmable. The composite loss over the range shall not be greater than 2 dB. The line side and equipment side return losses shall preferably be greater than 12 dB over the available bandwidth of the filter. The line side impedance of the device shall be suitable in the range 200-600 ohms for phase to phase coupling. The equipment side impedance shall be in the range of 75 ohms (unbalanced) to 150 ohms (balanced). The LMU shall be programmable for various coupling capacitances, line and equipment side impedances.

The units shall provide for impedance matching, filtering and operation safety and shall comply with IEC 60481. The LMUs shall be adaptable for either, centre phase to outer phase or inter-circuit coupling. For phase to phase coupling, it shall be possible to earth either of the LMUs and continue with carrier transmission on phase to ground basis using the other filter. All tuning elements shall be factory-tuned to the selected frequency band, impedances shall be factory adapted to the line and HF cable impedances.

All components shall be suitable for outdoor operation in the prevailing climatic conditions. Cubicles shall be of steel sheet material with weather proof door and cable inputs seals, adequately protected against condensation and shall be designed to a protection class of IP55 or better. They shall be suitable for mounting on CVT rectangular lattice type steel support structures.

The unit shall be designed to ensure the safety of operators and the protection of the carrier equipment against the effects of the network high voltage, and of transient over-voltage conditions. Full compliance with IEC recommendations shall be provided.

The unit shall have surge arresters and an earth switch. The terminal of the device connected directly to the substation earth shall be clearly marked.

All elements such as coupling filters drain coils or protective devices shall be suitable for the coupling capacitor to be applied. A drain coil shall earth the 50 Hz current so that the applied voltage meets the prevailing safety requirements i.e.:

a. The unit shall withstand without damage a shock-wave 1.2/50 µs of 6 kV peak value applied on the power line side.

b. Insulation level shall be of 5 kV rms applied for one minute between each coil and earth and between each coil and screen.



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The connecting cable between the coupling unit and the coupling capacitor shall be included. It shall have a diameter of at least 8 mm and shall be isolated and fixed sufficiently to withstand the mechanical and electrical stresses in case of HV faults.
The coupling box, the earth switch, the main surge arrester and the drain coil shall be equipped with name plates of weather-resistant material, placed so that it is easily visible, with irremovable inscriptions. They shall indicate as a minimum:

a. Manufacturer's name, type and serial number.
b. Rated voltage and current for the earth switch.
c. Rated voltage and the rated discharge current for the surge arrestor.

An arrangement diagram with weather-resistant inscriptions shall be fixed inside the door of the unit housing box. It shall in particular indicate the references of the carrier frequency cable outputs, the value of the tuning coil and the ratio of the adaptation transformer in relation to the connections used. Various connections of the filter and of the matching transformer shall be shown in a visible and practical way.

**6.14.5.2.5 Coaxial Cable**

High frequency cable of coaxial type shall be used as connection cable between coupling unit and the DPLC terminal and between the set of coupling units (connected in phase-phase and inter-circuit configuration).

The cable shall be PVC insulated, galvanized steel tape armored (two layers) with a further outer sheath of PVC and shall be suitable for direct laying in the earth/trenches and for use in tropical climates (temperature -10-70°C and humidity approaching 100%). The inner conductor shall be copper with a diameter of 1-2 mm whereas the outer conductor shall be bare copper braid.

Following electrical parameters shall be considered in cable design:

a. Impedance 75±5 ohm (unbalanced)
b. Attenuation at:
c. 100kHz ≤ 1.8dB/km
d. 300kHz ≤ 2.8dB/km
e. 500kHz ≤ 4.1dB/km.
f. Capacitance ≤ 66nF/km
g. Insulation resistance > 5 GΩkm
h. DC resistance at 20oC ≤ 26Ω/km
i. DC resistance of braid at 20oC ≤ 4.5Ω/km
j. Test voltage ≥ 6kV 50Hz/1min.
k. Bending radius with load ≤ 12xouter cable dia.
l. Maximum tensile strength Proposer shall state

Cross-section layout and technical data of cable mechanical and electrical characteristics shall be included in the Proposal.

The laying in trenches, burying in ground, back-filling, termination and protection pipes shall be included in the works. The protection pipes, if used, shall be properly closed at the ends with a suitable compound to prevent against vermin attack. The cable shall be suitable for laying in the trenches with the HV power cables. The distance between the two cables shall



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be at least 400 mm. Bending radius requirements shall be strictly adhered to during installation and any damage thereof shall be the Contractor's responsibility.

Complete lengths of cable shall be provided, with drum lengths according to requirement but not less than 1000 m. However, if straight through joints are required on any link, this shall be deemed to be included in the works.

#### 6.14.5.3 Fiber Optic Link

These specifications pertain to the following items:

a. Fiber Optic Line Terminal Equipment (OLTE)
b. Digital Protection Signaling Equipment (DPSE)
c. Approach Fiber Optic Cable.

#### 6.14.5.3.1 Fiber Optic Terminal Equipment

The fibre optic terminal equipment shall be provided to establish complete fibre optic links. This section presents the specifications of the equipment to be employed on these links.

The required fibre optic terminal equipment shall have a successful track record in telecom networks operated by power utilities. Thus, it shall be suitable for operation in harsh environment with electromagnetic interference and high temperature/humidity and shall have a high reliability and security. The equipment shall be field proven for installation and operation in power utilities, evidence of which shall be provided with the Proposal in the form of reference lists, Clients' certificates and type test reports.

#### 6.14.5.3.2 Design Based on Hierarchical Structure

The design of fibre optic terminal equipment shall be based on the SDH structure defined in ITU-T G. 707 and G. 783. The hierarchy, from top to bottom, shall comprise:

a. Optical Line Terminal Equipment (OLTE).
b. SDH-STM-4 multiplexer upgradeable to higher levels (STM-16) by vendor independent means and fully equipped for connection to sixty-three (63) vendor independent E1 lines.
c. Digital Access Multiplexer and Cross Connect (DAM&CC) and Add-Drop Multiplexer (ADM) as required on various nodes to meet the user interface requirements defined herein.

The user interfaces shall provide following facilities:

a. Data transmission.
b. Speech communication.
c. Alarm transmission.
d. Becoming a WAN node.
e. System and network management.
f. Protection signals transmission.

#### 6.14.5.3.3 Design Features

The equipment configuration shall be flexible to enable implementation of either point to point communication (1+1 configuration) or the ring topology among substations.

OLTE/SDH and DAM&CC/ADM shall be installed in racks that are Electro Magnetic Compatible (EMC) and suitable to work in EHV substation environment. The equipment shall



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be modular in structure and housed in completely enclosed, vermin/dust proof standard 19" swing rack cabinets.

The OLTE/SDH equipment shall operate in the 1550nm or 1310nm wavelength window depending on link budget calculations and shall be suitable for use on OPGW and underground fibre optic cables.

The equipment shall be able to perform both line terminating and multiplexing functions and shall be able to accommodate signals generated from various levels of PDH. The transmitter equipment shall use laser optical source with power output suited to the requirement of the links. All transmitter equipment shall use the same laser type with attenuation being provided to suit the optical performance of the link.

The SDH Equipment (Terminal Equipment, Add/Drop Multiplex, and Synchronous Digital Cross-Connect) shall meet the following:

a. It shall have at least all the functions outlined in ITU-T G.783.

b. The PDH electrical tributary interfaces to the SDH equipment shall conform to ITU-T G.703.

c. The SDH electrical and optical interfaces shall conform to ITU-T G.703 and G.957.

d. The cross-connect offered shall be capable of providing non-blocking connection between virtual containers.

e. The Optical Power shall be such that under normal operating condition, the BER of the system at the receiver is better than 1x10-10.

f. The multiplex structure shall conform to ITU-T G.707/Y1322, G.711, and G.712. Details shall be included in the Proposal and shall include the usage of the overhead bits.

g. The synchronous optical interface protection shall be achieved by having 1+1 protection. The protection at 2 Mbps level (working/access boards) shall also be provided.

h. The laser shall automatically cut-off when the link is disturbed.

i. Redundant cross connect, where failure on either one shall not cause link outage, and Path protection (Linear Trail Protection) on the traffic interface and 2Mbps levels shall also be provided.

j. It shall have 2Mbps inputs/outputs that can be directly connected to PCM, digital telephone exchanges, protection signaling equipment, protection relays, etc.

k. The equipment shall automatically switch to another clock if the reference timing is lost and automatically revert back upon restoration. Proposer shall provide details in the technical Proposal.

l. The accuracy of the internal clock as well as the details of the clock distribution shall be stated in the offer.

m. Error performance versus the receive signal shall be verified during the factory acceptance tests.

The SDH equipment shall provide the following:

a. Engineer's order–wire (EOW) which shall have conference and selective calling features. EOW handset shall be located in the OLTE cubicle.



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b. A Craft interface in accordance with ITU-T G.773 to allow a local terminal to access the network element.

c. A data communication channel interface for connection to the Network Management System, in accordance with ITU-T G.773.

d. Performance monitoring in accordance with ITU-T G.784 and G.826.

#### 6.14.5.3.4 Optical Budget Calculations

The Proposer shall submit the preliminary power budget calculations to justify that the proposed equipment shall operate on each link with acceptable BER $\geq 10^{-10}$. The calculations shall state the following:

a. Transmitter power

b. Attenuation over the link

c. Receiver sensitivity @ BER $1x10^{-10}$

d. Connector loss (0.3dB)

e. Splice loss (≤ 0.05dB)

f. Power penalty (Chromatic dispersion and LD reflection loss) (1dB)

g. Maintenance margin (2 dB)

h. System margin (1dB)

#### 6.14.5.3.5 Equipment Sizing

The STM-4 SDH equipment shall be equipped and wired to its maximum useable capacity (63xE1). Simple connection to vendor independent E1 lines shall only be required for expansion to full capacity in future.

Proposer shall explain in detail in the Proposal, as to how the above functions will be achieved.

External booster amplifiers/preamplifiers shall be provided as and where required, to achieve the desired optical power budget.

The number of user interfaces shall be decided by the Proposer according to the technical solution proposed in the Proposal. However, the number of user interfaces and spare capacity shall not be less than the following:

a. At least 30% spare slots for future addition of interface modules in SDH and Multiplexer racks.

b. At least 21x E1 interfaces in OLTE/SDH equipment and 4x 2Mb/s interfaces in the DAM&CC/ADM, fully wired up to the MDF.

c. 4/2W E&M interface for at least 8 ports.

d. LAN interface for 1+1 configuration.

e. Alarm interface for at least 4 ports.

f. V.24/V.28 RS 232 interface.

g. All channels shall be fully wired up to the MDF.

h. The capacity of the control/cross connection units shall be able to cater for a fully equipped rack.

i. Power supply modules shall be sized to sustain 50% additional load.



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Control/cross connection and power supply cards in SDH/OLTE and DAM&CC/ADM racks shall be duplicated (1+1) to prevent the equipment from going out of service owing to failure of a single card.

The Proposer shall provide a detailed list of the modules supplied at each node in the Proposal.

Protection signalling equipment shall be in 1+1 configuration.

#### 6.14.5.3.6 Power Supply

The OLTE/SDH and DAM&CC/ADM equipment shall be powered from 48V DC (power supply voltage range shall be from -40 to -58V DC). The duplicated power supply modules shall share the load during normal operation; however, upon failure of either one the other shall not be affected and cater for the total equipment load.

#### 6.14.5.3.7 Optical Distribution Frame (ODF)

An ODF shall be provided to act as an interface between the approach fibre optic cable and the optical line terminal equipment for performing optical isolation, which might be required either during testing/ commissioning or during the routine maintenance.

The equipment shall consist of a distribution frame, which can be either a shelf inside the OLTE cubicle or a separate wall mounted cabinet. Each fibre of the approach fibre optic cable shall terminate in a suitable connector and be available for use either on this contract or for future use. All connectors shall be of the same type within the frame. The connectors of unused fibres shall be protected against dust and dirt with a retained cap. The terminations shall be contained in an airtight, dust free container provided with means of securing the strain relief members of the cable. The pigtails with single fibres shall also contain strain relief members and shall be spliced to the external cable fibres using the fusion technique.

The distribution frame shall be suitable for termination of 24/48 fibres according to that stated in detailed requirements. All external cables shall be properly glanded.

Optical patch cords of suitable lengths shall be provided for connection between the ODF and OLTE. Capacity of the optic distribution frame shall allow free assignment between each fibre and the relevant optical I/O ports of the OLTE.

The optic distribution frame shall be equipped with low loss optical connectors (<0.3 dB). Auxiliary connectors shall be provided to facilitate testing and maintenance of the fibres/equipment.

#### 6.14.5.3.8 Digital Protection Signaling Equipment

Standalone/integrated digital protection signalling equipment (DPSE) shall be provided for secure and dependable transmission of protection trip signals over the SDH/OLTE. The equipment shall be designed in accordance with the following:

a. Command addressing (minimum 8 bit) for trip signal to prevent inadvertent signal transmission.

b. Possibility for transmission of four bi-directional trip commands.

c. Selectable and programmable, security, dependability and transmission speeds.

d. 1+1 path protection available as a standard feature. A switch-over of the protection signal command shall be guaranteed in less than 5 ms.



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e. Possible to drop and insert commands, transfer commands at a transit station and have AND- and OR- connections between commands. The equipment shall be able to support T-node configurations.

f. Signals adjustable from 24 to 250V DC by means of software. All inputs and outputs shall be isolated and with EMC immunity for harsh environment.

g. Provided with an integrated non-volatile event-recorder that can be synchronized internally and by Global Positioning System (GPS) and a command counter for recording trip commands.

h. Provision of individual command counters external to the equipment and manually resettable for each trip command. The equipment shall include at least the following counters:

   I. Command counter at transmitter input for memorizing the input trip command.

   II. Command counter for memorizing the trip command at the receiver.

i. Provisions shall also be available for remote signaling of the received and transmitted commands.

j. An automatic and periodic loop test (< 100s) provided for a signal delay measurement.

k. Configuration tool for the DPSE integrated into the test and maintenance software.

l. No false trip commands generated in the event of power supply failure or when the equipment is put into or taken out of service.

m. Power supply voltage in the range 48V DC (-15%, +20%).

n. The input/output interface between the protection relays and the DPSE by means of reed relays and the input/output rack wiring carefully segregated from other wiring.

o. The transmitter command initiated by the use of clean contacts on the protection relay which shall switch the 48V DC tele-protection supply to the reed relay.

p. DPSE receiver shall provide at least two output contacts per command for primarily operating the 220V DC protection and control supply.

q. Contacts wired to a separate terminal strip, which shall be specially labelled accordingly.

r. In addition, necessary auxiliary contacts supplied for alarm and indication purposes.

**6.14.5.3.9 Alarm and Test Functions**

All of the important system parameters shall be continuously monitored and an alarm signal shall be initiated whenever any system parameter deviates from the set limits. Alarms shall be indicated on the equipment and shall be made available on voltage free normally open contacts that shall be connected to the Gateway equipment for monitoring by the SCADA and SAS systems.

The alarm functions shall include but not be limited to:

- Alarms shall be classified critical, major, minor, and information.
- Indication of loss of incoming signal/high BER>10-3.
- Loss of incoming signal (2,048 Kbit/s).
- Loss of frame alignment.
- Alarm indication signal (AIS) detection.
- Failure of 64 k bits/s interface (signalling only).



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- Failure of power supplies.
- Visual and audible indication of alarms.
- Test function of alarm indicators to ensure workability of alarm indicators.
- Alarm functions shall be detailed by the Contractor. Test functions of the equipment shall include as minimum:
- Transmit output.
- Receiver sensitivity.
- BER.
- Protection switching.
- Engineer's order-wire.
- Alarms.
- Supply voltages.
- Test loops.

The Contractor shall give details of all other functions available on the equipment/system.

#### 6.14.5.3.10 Approach Fiber Optic Cable

The fibre optic cable shall be designed to withstand all prevalent environmental conditions including the effects of high electric and magnetic fields produced in proximity of live power cables.

A service life of at least 25 years is required, and test evidence to support Supplier's claim in this respect shall be submitted with the Proposal.

#### 6.14.5.3.11 Cable Type

The fibre optic cable shall be of the single mode type equipped with at least 24 fibres complying with ITU-T recommendation G.652 and shall be suitable for underground installation and laying in trenches/cable trays.

#### 6.14.5.3.12 Fiber Optic Cable Requirements

**a. Water-Tightness**

The cable shall be fully moisture-resistant and meet the longitudinal water-tightness test requirements.

**b. Electrical withstand**

Considering there is a potential danger through fault or leakage currents, the cable shall be non-metallic.

**c. Mechanical withstand**

The cable shall suitably withstand the mechanical radial stresses and shall be protected against rodents and termites. The crush resistance shall be at least 2kN/10cm.

**d. Temperature withstand**

The operating temperature range shall be -10 to +70°C and the cable shall be suitable for operation in tropical climate with humidity approaching 100%.

#### 6.14.5.3.13 Fiber Characteristics

The main features of the optical fibre shall be as follows:



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- Fibre type: Single mode according to ITU-T G.652.
- Wavelength: 1310nm and 1550nm.
- Max. Attenuation: 0.35dB/km at 1310nm and 0.2dB/km at 1550nm.
- Max. Splicing loss: 0.05dB.
- Max. End-connector loss: 0.3dB.
- Mode field diameter: 8.1-9.7µm.
- Cladding diameter: 125µm ± 2µm.
- Max. Concentricity error: 1µm.
- Max. Cladding non-circularity: 2%.
- Max. Chromatic dispersion: 4ps/nm.km at 1310nm and 20ps/nm.km at 1550nm.
- Cut-off wavelength: < 1270nm.
- Operational temperature range: -10 to +70°C

Inside the buffer tube the reserve length of fibres shall be at least 0.45% against the linear length of the complete OPGW to prevent the fibres from coming under stress. To prove this a sample of at least 80m shall be pulled up to endurance tensile strength while a continuous optical measurement of fibre length and attenuation is done simultaneously.

#### 6.14.5.3.14 Cable Construction

A loose tube, minimum strain configuration, which provides protection from external forces and possesses high tensile strength/resistance to crushing, shall be supplied. The 24 fibres shall lie loosely inside plastic tubes filled with a gel to protect the fibres from the ingress and propagation of moisture. The maximum number of fibres inside any one tube shall be 8. Each tube and fibre shall be color coded to be distinguishable from the other.

The cable construction shall comprise a dielectric central strength member surrounded by loose buffer tubes and fillers covered by moisture-resistant wrapping. The interstices among the loose tubes shall be filled with water blocking jelly compound. The wrapping shall be covered with thermoplastic sheath surrounded by aramid or glass yarn reinforcement. Anti-rodent protection shall be applied around the reinforcement layer by means of glass tape. The outer jacket of the cable shall be made of rugged non-metallic material of thickness not less than 1.5mm and covered with anti-termite coating.

Full constructional details of the cable offered shall be submitted with the Proposal.

#### 6.14.5.3.15 Ending Rules

After factory acceptance, the inner end of the cable shall be fitted with an end cap to ensure water-tightness; the outer end shall be fitted with a water-tight head compatible with cable pulling. Caps (material and implementation) shall comply with applicable standards. They shall not be removed until immediately prior to optical jointing.

#### 6.14.5.3.16 Cable Installation

The fibre optic cable shall be laid in a 50mm PVC duct from/to the terminal joint boxes either directly buried or installed in trenches. Within building premises, it shall be laid in a flexible duct on cable trays. Drawings showing the installation details shall be submitted to the Employer for approval.

Any damage to the cable which is laid and exposed but not protected and during installation shall be made good by the Contractor at his expense and to the satisfaction of the Employer.



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For buried PVC duct, a trench 0.5m wide x 1m deep shall be excavated with provision of manholes at bends for cable pulling and future maintenance. PVC duct shall be laid on a sand bed of at least 100mm thickness and shall be covered by sand layer of 300mm thick. A cable warning tape shall be placed on the top of sand layer. It shall be bright yellow in color and of plastic material 300 mm wide by 0.1mm thick shall be supplied. The tape shall be continuously and indelibly marked in English and Urdu with the words:

**CAUTION CAUTION CAUTION**

**FIBRE OPTIC CABLE 700 mm BELOW**

The lettering shall be black on yellow.

The excavated material shall be used for the remaining back filling of the trench.

The openings to the ducts shall be closed with a suitable compound after the cable has been laid. A 10m loop shall be kept in manholes.

#### 6.14.5.3.17 Cable Drums

Fibre optic cables shall be delivered on drums of wooden reels. The lengths of the cable drums shall be such that intermediate jointing is kept to a minimum on any of the cable routes. The minimum drum length shall be 1000m.

#### 6.14.5.3.18 Labelling

All cables and cable ends should be labelled clearly in accordance with the specification. The meter run should be marked on the outer sheath. These speeds up localization of faults which are detected during calibration of cable.

Drums shall be fitted with securely attached, unalterable identification plate bearing the following information:

a. Employer's name.
b. Supplier's name.
c. Contract number
d. Content (including drum no.).
e. Manufacturing date.
f. Length of cable on drum.
g. Direction of rotation of the drum.
h. Position of the cable nose.
i. Weight of drum.

#### 6.14.5.3.19 Storage and Transport

The permissible mechanical stress values (tensile force, bending radius) shall be adhered to during transport and storage. The barrel diameter of the shipping drums shall be at least 30 times the outer diameter of the cable, but not less than 400 mm.

The transportation and storage shall not be done in conditions exceeding the permissible temperature limits.

#### 6.14.5.3.20 Joint Box

Joint boxes shall be provided to protect the splices and shall be suitable for underground installation in harsh environment. The units shall be weather-proof type of protection Class IP65 made of non-corrosive Aluminium alloy or similar material. All necessary hardware to

terminate, protect and fix 24 no. spliced fibres shall be included. The cover shall be provided with a long-life neoprene gasket to provide a seal against moisture and dust. The cable inlets shall be similarly sealed. Entry for four cables shall be available. A name plate giving important information shall be attached to the joint box. This name shall have embossed characters and shall be made of weather-proof material. Operating temperature range shall be -10 to +70°C and relative humidity range 5-95%.

The underground joint boxes shall be supplied as spares for future splicing to meet the contingency in case of a cable cut.

#### 6.14.5.4 Digital PAX Equipment

The digital PAX shall cater to the specified operational speech requirements for the Project. The equipment shall be field proven and already working satisfactorily in telecom networks operated by power utilities. Thus, it shall be suitable for operation in harsh environment with electromagnetic interference and high temperature/humidity and shall have a high reliability and security. Evidence shall be provided with the Proposal in the form of reference lists, Clients' certificates and type test reports regarding installation and operation of proposed PAX in power utility environment.

In the event that the Contractor and Manufacturer are different, the Manufacturer's representative shall commission the PAX in strict accordance with established installation practices.

##### 6.14.5.4.1 Operational Requirements

**1) Network Organization**

PAX shall become an integral part of the operational telephone network for NPCC/RCC in which the first priority of communication is with the despatcher positions at NPCC. Users of the network are classified in following four categories in order of their importance.

a. Level A: Despatchers at NPCC.
b. Level B: Control Rooms at 132kV substation.
c. Level C: All other subscribers.

The despatchers are able to communicate with any station in the network as and when they desire. The connection of the Power Station and other substations with the despatchers is via dedicated "Hot-line".

A number of different types of service restrictions have been incorporated into the network for Levels B to D in order to minimize the flow of unwanted traffic in the network.

The Contractor shall be responsible for fully integrating the offered PAX into the above operational telephone network. Complete integration requires that the exchange supports all network facilities (in particular priority intrusion and forced release) over the digital and analogue trunks. The compatibility of the new PAX shall be demonstrated in the field before formal approval can be accorded. This shall take place before site testing and commissioning.

**2) Numbering Scheme**

The new PAX shall use a closed numbering scheme in which a singular number shall be dialled for a given extension irrespective of the calling party. The numbering scheme shall be uniform and consist of four digits. The selection of appropriate trunk lines shall be as flexible as possible and shall be made through the analysis of the dialled number. Only digits that are required for determination of the call direction shall be analysed.

Changes in the numbering plan by the Employer shall be possible in a flexible and easy manner without any modifications in hardware or wiring.

**3) Channel Routing**

Whenever several routes are possible within the meshed network for connecting to NPCC/RCC, the PAX equipment shall allow free line selection, so that when one trunk or a group of trunks (route) is busy/occupied, the call is automatically transferred to the next available line according to a pre-programmed sequence. Such selection shall be programmed in the PAX according to traffic considerations and network topology. Whenever extra equipment is required for this purpose, it shall be stated and if not stated shall be deemed to be included in the Proposal.

**4) Caller Number Identification**

The existing PAX equipment has the capability of transferring the caller number identification throughout the network to enable the appearance of this information (on a per call basis) on the despatcher control telephone at remote control center. The new PAX shall similarly have this facility.

**6.14.5.4.2 Technical Requirements**

**1) General**

The PAX shall be state-of-the-art digital, non-blocking type utilizing pulse code modulation (PCM), time division multiplexing (TDM) and stored program control (SPC). The transmission shall conform to the ITU-T A-Law Companding standard (ITU-T Rec. G.711 and G.712). Centralized circuits shall be provided for tone generation and detection. The system shall use digital technology and microelectronics, with minimum 32bit main processor control, and fully modular hardware to allow future expansion in extension and trunk lines. The software of the system shall be written in open standard software architecture and a high level programming language recommended by ITU-T.

The proposed system shall comprise integrated and discrete components of a high level of reliability to guarantee a system availability of 99.98% over a fifteen year operating period.

The PAX shall be suitably designed to operate over any kind of transmission media such as DPLC, FO, digital microwave and pilot cable. The Contractor shall provide details of the signalling schemes, in accordance with the ITU-T standards.

Plug-in printed circuit boards shall have gold plated connectors, if applicable, and shall be connected by means of printed back panels.

Line terminals shall consist of solderless connectors of well-proven design for easy wiring, testing etc.

Extensive and adjustable time-out facilities shall be available in the PAX to enable the time-out and release in the following cases:

a. When a call is not answered in a predefined period.
b. When while dialing, the inter-digit time period is exceeded.
c. When an incomplete or invalid number is dialed.
d. When a station user attempts to access a feature, he is not allowed.

The PAX shall incorporate a backup memory on flash ROMs/magneto optical disk to protect the system against loss of memory due to power failure or breakdown of the system. Upon



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restoration of power to the system, the backup memory shall automatically reload the required system and customer data files into the active memory area within a period of less than ten seconds whereas in case of a complete blackout requiring reload of the operating system, the PAX would be operational within a period of less than two minutes.

The programs and data of the system shall also be stored on removable disks which can be used to load the system in case of a main system disk failure.

The PAX system shall incorporate a wide range of self-initiating diagnostic routines for the monitoring of the system performance and identification of errors i.e., major and minor hardware and software faults, faulty line/trunk card, power supply, etc. Details of hardware and software covered by self-diagnostics shall be explained with the Proposer's proposal.

**2) Interface Circuits**

The various types of interface circuits shall be in accordance with the following standards/ protocols:

| | |
|---|---|
| Analogue Extension | Two wire Dial Tone Multi-Frequency (DTMF) according to ITU-T Q.23 |
| Digital Extension | Standard BRA 4 wire ISDN S0 bus (ITU-T I.430)<br>UPn 2 wire interface (in 1B+D or 2B+D modes), Uk0 2 wire interface |
| Analogue Trunk | 2 wire/4wire E&M Interface with MFCR2 (ITU-T Q.400 TO Q.490)<br>2 wire loops disconnect Interface |
| Digital Trunk | 30B+D interfaces conforming to ITU-T G.703/G.704 with 1TR6, DPNSS and QSIG protocols<br>2 MB/s CAS protocol<br>2B+D interface conforming to ITU-T I.430 with 1TR6, DPNSS and QSIG protocols |

**3) Software Features**

The PAX system shall possess, as a minimum, the following software features. The features shall be fully transparent to the network.

**a. Call Priority**

Call priority can be assigned to certain extensions or Network Tie Lines as a fixed attribute; calls originated by these extensions or on these lines will always have priority over routine calls. Alternatively, extensions may be given a Service Class which allows them to obtain Priority on a call-by-call basis when needed. During the application of priority, priority intrusion is used to intrude upon an established call when congestion is encountered upon initiating a call to another extension. The Priority feature is a mandatory function which shall function over the PAX network. It may be inhibited either manually or automatically.

**b. Automatic Priority Intrusion**

If a call is initiated with Priority, a busy line in the first choice route will be selected once congestion has been detected in the alternative routes. The caller will then automatically enter into a conference with the parties in conversation on this line, after a short intrusion tone has been provided to all parties, including the intruding party. The duration of this conference is limited to a configurable amount of time (default duration of thirty seconds), after which the intruding party will be disconnected.

**c. Manual Priority Intrusion**

If the call has not been initiated with Priority and congestion is found on the line, the caller shall receive an audible and visual indication of this. The caller shall then have the option of upgrading the call's priority. This is accomplished by pressing the appropriate PRIORITY key on his telephone within a configurable period of time (default duration of fifteen seconds), otherwise, the caller will be disconnected.

Once manual intrusion has been performed, a busy line is selected and a conference established as described above for Automatic Priority Intrusion. At this time, the call will be tagged as a Priority call in each node along the route to the destination, as the intrusion order is transmitted from node to node.

**d. Forced Release of Call**

A Forced release order is used by the intruding party to forcibly release the parties in an established call which has been intruded on, in order to free the line for use by the intruding party. Once the caller has intruded on an established call, he may initiate a Forced Release Order by pressing the PRIORITY key before the maximum duration of the intrusion has elapsed.

After application of the Force Release Order, the intruding party will be either automatically connected to its destination without any redialling or further dialling by the NPCC despatcher/intruding party or by redialling of some number or code to establish the connection. The Proposer will state the provision available in the proposed PAX.

**e. Hot-line Extension**

This type of extension shall have the facility to automatically call a pre-designated number by only lifting the handset.

**f. Call Diversion on Busy**

Calls to an extension are diverted to a predefined directory number when the extension is busy.

**g. Call Diversion on No-answer**

Calls to the extension are diverted to a predefined Directory Number (DN) when the call is not answered within a specified period of time (default duration of ten seconds).

**h. Call Transfer**

Allows an extension user on any two party call to Hold the existing call, originate a call to a third party and then transfer the call to a third party. The station user can then consult privately with the third party before completing the transfer, or can return to the original caller.

**i. Call Forward**

All incoming calls to a station user can be automatically forwarded to another pre-selected destination within or outside the PAX to which the station user is connected.

**j. Call Waiting**

Alerts the station user, busy with an established call that additional calls are waiting to be transferred.

**k. Ring Again**

Allows a station user, on encountering a busy connection, to be alerted when a called party or trunk route becomes free. The system will then automatically redial the desired destination.



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**l. Call Pick-up**

Enables the definition/programming of specific call pick up groups whereby a station can pick up an incoming call for another station in his call pick up group by lifting his handset and dialling a pre-designating call pick up code.

**m. Conference**

Allows a station user to establish a three-party conference. Conferences may be inside or outside the PAX to which the station user is connected.

**n. On-hook Dialing**

Enables a station user to originate a call without lifting the handset.

**o. Privacy**

When a station user is engaged in a two party conversation, no other party can enter the conversation.

**p. Authorization Code**

For the purpose of overriding the access restrictions, a specific two to three digit pre-programmed code is dialled by a designated station, to enable him to gain free access to the network. Dial tone is returned to the station user after dialling the code and he is able to call the destination without restriction.

**4) Equipment Design**

The equipment configuration shall be flexible to enable implementation of point to point, tandem as well as ring topology communication with other substations. The PAX system shall be expandable without any interruption in service.

The proposed PAX equipment shall incorporate at least a 30% spare equipped capacity in the user interfaces and shall be expandable to 100% of the equipped capacity by simple addition of plug-in modules. The equipped capacity shall be fully wired up to the MDF.

The PAX system structure shall be based upon a multi-processor hierarchy, in which the processing requirements are subdivided on the basis of both the type of function to be carried out and the time limits set. The architecture shall allow for the optimum use of system resources by use of a combination of advantages of distributed processing with the low costs and efficiency of centralized management. The system shall consist of the following functional units.

**a. Common control group**

In order to avoid the duplication of information and allow for a setup of a reliable and flexible structure, this group centralizes the decisional-management system functions, operator interface functions and system functions such as down-loading programs to processing subsystems (peripheral equipment modules). This group collects all pertinent information relating to the state of the various parts of the PAX system, activating, if necessary, alarm procedures and regulating access to the system's memory areas in order to optimize their use.

It contains all the system programs, semi-permanent system data, subscriber categories and features, numbering schemes, network characteristics and all other information used to provide services.

The Input/output communication shall be achieved via a terminal (VDU) which displays/prints on request all system information, alarm messages, traffic and call recording data.

**b. Switching group**

This portion of the system performs the switching functions of the communication channels in a non-blocking mode, with a bit transfer rate according to ITU-T standards. It consists of the appropriate digital/analogue converters for the subscriber and trunk modules/cards plus a memory time switch for establishment of the connections required by the Common Control Group.

The data exchange between the Switching Group and the Common Control Group shall be via the high speed data bus incorporating a bidirectional V.24 interface, through which the Common Control unit gives instructions for;

a. Controlling the switching operations.
b. Injecting audible signals.
c. Setting up conferences.
d. Peripheral equipment group

This group shall consist of the various types of line and trunk modules and associated bus extension units. It shall be possible to incorporate both the analogue and digital versions of the line and trunk cards.

**c. Operation/maintenance ports**

The PAX system shall incorporate at least two EIA RS232C serial ports for connection of input/output terminals to enable the program of customer data information and recording and monitoring of traffic data.

**d. Operation/maintenance facilities and alarms**

An adequate range of alarm and test facilities shall be provided to enable the maintenance personnel to rapidly access and localize the fault conditions. The exchange shall be supplied with system management & diagnostic software.

The facility of remote access of the PAX for operation and maintenance purposes shall also be available.

The system shall also contain appropriate hardware and software for the audible and visual display of the whole range of alarms from the PAX equipment to enable the local maintenance personnel to undertake corrective action immediately upon the occurrence of a fault.

The Proposer shall provide complete technical details of the operation/maintenance facilities and alarm display and rectification.

**5) Equipment Cubicle**

The exchange equipment shall be installed in racks mounted in a free-standing swing rack cubicle, of completely enclosed type with a protection class of IP 54 and shall preferably not require any rear access. The cubicle shall be dust and vermin-proof with suitable dust filters and ventilation provided. Accessibility shall be provided from the front for testing, commissioning and maintenance purposes. The cubicle shall have the provision of being locked from the outside. Entrance of the cables shall be through a gland plate provided at the bottom of the cubicle.



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All modules shall be identified as to their shelf location and it is preferred that coded key slots are used in the edge connectors in order that modules cannot be plugged into the wrong shelf position.

**6) Telephone Sets**

**a. Desk telephone set**

Desk telephone shall be a standard single line push button analogue tone dialling set. The keypad and the dialling from the telephone set shall conform to the ITU-T Q23 standard. It shall be possible to attach a hands-free unit, if required.

**b. Wall mounted telephone set**

Wall mounted telephone shall be a push button analogue tone dialling set designed for installation on the wall only. The keypad and the dialling from the telephone set shall conform to the ITU-T Q23 standard.

**c. Executive telephone sets**

Executive telephone shall be a push button tone dialling set with display of at least 2x24 characters to show Names and CLIP, at least 24 programmable memories, digit display, provide full hands-free operation, have programmable function keys with LED indication, support context sensitive features, name dialling and display as well as Message display.

**7) Cabling**

All cabling, between the telephone sets and the PAX and between the PAX and MDF/communication equipment shall be supplied and installed by the Contractor in trenches/ducts and/or cable trays. The telephone cables shall be multi-pair, twisted and screened with suitable protection against vermin/rodent attack.

**8) Power Supply**

The PAX equipment shall be powered from the 48V DC power system.

**6.14.5.4.3 Main Distribution Frame (MDF)**

The termination frames shall be housed in a self-standing 19" cabinet (separate from the PAX cubicle) lockable from the outside. The cabinet shall be dust and vermin proof, designed to a protection class of IP54. Provision shall be made to bond and earth the cabinet to the grounding system within the substation in accordance with the approved earthing scheme. The entry of cables shall be from the bottom through suitable glands provided in the plates and care shall be exercised that the glands are tightly closed after the installation of cables.

The connecting blocks shall be of the quick-connect type, each capable of accommodating at least 10 pairs. It shall incorporate over-voltage and over-current protection on all external trunk and subscriber circuits. These protectors shall be either carbon or gas tube type. Access to the connecting blocks shall be from the front. One (1) quick connect tool shall be provided with the MDF cabinet.

**6.14.6 Substation SCADA System Specifications**

**6.14.6.1 General**

This section pertains to the specifications for SCADA system required for establishing the connection between NPCC/RCC and SAS system at 132 kV Attabad Lake HPP substation. The detail specifications / functional description shall be in the Substation Automation System chapter in the Technical Specifications. / Contract Document.

### 6.14.6.2 Operational and Control Philosophy

Substation shall be under the control of two separate control centres arranged in a hierarchical configuration:

National Power Control Centre (NPCC)/ Regional Control Centre (RCC),

SAS at the substation control room.

The NPCC/RCC shall be responsible for the overall monitoring of 132 kV Attabad Lake HPP substation, and the SAS shall be responsible for the detailed station control requirements.

### 6.14.6.3 Operational Requirements and Control Authorization

The 132kV circuit breaker, disconnect or/earthing switches shall be monitored/controlled from following locations:

a. NPCC/RCC.
b. Substation control room.
c. Bay control cabinet / Equipment own control cabinet

A two position selector switch shall be installed on bay control panel for selection of operator workstation and bay control panel. The control will be shifted to desired location in accordance to switch position.

Status of all equipment shall be provided on NPCC/RCC and substation control room.

### 6.14.6.4 SCADA System & Functions

The SCADA System shall have following major functions:

a. Acquisition and processing of network data,
b. Processing and indication of status signals, alarms, measurements,
c. Visualization of process information and logging (Human Machine Interface),
d. Processing of commands and set point values,
e. Storage and retrieval of archive data including disturbance data processing,
f. Topology calculation and dynamic network coloring,
g. Equipment statistics,
h. Load shedding,
i. Check before execute function.

### 6.14.6.5 Energy Management System (EMS) Functions

a. Short term load forecast (STLF).
b. Schedules management system (SMS) with following modules:
    i. Interchange transaction scheduling (ITS),
    ii. Transaction evaluation (TE),
    iii. Generation scheduling (GS),
    iv. Unit commitment (UC)
c. Real-time Dispatching functions:
    i. Interchange transaction monitoring (ITM)
    ii. Reserve Monitoring (RM)



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iii. Automatic generation control (AGC)
iv. Energy Accounting (EA)
v. Economic Dispatch (optional)

d. Network application (NA) functions (network oriented EMS functions):
i. State estimation (SE) incl. network model builder (NMB)
ii. Bus Load Forecast (BLF)
iii. Dispatcher power flow (DPF)
iv. Optimal power flow (OPF)
v. Contingency analysis (CA)
vi. Outage scheduler (OS)

#### 6.14.6.6 Performance Requirements

The SCADA equipment to be supplied shall be built with high performance, reliability, availability and environmental characteristics.

Time tagging of events and alarms will take place at the substation for both events/alarms list as well as sequence of events recording. The manufacturer shall propose suitable input cards to provide time tagging between events. Provision shall be made to include all measured values, indications and alarms in the sequence of events list, although selected parameters shall be included in the actual list.

#### 6.14.6.7 SCADA Equipment

The solution comprises redundant data links between the 132 kV Attabad Lake HPP substation SAS and the NPCC/RCC to meet the SCADA requirements; provided that the intent of these Specifications is met.

#### 6.14.6.8 Gateway Controller

A gateway controller, especially tailored for data interchange between the SAS computers and the SCADA master system installed at NPCC/RCC, shall be installed at 132 kV Attabad Lake HPP substation for monitoring of the station equipment under SCADA.

The amount and type of information (scope of signals) to be exchanged between the main SCADA computers at NPCC/RCC and the SAS process computers shall be controlled by software blocking/authorization in the gateway controller and the SAS system; such that, in future, if any additional information is required to be transmitted, it can be done with minimum work.

#### 6.14.6.9 Dual Processor Configuration

The design of the gateway controller shall be based on dual processors with duplicated database and operating system. These processors shall be configured in a "hot-standby" mode with switch-over from one processor to the other without any interruption to the SCADA system. The gateway controller shall have built-in hardware/software diagnostic facility which will be able to diagnose the fault at least up to the PCB level. The status of the gateway controller shall be continuously monitored by the SAS operator workstation and any fault/malfunction in the gateway shall be reported to both the operators' consoles and the event/alarm lists of the station.



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#### 6.14.6.10 Communication with NPCC / RCC

The gateway controller shall communicate with the main SCADA equipment at the remote NPCC/RCC via the front end computers utilizing duplicated data channels, preferably on separate physical routes. The data exchange between the NPCC / RCC and the SAS shall include appropriate message coding and security. Errors detected shall cause the data concerned to be invalidated and retransmitted.

#### 6.14.6.11 Communication Interfaces

a. The Gateway controller shall supply all necessary hardware for connection of gateway controller with the communication equipment.

b. For communication with NPCC/RCC, redundant RS-232 and RJ-45 Ethernet ports shall be provided in the Gateway controller for connection to duplicated data channels. The selection of a communication path to the Gateway controller shall be controlled by the SCADA.

c. The serial interfaces shall individually selectable and support a data rate up to 38400 bps using 4-wire, full-duplex communications.

d. The Gateway Controller shall support the following communications protocols:

   I. IEC 60870-5-104 to communicate with NPCC/RCC.
   II. IEC 60870-5-101 to communicate with NPCC/RCC.

e. The Contractor shall provide and implement the communication protocols for each communication port in the Gateway controller. The Employer shall be authorized to disclose the Gateway protocol implementation to third-party suppliers of the Employer equipment.

#### 6.14.6.12 Time Synchronization

For accurate time synchronization satellite based redundant Global Positioning System (GPS) receiver shall be provided at 132 kV Attabad Lake HPP substation. This shall communicate with the GPS installed at NPCC/RCC master clock system.

a. The Gateway Controller shall have an internal clock for data collection coordination and time tagging. This shall include support for sequence of events and disturbance data reporting.

b. The resolution of the clock shall be 1ms, and the clock shall drift by no more than 100ms per day. SAS at 132 kV Attabad Lake HPP substation shall synchronize its internal clock from the Global Positioning System (GPS) receiver.

#### 6.14.6.13 Cabling

Cables between equipment shall be terminated with quality connectors. Shielded cables shall follow the single point grounding system to prevent ground loops. Insulation of all wires shall be non-combustible, flame retardant type. All cables shall be terminated in color and core number order at both ends for easy identification.

#### 6.14.6.14 Power Supply

The SCADA equipment shall be powered from the 48V DC supply or 230V AC UPS.



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### 6.14.7 48V DC Power System Specifications

#### 6.14.7.1 Basis of Design

The 48V DC system at 132 kV Attabad Lake HPP substation shall be designed in accordance with IEC 60146, 60478 and 60896 and shall consist of:

a. Duplicated battery chargers.
b. Duplicated half battery banks.
c. DC distribution.

The design of the DC unit shall minimize the risk of short circuits and shall ensure personnel and operational safety at all times.

The design and selection of equipment and components shall be based on achieving a lifetime of at least 15 years, when operating under the specified service conditions.

The DC power supply shall be rated 48 V. Both "half" battery banks in parallel shall be able, when fully charged, to supply the total load (comprising the delivered load with 30% spare for future use) for at least 10 hours in the event of failure of the AC mains.

The chargers shall be completely suitable for parallel operation and shall have facilities for manual boost charging over a pre-determined period. Each charger shall be capable of supplying the total load independently.

For maintenance purposes it shall be possible to disconnect one "half" battery and associated charger whilst the other "half" system supplies the load.

The DC power supply shall limit the output voltage to within (+20%,-15%) of the nominal value, provided that these voltages do not exceed the voltage guarantee of the load equipment. The power supply positive output shall be connected to the station earth.

The Contractor shall submit load calculations for the battery banks and battery charger ratings, taking into consideration the loads of the proposed equipment.

In the event of AC mains failure causing the batteries to become discharged, each charger shall be rated to:

a. Fulfill the total load requirements (comprising the delivered load plus 30% spare for future use), and charge its battery from the discharge condition to 95% normal capacity within 20 hours, with the output voltage maintained within (+20%,-15%) of the normal value.
b. Rapid charge its battery, at a higher rate (typically 2.4 V per cell) from the discharged condition to 100% nominal capacity within 10 hours.

At the peripheral stations augmentation in existing 48V DC distribution boards shall be provided to power the telecom equipment supplied under this Contract.

#### 6.14.7.2 Configuration

The power supply installation for 132 kV Attabad Lake HPP substation shall be a duplicated system and shall comprise two charging sources and two "half" batteries. The load shall be fed from two DC distribution boards by means of miniature circuit-breakers (MCBs). For the Peripheral station one battery and one DC distribution board shall be provided.

The primary power shall be fed from the essential services busbar.



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### 6.14.7.3 Mode of Operation

In normal operation, the chargers shall operate in parallel and each charger shall be able to float charge its own battery as well as supply the total load.

In the event of a mains failure, both "half" batteries shall be able, when fully charged, to supply the total load, for not less than the specified standby time whilst maintaining the output voltage within permissible limits.

For maintenance purposes it shall be possible to disconnect one "half" battery from the load so that it can be boost charged by its associated charger whilst the other charger supplies the load and floats its "half" battery. When the first "half" battery is fully charged it shall be possible to switch it to feed the load while the other half battery is connected for boost charging. If the AC supply fails during boost conditions the two "half" batteries shall be automatically connected in parallel by "no volt" contactors. It shall not be possible for the load to become disconnected from both batteries and chargers simultaneously.

It shall also not be possible to connect a "boosted" battery to the load until its terminal voltage has fallen below the upper limit of float charge voltage.

### 6.14.7.4 Requirements

The battery chargers and DC distribution boards shall be located in the telecom room of the substation control building. The battery banks shall be installed in the battery room.

### 6.14.7.5 Battery Chargers

#### 6.14.7.5.1 General

Two identical industrial chargers for operation in the substation environment shall be supplied for 48V DC system. Evidence shall be provided with the Proposal for five years satisfactory operation of similar units in power utility/substation applications. The units shall be modular in structure and switched mode power supply (SMPS) type. The chargers shall incorporate measures to limit the distortion caused by the unit on the AC mains.

#### 6.14.7.5.2 Technical Characteristics

The chargers shall, in normal operation, maintain the battery normally floating so that no discharge occurs under normal loading and the battery remains fully charged. The operation of the chargers shall follow the I-U characteristics according to the latest IEC recommendations.

The chargers shall be designed for three phase AC supplies with nominal voltages of 400V ± 10% respectively, at a frequency of 50Hz ± 5%. The units shall maintain the float charge automatically irrespective of the variations in the voltage/ frequency of the AC supply and the DC load within the specified limits.

The voltage/current characteristics of boost charge shall have tapering characteristics in order to minimize gasification. The Contractor shall state the float and boost charge voltages.

The chargers shall have protection against overloads and limit the output typically to 125% of its maximum rating on short- circuit of the DC output. A current limit circuit shall protect a discharged battery from overcharging when connected to the charger.

Fast acting fuses shall be incorporated in the charger to protect the equipment from damage.



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The charger efficiency shall not be less than 90%. For all chargers, Proposer shall specify the efficiency and input power factor at both full and lightly loaded conditions.

#### 6.14.7.5.3 Requirements

The battery chargers shall be designed in accordance with relevant IEC standards and requirements listed hereunder:

- Nominal system voltage :48V
- Float voltage :2.2-2.23V/cell
- Boost voltage :2.35-2.4V/cell
- Rated current :100A (30A at Peripheral stations)
- Duty class (as per IEC 60146) :1
- Number of chargers :2
- Guaranteed temperature range: -10 to 50°C

#### 6.14.7.5.4 Float Charging Conditions

The output voltage regulator shall be adjustable within limits, approved by the Employer, and shall be so designed that special tools are not required for any adjustment.

The voltage reference point for control of the charger output voltage shall not be obtained from a source external to the charger.

The output of the charger on float charge shall be equal to the normal battery standing load plus the recommended finishing charge rate.

The charger shall have electronic protection to avoid discharging the battery through the charger should the latter become defective.

#### 6.14.7.5.5 Boost Charging Conditions

Under boost charging conditions the charger shall fully recharge the battery after a heavy discharge without gassing or damage to the battery. A suitable boost timer switch shall be included in the circuit.

The boost voltage and boost timer settings shall be chosen to ensure that a discharged battery can be fully charged within the period specified above.

Manual boost charging facility shall be required in the following instances:

a. During the initial charging of the battery, prior to it being put into operation.
b. During a prolonged AC mains shutdown.
c. Prior to performance of the battery capacity tests.

#### 6.14.7.5.6 Controls and Alarms

Each charger shall be equipped with a switch fuse for the incoming AC supply and either a circuit-breaker or fuse for the DC output. Potential free changeover contacts shall be provided for external alarm extension of these fuses/circuit breakers in the telecom room/control room.

The following alarms shall be provided, as a minimum:

a. AC mains failure.
b. Charger failure.



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c. High output volt.
d. Low output volts.
e. Charger on manual boost.

Potential free changeover contacts shall be provided for external extension of the above alarms.

#### 6.14.7.6 Instrumentation and 48V DC Distribution

##### 6.14.7.6.1 Instrumentation

Common control and interlocking shall be kept to a minimum. Instrumentation for the system shall comprise, but shall not be limited, to the following:

a. DC voltmeter for each charger output and the distribution busbar.
b. DC ammeter for each charger output.
c. DC ammeter for each battery marked "charge" and "discharge".
d. DC voltmeter for each battery.
e. DC ammeter for total load current.

##### 6.14.7.6.2 48V DC Distribution

The distribution section for 132 kV Attabad Lake HPP substation shall be designed for both incoming and outgoing 48V supplies as follows:

a. Two independent 48V supplies incoming from the batteries and associated chargers. Each battery negative supply shall be connected to the cubicle busbar through a blocking diode and a single pole switch.

   The 48V DC battery positive leads shall be connected directly to the station earth.

b. Each load equipment shall be connected to a distribution outlet. The use of teed supplies to more than one load equipment will not be permitted.

c. Double pole miniature or molded case circuit-breakers to IEC 60157 shall be supplied, fitted with auxiliary contacts which shall raise both local and remote alarms, for loss of supplies.

d. The outlets shall be rated to meet the requirements of the loads and shall be labelled with the destination of the output. Outgoing connections shall be brought to terminals mounted in the cubicle, provided with strip connectors and cable lugs. The number of outlets shall cater for the quantity of load equipment items plus 50%, with a minimum of 10 outlets being provided in each distribution board. Space shall also be available for the installation of 50% extra outlets with terminals for future use.

#### 6.14.7.7 Alarms

An alarm indication shall be provided if the busbar voltage falls below the battery cut-off voltage or deviates from the float/boost values. The actual alarm limits are to be determined during detailed engineering. All alarms shall be extendible from potential free contacts to an external alarm monitoring system.

#### 6.14.7.8 Housing

The battery chargers and the control/distribution equipment shall be housed in separate cubicles (total 3 cubicles) at 132 kV Attabad Lake HPP substation; installation in single cabinet shall not be accepted.



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The charger cubicles shall be of strong steel, floor mounted type, completely vermin-proof and suitable for installation in tropical climates. The DC distribution cubicle shall preferably be wall mounted. The entry of the cables shall be from the bottom, with suitable cable glands being provided at the entry points. Provision shall be kept for separate earthing of the cubicles.

The cubicles shall be adequately ventilated for self-cooling by natural convection. Forced cooling shall not be permitted.

Access to the components shall be from the front of the cubicle. Ease of access for operation and maintenance shall be kept in the design. In case rear access is required, the steps taken shall be identified. Cubicles shall be lockable from the outside.

#### 6.14.7.9 Batteries

#### 6.14.7.9.1 General

Lead acid vented cells of the Plante type shall be provided. Containers shall be of stout glass or high impact plastic.

Cells shall be permanently marked with the following information:

a. Manufacturer's name, reference number and code.
b. Year and month of manufacture.
c. Voltage and nominal capacity at the specified discharge rate.
d. Cell number.

#### 6.14.7.9.2 Construction

The batteries shall be of compact design with a small weight to capacity ratio. The construction shall ensure minimum self-discharge and low internal resistance.

Adequate measures shall be taken for prevention of internal short circuits and protection of the element against mechanical damage.

#### 6.14.7.9.3 Requirements

The battery bank shall be designed in accordance with relevant IEC standards and requirements listed hereunder:

| | |
|---|---|
| Nominal system voltage | 48V22 |
| Nominal voltage per cell | 2V |
| Aging factor (minimum) | 1.25 |
| Rated capacity at 10 hours discharge rate | 540AH at 132 kV Attabad Lake HPP substation<br>170AH at Peripheral stations |
| Number of Batteries | 2 at 132 kV Attabad Lake HPP substation, 1 at Peripheral stations |

The Contractor shall submit load calculations to fully justify the battery chargers and battery ratings.



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#### 6.14.7.9.4 Battery Mounting

The batteries shall be mounted on wooden or metal stands or racks in a manner such that all the plates of each cell are visible for inspection, test and maintenance purposes. Stands or racks shall have a maximum of two tiers. In all cases adequate space shall be left between the tiers for maintenance purposes and to permit the topping up of the electrolyte. Stands or racks shall have a protective finish of not less than two coats of electrolyte resisting enamel or gloss paint. Alternatively, an epoxy resin sintered finish may be used.

Cell containers shall be accurately set up in alignment on the stand or rack with lead and/or rubber discs under the feet molded on each container. Cell lids shall be so positioned that at least one topping-up aperture is on the access gangway side of the cell and not obstructed by any inter-cell connecting arrangements. Each battery shall be labelled together with the appropriate cell numbers.

#### 6.14.7.9.5 Battery Main Fuses

Bolted cartridge fuses shall be provided in both positive and negative leads and positioned as close to the battery as possible. The fuses shall be rated at five (5) times the charger float output rated current. Monitoring of the battery fuses shall be provided on the DC distribution, and an alarm (red LED) shall be generated in the event of blowout of the fuse. A cartridge fuse shall be provided in the charger-input lead to the negative pole of the battery and rated at twice the charger float output rated current. These fuses shall be mounted preferably on the end of the battery stand or rack. The fuse links shall be mounted in fuse carriers with an insulated barrier between the poles.

The cable or busbar to the battery shall be firmly supported at a point near the cell terminal pillar. Where two cables are used, they shall be terminated one on either side of the terminal pillar. These cables shall be arranged as to allow some flexibility and to avoid any forces being applied to the cell terminal pillar.

#### 6.14.7.9.6 Connections

The positive pole of the battery shall be connected to the station earth via a single bolted link at the distribution cubicle. Low resistance inter cell connectors shall be used. Connections between tier of cells and between end cells and fuses shall be made with insulated copper rod that shall be of equivalent cross-section to the distribution busbars.

Connections from the battery fuses to the chargers and distribution cubicles shall be made with insulated cable of equivalent cross-section to the distribution busbars. The positive and negative terminals of each cell shall be clearly indicated. Red and black marking respectively shall indicate the positive and negative terminals of the complete battery.

#### 6.14.7.9.7 Accessories

All accessories required for installation, connection, service and maintenance shall be provided. The accessories shall include, but not limited to; one portable hydrometer syringe, one portable thermometer, one cell-lifting device for each battery, one digital voltmeter and battery acid in two containers.

Lead plated copper inter cell connectors shall be supplied to provide 1.25cm spacing between cells when installed with plates at right angles to the rack rails.

#### 6.14.7.9.8 Life

The end of service life shall be the time when the battery no longer delivers 80% of its rated capacity. The batteries shall have a minimum of Fifteen (15) years of guaranteed life.



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### 6.14.8 Factory Acceptance Tests

#### 6.14.8.1 Type Tests

Evidence shall be given that the proposed Telecommunication and SCADA equipment have been subjected to type tests certified by an internationally recognized testing laboratory. If deemed necessary, Employer will decide whether additional tests are necessary to be performed by the Contractor.

The telecom and SCADA equipment (i.e., DPLC, OLTE/MUX, DPSE/PSE, LMUs, PAX, and Gateway Controller) shall have successfully undergone, as a minimum, the following type tests:

a. Dry heat test (according to IEC 60068-2-2).
b. Damp heat test (according to IEC 60068-2-78).
c. Vibration test (according to IEC 60068-2-27).
d. Shock test (according to IEC 60068-2-6).
e. Insulation tests (according to IEC 60950-1).
f. EMC immunity tests (according to IECTS 61000-6-5/EN-61000-6-2).
g. EMC emission tests (according to CISPR22/EN 61000-6-4).

The following type tests shall be made on the line traps in accordance with the latest issue of IEC 60353. However, duly certified and complete test reports for type tests carried out by an independent authority/laboratory on same type of line traps shall be acceptable in lieu of performing the actual tests. Independent laboratories are specified elsewhere in these Specifications.

a. Temperature rise test.
b. Measurement of radio influence voltage.
c. Insulation tests.
d. Short-time current tests.
e. Measurement of the rated inductance of the main coil.
f. Measurement of power frequency inductance of the main coil.
g. Measurement of blocking resistance and blocking impedance.
h. Measurement of tapping loss and tapping loss based on the blocking resistance.

The Proposer shall submit certified copies of type test reports covering the above equipment. Type tests reports shall be considered acceptable if they are in compliance with the relevant Standards and the following:

a. Type tests conducted at an internationally recognized laboratory approved by Client.
b. Type tests performed at manufacturer's laboratory and witnessed by representative(s) from an internationally recognized laboratory.

Failure to provide the type test reports or if the presented reports are not in accordance with the above requirements, then the type tests shall be carried out in the Manufacturer's premises or other places subject to the approval of the Client in the presence of Employer's and Employer representatives and at no additional cost to the Employer. These tests shall be performed in the presence of an internationally recognized laboratory representative, who shall issue the relevant type test reports upon successful tests.



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#### 6.14.8.2 Routine Tests

Routine Tests shall be performed, comprising, as a minimum, the following:

#### 6.14.8.3 General

a. Visual checks.
b. Checks of wiring and labelling.
c. Verification of material and quantities for each equipment.
d. Test of cubicles internal illumination.
e. Check of spare parts and quantities.
f. Check of calibration of test equipment.

#### 6.14.8.4 Power Line Carrier Equipment

a. Functional checks on simulated 80W DPLC links for communication of speech, data and Tele protection signals.
b. Measurement of regulated power supply outputs.
c. Measurement of transmit and receive frequencies.
d. Measurement of transmitter power.
e. Measurement of receiver sensitivity.
f. Tuning/adjustment of transmit and receive filters.
g. Level adjustments for transmitter, teleoperation and telephony.
h. Automatic gain control (AGC) and equalization settings.
i. Frequency response over the specified bandwidth.
j. Measurement of cross-talk.
k. Verification of configuration and diagnostics (if any) software.
l. Functional check of indications and alarms.
m. Check of service telephone.

#### 6.14.8.5 Analogue and Digital Protection Signaling Equipment

a. Measurement of voltage at regulated power supply outputs.
b. Measurement of transmit and receive levels.
c. Check of various codes.
d. Check of correct transmission of trip commands.
e. Measurement of command transmission times.
f. Tests to demonstrate equipment dependability and security, in the presence of interfering signals or noise at levels likely to be encountered in the grid stations.
g. Functional check of indications and alarms.

#### 6.14.8.6 Line Matching Unit (Coupling Filter)

a. Drain Coil:

   I. Measurement of impedance at power frequency,
   II. Current carrying capacity at power frequency of 1 A rms continuous,
   III. Current carrying capacity at power frequency of 50 A rms for 0.2 seconds.



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- Composite loss over the working range of the coupling filter.
- Return loss over the working range of the coupling filter.
- Power frequency voltage tests on the balancing transformer of 5kV rms for 1 minute between each coil and earth, and between each coil and screen.

#### 6.14.8.7 Coaxial Cable

a. Visual check of drum and cable sample.

b. Measurement of characteristic impedance.

c. Measurement of attenuation in frequency range 40-500 kHz.

d. Measurement of conductor resistance.

e. Measurement of insulation resistance.

f. Measurement of mutual capacitance.

g. High voltages withstand capability.

#### 6.14.8.8 SDHOLTE / Multiplexer Equipment

a. Measurement of voltage at regulated power supply outputs.

b. Measurement of optical transmitted power and received level.

c. Measurement of receiver sensitivity.

d. Redundancy checks in OLTE, power supplies and control units and multiplexer section protection.

e. Verification of configuration and diagnostics (if any) software.

f. Functional check of indications and alarms.

g. Check of EOW service telephone.

h. Functional checks including synchronization checks and path protection etc.

i. Functional checks of available channels.

j. Verification of configuration and diagnostics software.

k. Check of Management system.

#### 6.14.8.9 Telephone (PAX) Equipment

a. Functional test of trunks and extensions.

b. Check of all types of tones in the system.

c. Tests of system reloading and resetting capabilities in the event of occurrence of various categories of faults.

d. Tests to ensure correct receipt and logging of alarms and correct functioning of automatic diagnostic routines.

e. Verification of the configuration and diagnostic software.

f. Check of Management system.

#### 6.14.8.10 48V DC Power Equipment

g. Tests to record DC output voltage variation under float/boost charge conditions for the various settings of the DC current output variation from zero to maximum values.



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h. Tests to record DC output voltage variation under float/boost charge conditions for the various settings of the DC output current switch variation in AC mains voltage from 313 to 452V for 3-phase chargers.

i. Tests to confirm maximum temperature rise of main transformer and other components of the battery charger.

j. Capacity test of battery bank, according to IEC 60896-1.

### 6.14.9 Drawings And Documentation

#### 6.14.9.1 General

a. A comprehensive set of drawings and associated documents shall be provided for each substation. The station name shall appear in the title block of each drawing and the use of drawings common to several substations shall be avoided. When the drawings are finalized, the Contractor shall provide for each drawing an electronic file on CD/DVD.

b. Drawings shall be on ISO 'A' size sheets. The preferred size shall be A3 (297 x 420 mm).

#### 6.14.9.2 Information to be included with the Proposal

The Proposal shall be accompanied with following information:

a. Completely filled-in Specific Works Data sheets.

b. Type test reports for offered DPLC, SDHOLTE/MUXDPSE/PSE, PAX, Gateway Controller and 48V DC charger equipment.

c. Documentary evidence (Project lists, Client's certificates etc.) for DPLC, SDHOLTE / MUX DPSE / PSE, PAX, Gateway Controller and 48V DC chargers / batteries.

d. Manufacturer's booklets giving technical details of all equipment included in Proposer's offer.

#### 6.14.9.3 Approval Drawings and Data

Approval drawings/documents shall be submitted after Contract award that shall show detailed physical arrangements and connections. The information, as a minimum, shall include:

#### 6.14.9.4 For Base Design

Following documents/drawings shall be submitted:

a. Site survey report of existing facilities,

b. Telecommunication network layout.

c. Telephone network layout.

d. Tele protection interconnection concept.

e. Schematic layout of DPLC data channels between 132 kV Attabad Lake HPP substation and NPCC/RCC.

f. SNR calculations for the DPLC links.

g. Frequency allocation plan for the DPLC links.

h. Optical budget calculations for fiber optic links.

i. Cabinet and rack layout drawings for DPLC, SDHOLTE / MUX, DPSE/PSE, PAX, Gateway Controller, GPS.

j. SCADA point count details.

#### 6.14.9.5 For Detailed Design

Following documents/drawings shall be submitted after finalization of Base Design:

a. Overall station arrangement drawings.

b. Functional specifications of DPLC / PSE, SDHOLTE / MUX / DPSE, PAX, Gateway Controller, GPS, 48V DC Power, systems including technical details for each equipment item.

c. Wiring charts / diagrams, cable schedules and lists of apparatus.

d. MDF cross-connection termination details.

e. Tele protection interconnection drawings.

f. Telephone numbering and routing plan.

g. Layout of equipment in control building.

h. Interconnection drawing (with termination details) showing the end-to-end route of each data channel between 132 kV Attabad Lake HPP substation and NPCC/RCC.

i. List of spare parts and unit rates.

j. List of erection and testing equipment and maintenance tools.

k. Details of maintenance and testing facilities.

#### 6.14.9.6 For Testing/Commissioning:

Following documents shall be submitted at least three months prior to holding the FAT/SAT:

a. Factory Acceptance Test (FAT) procedures/protocols.

b. Site Acceptance Test (SAT) procedures/protocols.

#### 6.14.9.7 Prior to taking over by Employer:

a. As-built drawings, schematic and wiring diagrams.

b. Operation and maintenance (O&M) manuals.

## 6.15 CONTROL AND POWER CABLES

### 6.15.1 General

These Specifications cover the requirements for design, manufacture, and installation of control and power cables. The cables shall be used for AC and DC supplies, protection & measurement, control & annunciation and lighting circuits.

The cables shall be suitable for continuous operation at conductor temperature of 90 deg. C. The cables shall be designed, manufactured and tested according to the latest issue of the relevant IEC Publications.

#### 6.15.1.1 Services

(1) **AC Power Supply Circuits:** The AC cables shall be used for connections between auxiliary transformers and AC panels, connections related to auxiliary services such as



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supply of transformer fans, power receptacles, lighting etc. and power supply to equipment, such as motors for breakers, heaters in local control cubicles, etc.

(2) **DC Power Supply Circuits:** DC power supply circuits constitute the connections between batteries, chargers, DC distribution boards and DC loads.

(3) **Protection and Measurement Circuits:** AC protection and measurement circuits are the connections between voltage and current transformers and equipment such as protective devices, meters and recorders.

(4) **Control and Annunciation Circuits:** These circuits consist of all AC/DC supply circuits between control boards, marshalling boxes, relay panels etc. for control and annunciation of different activities in the switchyard.

(5) **11 kV Power Cables:**11kV XLPE insulated cables suitable for 8.7/15 (17.5) kV voltage class for interconnection between the two outgoings of 11kV switchgear to two Nos.11kV/400V station auxiliary power transformers and 11kV switchgear power house to the 11kV switchgear incoming-I & Incoming-II.

### 6.15.1.2 SELECTION OF CABLE SIZE

(1) The Contractor shall provide detailed design calculations to determine the exact size and number of cores for each circuit. The voltage drop in the cable at load terminal shall not be more than 2.5% of voltage at main distribution board. At least 25% spare cores shall be provided in addition to the required cores where multicore cable of more than for (4) cores is used.

(2) The derated values of current ratings of cable obtained after applying all applicable derating factors shall be greater than load currents for which those cables are selected.

The cable shall be of adequate size to withstand the short circuit current equal to the interrupting current of the circuit breaker protecting the circuit.

### 6.15.1.3 SPECIFICATIONS

#### 6.15.1.3.1 General

All cables shall have copper conductor, XLPE insulation and extruded PVC sheath. All control and power cables shall be armored as specified. Protection and measurement cables shall be shielded with metallic screen. Control and annunciation circuit cables shall have bundle helical wrapping of MYLAR tape and shielding of metallic screen. All cables shall have overall black PVC jacket.

#### 6.15.1.3.2 Applicable Standards

All cables shall be designed, manufactured and tested in accordance with latest revision of the applicable standards listed below, unless otherwise stated in these specifications:

(1) IEC 60228 — Conductors of insulated cables.

(2) IEC 60502 — Power cables with extruded insulation and their accessories for rated voltage from 1kV to 30kV (Um=36kV):

a) Part-1: Cables for rated voltages of 1 kV ($U_m$=1,2kV) and 3 kV ($U_m$=3,6 kV).

b) Part-2: Cables for rated voltages from 6 kV ($U_m$=7,2kV) up to 30 kV ($U_m$=36 kV).



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c) Part-4: Test requirements on accessories for cables with rated voltages from 6 kV ($U_m$=7.2 kV) up to 30 kV ($U_m$=36 kV).

(3) IEC 60811 Insulating and sheaths material of electric and optical cables. Common test methods

**6.15.1.3.3 Control and Small Power Cables**

(a) **Conductor:** The cores of the cable shall be of circular annealed stranded copper conductor. The minimum size for control circuit cables shall be 2.5 sq. mm. However, the minimum size of cable acceptable for current transformer output connections shall be 6 sq. mm. The copper conductor shall conform to IEC 60228. The size and number of individual conductor strands shall be as specified in the applicable standards.

(b) **Insulation:** The insulated sheath of conductors shall be cross linked polyethylene (XLPE) suitable for maximum operating class of 600/1000V in accordance with latest IEC Publication 60502. It shall be capable of being isolated easily from the conductor. The insulation over the conductor shall be applied by extrusion process. The insulation shall be heat and moisture resistant.

(c) **Assembly:** The insulated cores shall be assembled and padded in an extruded PVC sheath, which shall have no harmful influence on the components, nor propagate the flame.

(d) **Screen:** The metallic screen shall be superimposed directly on the conductor assembly for shielding. The metallic screen shall be seamless copper or aluminum or other non-magnetic material as recommended by IEC.

(e) **Armor:** The armor shall be "Aluminum wires or aluminum strips with a minimum thickness as specified in the standards, applied over the conductor's assembly.

(f) **External** Protective **Jacket:** The conductors shall be sheathed in black PVC applied by extrusion methods. The Jacket shall have flame retardant properties and shall be compounded for maximum resistance for sunlight. It shall conform to thickness and physical properties as specified in IEC Publication 60502.

**6.15.1.4 15 kV XLPE Power Cables**

**(a)** **Composition:** The 1 core cable shall be suitable for 8.7/15 (17.5) kV voltage class to be used for 11000 volts A.C. 50 Hz supply and shall conform to the following. The size of cable shall be as per Clause 6.15.1.2:

1. Conductors shall consist of circular stranded copper of electrical grade purity. It shall be covered by an extruded semi-conducting layer which shall adhere firmly to it.
2. The insulation shall be made of cross linked polyethylene. The insulation shall be applied over the semi-conducting layer and shall be permanently and completely bonded to it without any voids. The thickness of insulation shall be in accordance with IEC 60502-2.
3. A semi-conducting layer or tape shall be supplied over the surface of the insulation and shall adhere firmly to the surface. However, it shall be capable of being removed cleanly and conveniently for jointing purposes.



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4. Annealed copper shielding tape shall be applied helically to the surface of the insulation with an overlap of 50 percent of the tape width.

5. The cable shall be covered with an Inner Jacket made of 105 deg. C polyvinyl chloride compound which shall be formed tightly around the cable.

6. A bedding tape made of rubberized cotton or shall be applied over the inner PVC jacket.

7. Armour shall be applied over the bedding. The armour shall consist either of two layers of galvanized steel tape or a single layer of interlocked galvanized steel tape or Aluminium wire. The armour shall be sized to sustain short- circuit current for 5 seconds.

8. Applicable IEC standards to be followed.

**(b) Service Conditions**

1. The cables shall be suitable for operation in 11000 volts, 50 Hz, three phase distribution system. Cables shall be operated in a three phase three wire system with the power transformer neutral solidly grounded.

2. The cables shall be suitable for direct burial or installation in ducts. The duct and soil conditions vary from dry to wet. Highly corrosive salts are encountered in the soil. The ambient temperature ranges from-5 deg C. to 50 deg C.

3. The cross-linked polyethylene cable shall be suitable for conductor operating temperatures as follows:

| | |
|---|---|
| Continuous operation | 90°C |
| Emergency overload | 130°C |
| Short Circuit (5 seconds) | 250°C |

4. The cables shall be designed to withstand the emergency overloading conditions without loss of life for emergency operating periods of approximately 100 hours per annum.

5. The cables shall be laid in complete lengths. Jointing of cables shall not be allowed.

**(c) Dimensions and Characteristics**

1. The cables shall be of sizes as per Clause 6.15.1.2.
2. The dimensions of the conductors, test voltage etc; shall be in accordance with IEC 60228 and IEC 60502 Part-1 and Part-2.

3. The cross-sectional area of the conductor shall be the sum of the area of its component wires at any point. It shall not be less than 98 percent of the area specified.

**(d) Insulation**

**Cross-linked polyethylene:** The cross-linked polyethylene insulation shall be suitable for use in wet and dry locations, and a continuous conductor operating temperature of 90 deg C throughout its life and for service under the conditions described in Clause 6.2.2 of these Specifications.

**(e) 15KV Heat Shrinkable Cable Termination:** The heat shrinkable cable and terminations for XLPE cables shall be in accordance with relevant standard.



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The heat-shrinkable material shall be either extruded or molded polymeric material which shall be cross-linked, either by eradication or by chemical means, such that when their temperature is raised beyond the normal base polymer crystalline melting point, they shall be held in expanded state.

**(f)** **Service Requirements:** Components shall be suitable for use in high voltage cable joints and terminations and shall be suitable for indoor or outdoor applications as required. Components shall be suitable for use in XLPE insulated cables manufactured in accordance with IEC Publication 60502-2. Components shall not be adversely affected in any manner by contact with other materials normally used in the construction of cable joints and terminations, and shall not increase the rate of corrosion of any metal with which they may come into contact. Assembled components forming part of the supply system shall perform without distress under the following conditions:

1. **Normal Conditions:** Polymeric Insulated Cables - Continuous operation at a conductor temperature of 90°C.

2. **Fault Conditions:** XLPE Insulated Cables - Operation at a conductor and screen / earth wire temperature of 250°C.

**(g)** **Identification and Packaging:** For the purposes of identification, gloves shall be marked clearly and permanently in a prominent position with the supplier's name and reference number.

Electrically conducting components shall be marked ‘conducting' clearly and permanently.

Components shall normally be supplied in a package as a complete joint of termination which shall be clearly marked with the supplier's name, reference number, batch references, voltage, application and cable size.

Packaging shall be designed to protect against ingress of moisture and mechanical damage.

Components supplied individually shall be packaged in accordance with the above.

Where the Employer requires tubing to be supplied on reels these shall have adequate flanges to contain fully the length of tubing. Reels shall be packaged in accordance with the above.

Components supplied with adhesive coatings shall have means to prevent coated surfaces from adhering to each other.

**(h)** **Storage:** Components shall be capable of being stored without deterioration within the temperature range -10°C to +45°C.

Components or materials, if subject to a shelf life limitation, shall have the final date of use, prominently and permanently shown on all package.

**(i)** **Tubing Components**

1. **Internal Insulating Tubing:** A heat-shrinkable flexible polymeric tubing, preferably clear or colored white, for use in internal construction of cable joints and terminations at installations where it will not be exposed to daylight.



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2. **Stress Control Tubing:** A heat-shrinkable flexible polymeric tubing, permanently colored black, possessing properties to provide electrical stress control over insulated cores in cable joints and terminations, at installations where it will not be exposed to daylight.

3. **Anti-track Tubing (Indoor):** A heat- shrinkable flexible polymeric tubing, easily distinguishable by color from non-anti- track material, but preferably colored brown, possessing anti-track and erosion- resistant properties for use as an external covering of insulated cores in cable joints and terminations in situations where it will not be exposed to direct sunlight.

4. **Anti-track Tubing (Outdoor):** A heat- shrinkable flexible polymeric tubing, easily distinguishable by color from non-anti- track material, but preferably colored red, possessing anti-track and erosion-resistant properties for use as an external covering of insulated cores in cable joints and terminations at indoor and outdoor installations.

5. **External Protective Tubing:** A heat- shrinkable flexible polymeric tubing, preferably colored for protecting exposed metallic sheaths and sheath/earth connections on cable joints and terminations at indoor and outdoor installations.

**(j) Molded Components**

1. **Anti-track Insulating-Glove (Indoor):** A heat-shrinkable flexible polymeric molding, easily distinguishable by color from non- anti-track material, but preferably colored brown, possessing anti-track and erosion- resistant properties, for sealing a prepared crotch in cable joints and terminations at installations where it will not be exposed to direct sunlight.

2. **Anti-track Insulating Glove (Outdoor):** A heat-shrinkable flexible polymeric molding, easily distinguishable by color from non- anti-track material, but preferably colored red, possessing anti-track and erosion- resistant properties, for sealing a prepared crotch in cable joints and terminations at indoor and outdoor installations.

3. **Conducting Glove:** A heat-shrinkable flexible polymeric molding, permanently colored black possessing electrical conducting properties, or for sealing a prepared crotch in cable joints and terminations at indoor and outdoor installations.

4. **Anti-track Shroud (Indoor):** A heat- shrinkable flexible polymeric molding, easily distinguishable from non-antitrack material, but preferably colored brown, possessing anti-track and erosion-resistant properties, for enclosing and sealing prepared cable-core connections at installations where it will not be exposed to direct sunlight.

5. **Anti-track Weather Shed:** A heat-shrinkable flexible polymeric molding, easily distinguishable from non-antitrack material, but preferably colored red, possessing anti-track and erosion-resistant properties, for application over prepared cable cores.

**(k) Sealants:** Where required, sealants shall be used in conjunction with heat-shrinkable components to affect seals on joints and terminations, and shall be able to accommodate the creep or relaxations that may occur with recovered heat- shrink materials.

The sealants shall have adhesive properties to maintain hermetic seals between components at all times when used on polymeric.

### 6.15.2 Cable and Core Identifications

#### 6.15.2.1 Cable Identification

The following information shall be permanently marked at the interval of 1 meter on the outer PVC jacket of each cable:

(a) Name of manufacturer.
(b) Cable Type
(c) Year of manufacturer
(d) Running length of cable in meters after every meter of length.

#### 6.15.2.2 Core Identification

The identification of the insulated cores shall be made by color compound and surface printing of number.

2 cores Red, Black
3 cores Red, Yellow, Blue
4 cores Red, Yellow, Blue, Black
5 cores to the colors of the insulation
6 cores shall be black and coding shall consist of printed digits and number written in text.

The color shall be clearly distinguishable under all normal conditions of illumination and shall remain legible under all normal conditions of usage. Numbers shall be clearly imprinted using character as large as possible considering the conductor size. The material used shall not interact with the insulation or the associated fillers or binders used in the cable construction in any way such as might produce deterioration of the insulation or fading or blurring of the imprinted characters.

This identification number shall be repeated along the length of the conductor with a gap of approximately 300 mm.

### 6.15.3 Flame Retardancy

The finished cables shall be flame-retardant and suitable for direct burial in earth.

### 6.15.4 Cable Terminations

Contractor shall provide all materials for termination of power and control cables. Control cables terminal lugs shall be clamp type ring terminals, or crimped connectors suitable for stud termination or approved equivalent.

Power cable terminal shall be rectangular tongue type suitable for compression crimp method of installation or approved equivalent.

Cable glands of appropriate sizes shall be used at cable entrance into control panels, relay panels, marshalling boxes etc. Cable shield and armor shall generally be grounded on the both ends of cable.

Cable identification tags, sleeves shall be provided at cable terminations.

Identification labels for panel's internal wiring, cable cores termination at terminal blocks and cables shall be provided as per the following examples.



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There shall be cross ferruling containing local as well as destination addresses. The ferrules shall be slip over type of high quality material suitable for the specified climatic conditions.

**a) Panel Internal Wiring**

**Example:** Wire between terminal 4 of device -S11 and terminal 46 of terminal block -X201.

At device -S11:

| | | | | | |
|---|---|---|---|---|---|
| :4 | / | - X201 | 46 | / | 16 |
| Terminal number of -S11 | / | Terminal block No. | Terminal No. in terminal block | / | Sheet No. in Schematic Diagram |

Destination

At terminal Block -X201:

| | | | | | |
|---|---|---|---|---|---|
| :46 | / | - S11 | 4 | / | 16 |
| Terminal number in terminal block | / | Device | Terminal No. of device | / | Sheet No. in Schematic Diagram |

Destination

**b) Cable Core Termination Identification**

Example:

| | | | | |
|---|---|---|---|---|
| :011 | / | - X501 | / | 35 |
| Cable number | / | Terminal Block Number | / | Terminal No. in terminal block |

**c) Cable Number Identification**

**Example:** Cable between Marshalling Kiosk +S11 and Control Panel +WC02 of bay feeder G021

At Marshalling Kiosk:

| | | | | |
|---|---|---|---|---|
| : G021 | / | 356 | / | +WC02 |
| Bay Number | / | Cable Number | / | Destination |

At Control Panel:

| | | | | |
|---|---|---|---|---|
| : G021 | / | 356 | / | ++S11 |
| Bay Number | / | Cable Number | / | Destination |

**6.15.5 Cable Installation**

All power and control cables shall be installed in cable trenches or on cable trays, cable racks or in metallic conduits. The Contractor shall provide and install all cable trays, cable racks and cable conduits as approved by the Employer.



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### 6.15.6 Cable Conduits

The Contractor shall furnish and install all conduits, boxes, wire ways, and fittings required for the electrical power, control, annunciation, instrumentation, communication systems as required or as directed. All necessary hardware such as screws, bolts, hangers, concrete, clamps, locknuts, bushings, sealing bushings, couplings, pulling- in irons, identification tags, etc., shall be included.

Rigid, flexible steel conduits shall be hot dip galvanized steel conforming to the specified standards. Flexible liquid tight conduits shall conform to the specified standards. These shall be used in wet locations or where exposed to weather.

Metal conduit fittings and covers shall be of standard manufacture and shall be galvanized. Long radius bend and expansion joint fittings shall be provided where required while gaskets shall be provided where required to prevent ingress of moisture.

Junction, outlet, and pull boxes and covers made of sheet steel or cast metal shall conform to the specified standard. Covers shall be secured with screws, except for boxes 0.5 sq.mm or larger which shall have hinged covers. All outdoor boxes shall conform to protection class IP55.

Installation of all conduits, boxes, fittings, and accessories shall conform to IEC insofar as these are applicable. Conduits shall be inspected before conductors are installed and thoroughly cleaned of water and dirt by means of compressed air, swabs or other approved methods. Conduits shall be checked for freedom from obstructions by pulling a wooden mandrel of the proper size through the conduit, wherever required or directed. All boxes and fittings shall be kept closed and free from dirt, moisture and debris.

Exposed conduit, minimum size 18 mm, shall be supported at not more than 1.5 m intervals, and conduits 25 mm and larger shall be supported at not more than 2.5 m intervals. Embedded conduits shall be 25 mm except that 19 mm conduit may be used for communication circuits. Embedded conduit shall be slopped towards drain points and shall be rigidly supported and braced to avoid shifting during placement of concrete. A minimum spacing of 50 mm shall be maintained except where conduits enter boxes, equipment or hand holes.

#### 6.15.6.1 Cable Trays, Racks and Supports

The Contractor shall design, furnish and install all equipment including brackets, steel supports or transit barriers, hardware, and special fittings for routing of power and control cables in the switchyard and building(s), as required. Complete cable trays layout and tray support drawings shall be prepared by the Contractor and submitted for Employer's review and approval.

Tray support brackets shall be steel ladder type of required width with 225 mm rung spacing and a minimum of 75 mm inside depth and shall conform to the requirements of specified standards. Steel trays and fittings shall be hot-dip galvanized after fabrication.

Tray support brackets shall be mounted on steel supporting structures anchored to the wall, floor or ceiling.

Supporting structures shall permit a certain degree of flexibility for adjustment in position of the trays or racks. Embedded sections shall be used for better appearance. All steel fittings, bolts, and nuts shall be hot-dip galvanized.

A grounding conductor shall run in the cable tray which will be grounded with the main grounding mash at a regular interval of 20m. The conductor shall also be clamped with the cable trays at a regular interval of 10m.



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The Contractor shall furnish certified test reports of the tests covered by the specified standards for cables and accessories.

**6.15.7 Tests**

**a) 0.6/1(1.2) kV Cables**

The following routine tests shall be carried out as per IEC 60502-1:

**1. Routine Tests**

The following routine tests shall be carried out on each manufactured length of cable as per IEC 60502-1:

a) Measurement of the electrical resistance of conductors.
b) Voltage test.
c) Insulation resistance test.

**2. Sample Tests**

a) Conductor examination
b) Check of dimension
c) Hot set test for XLPE insulations and elastomeric sheaths.

**3. Type Tests, Electrical**

a) Insulation resistance measurement at ambient temperature.
b) Insulation resistance measurement at maximum conductor temperature.
c) Voltage tests for 4h.

**4. Type Tests, Non-Electrical**

a) Measurement of thickness of insulation.
b) Measurement of thickness of non-metallic sheaths including extruded separation sheaths, but excluding inner coverings.
c) Tests for determining the mechanical properties of insulation before and after ageing.
d) Tests for determining the mechanical properties of non-metallic sheaths before and after ageing.
e) Additional ageing test on pieces of completed cables.
f) Loss of mass test on PVC sheaths of type ST2.
g) Pressure test at high temperature on insulations and non-metallic sheaths.
h) Test on PVC insulation and sheaths at low temperatures.
i) Test for resistance of PVC insulation and sheaths to cracking (heat shock test).
j) Ozone resistance test for EPR and HEPR insulations.
k) Hot test for EPR, HEPR and XLPE insulations and elastomeric sheaths.
l) Oil immersion test for elastomeric sheaths.
m) Water absorption test on insulation.
n) Flame retardance test.
o) Measurement of carbon black content of black PE over sheaths.



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p) Shrinkage test for XLPE insulation.

q) Special bending test.

r) Determination of hardness of HEPR insulation.

s) Determination of the elastic modules of HEPR insulation.

t) Shrinkage test for PE over sheaths.

**b) 8.7/15 (17.5) kV XLPE Cables**

The following tests shall be carried out as per IEC 60502-2:

**1. Routine Tests**

The following routine tests shall be carried out on each manufactured length of cable:

- Electrical resistance of conductors.
- Partial discharge test.
- Voltage test.
- Insulation resistance test

**2. Sample Tests**

- Conductor examination.
- Check of dimensions.
- 4h voltage test.
- Hot test for EPR, HEPR and XLPE insulations and elastomeric sheaths.

**3. Type Tests, Electrical**

- Bending test followed by a partial discharge test.
- Tan δ measurement.
- Heating cycle test, followed by a partial discharge test.
- Impulse test, followed by a voltage test.
- Voltage test for 4h.
- Resistivity of semi-conducting screens.

**4. Type Tests, Non-Electrical**

Non-electrical tests shall be carried out as per Table 16 of IEC 60502-2, second edition 2005-03 or the latest edition thereof.

Duly certified and complete test reports for the type tests carried out on the same type of cable as offered satisfying the conditions specified in Clause 18 of IEC 60502-2 shall be acceptable in lieu of actual tests. Six copies of the test reports shall be submitted for Employer's review.

**6.15.8 Drawings, Technical and Descriptive Data**

The Contractor shall submit the following information for each size and type of power and control cables for Employer's approval:

(1) Technical data of control and power cables as per the Specific Facilities Data format provided in Employer Requirements.



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(2) Type of cable, conductor diameter, insulation thickness, jacket thickness and overall dimensions.

(3) Calculations for selection of cable size for different circuits.

(4) Current rating, maximum voltage, resistance per 100 meters.

(5) Physical characteristics and type of the insulation, sheath, armor and jacket.

(6) Cross-section of each type of cable showing the construction.

(7) Maximum pulling resistance, bending radius, and weight/meter.

(8) Size and type of end connectors for conductor and all other information that shall be of interest to the Employer

(9) Cable trays and accessories construction detail.

(10) Cable layout drawings.

### 6.15.9 Grounding System

#### 6.15.9.1 Scope of Work

These specifications cover the requirements for design, supply, installation, testing and commissioning of 132kV switchyard grounding system. The E&M contractor shall only be responsible for their own equipment earthing protective connections, either connection from already installed embedded copper plates or directly through earthing mesh.

The Contractor shall supply, install and make the joints between the switchyard equipment and the earthing mat supplied and installed by the Civil Contractor. The Civil Contractor will not backfill any earthing trenches until the equipment grounding connections are made and tested by the E&M Contractor for the approval of the Employer/Employer's Representative.

Lightning protection shall be provided by the overhead earth wires connected to the tops of the switchyard gantries. The overhead shielding shall be provided as specified in the relevant section of this document. The provision of lightning protection for the buildings at switchyard shall be a part of civil works contractor.

## 6.16 EQUIPMENT GROUNDING

The work under this section consists of design supply, and installation, of all materials and complete protective earthing connections for Switchyard equipment as specified herein.

All grounding conductors shall be copper, stranded, soft-drawn, and of adequate cross-sectional area to safely carry the maximum prospective earth fault current without damage.

(1) **Switch racks and Structural Steel:** Switch racks and steel structures shall be grounded with 185 sq.mm conductor from two different diagonally opposite legs. A square structure shall be grounded at two points diagonally opposite to each other. In case of structures consisting of several bays each leg shall be grounded.

(2) **Metallic Conduit:** All metallic conduits shall be connected to the grounding grid by connections at each manhole or terminating point. Conduits terminating in metal junction boxes located adjacent to each other, a 20 sq.mm wire may be used to interconnect them together and at one point connected to the grounding grid. Cable trays and racks in trenches shall be grounded as well.



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(3) **Circuit Breakers:** The metal structure supporting the circuit breaker shall be grounded by two connections of 185 sq.mm at diagonal corners. One grounding conductor of 185 sq.mm shall be extended to the breaker operating mechanism.

(4) **Disconnectors:** The housing of all disconnectors and earthing switches and their operating mechanism(s) shall be grounded at a point as near to the operating handle as possible. The switch operating platform shall be grounded as specified under in relevant section. The grounding conductor shall be connected to the base of each switch from two separate points of grounding grid.

(5) **Instrument Transformers:** Every metal structure supporting current and voltage transformer shall be grounded with 185 sq.mm cable by two connections at diagonal corners. Metal cases shall be independently grounded. Secondary connections of voltage and current transformers shall be grounded where required by copper conductor.

(6) **Surge Arresters:** Surge arresters shall be connected to the grounding grid by insulated cable of appropriate size, which shall be able to conduct the lightning and switching surges to ground effectively without generating any potential gradient. A 185 sq.mm conductor shall ground the supporting structure. Additional grounding rods shall be driven adjacent to the surge arresters connected to the grounding grid.

(7) **SMS Room:** One ground conductor shall accompany each group of cables entering the SMS room/control room of 132kV switchyard and terminate at the ground buses of all the boards/panels to be installed inside the room ground bus. The cable trays inside the 132kV control room shall have a 185 sq.mm ground conductor with each of them.

The Contractor shall ground all metallic equipment supplied inside Control room such as Control Board, Recorder Board, Relay Board, A.C. and DC distribution Boards, PLC panels, chargers, cabinets, metallic piping, metallic supports of equipment, cable trays etc. with the station grounding grid. The Contractor shall submit the design of the grounding system to the Employer for approval.

(8) **Cable Trays in Trenches:** A grounding conductor shall be laid in the trench and shall be connected to the main mesh at a distance of 20-25 meters. All the cable racks shall be connected to the running grounding conductor.

(9) **Cable Shield Grounding:** In general, the shield and armor of power and control cables shall be grounded properly at both ends.

(10) **Metallic Pipes:** All water pipes and other piping in the station shall be tied to the station grounding grid by 35 sq.mm copper conductor.

(11) **Overhead Shield Wire:** The overhead shield wire shall be directly connected to the station grounding grid/mesh

## 6.17 AC AND DC AUXILIARY SUPPLIES

### 6.17.1 General

These Technical Specifications cover the requirements for the design, manufacture, supply, erection, testing and commissioning of the AC and DC auxiliary supplies system at Attabad 132 kV switchyard.

All equipment under these Technical Specifications shall be manufactured and tested in accordance with the latest revision of the relevant IEC standards.



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### 6.17.2 Scope of Work

Separate D.C. auxiliary supply system shall be provided for 132kV switchyard. The system shall comprise two set of batteries and High Frequency charger will be acceptable in addition to SCR type charger. If high frequency charger offered, then n+2 module shall be provided with each charger and if SCR offered, then three No of chargers with automatic change over to third charger (stand-by) in event of fault shall be provided."

For 132kV system batteries and chargers shall be rated for 110V, 600AH and 60A respectively. The systems shall consist of batteries, battery chargers, D.C. distribution boards, battery mounting racks and all accessories necessary for the proper operation and maintenance of the systems. The batteries, battery chargers and distribution boards etc. to be supplied under this Contract shall be installed in 132kVswitchyard Control Building. as specified in the Specification Drawings. Single Line Diagram indicating the scope of work has been provided in Volume-II Part-III of the Employer Requirements.

A 400/230V distribution board complete with switchgear and other accessories, as specified in section 6.17.4.1 of these Technical Specifications shall be provided in the 132kV switchyard control house building. AC sub- distribution boards, indoor and outdoor, wherever required, shall also be installed.

The Contractor shall design the complete AC and DC system according to the basic requirements mentioned herein and submit design calculations to justify the ratings and characteristics of the offered equipment including MCBs, MCCBs.

All materials and equipment required for providing AC and DC auxiliary supplies to the equipment to be supplied under this Contract and otherwise necessary for proper functioning of the systems shall be supplied and installed by the Contractor.

### 6.17.3 D.C. Distribution Boards

The distribution boards shall be of modular, robust and sturdy design constructed in conformity to the relevant part of IEC 60439. Each distribution switchboard shall be mounted adjacent to its associated charger control panel and shall be of cubicle type. Care shall be taken to make the cubicles dust and vermin proof. Each distribution cubicle shall be provided with copper bus bar arranged so that the bus bars can be joined together to form a common bus for connection to main grounding system. Each D.C. distribution board shall consist of a two pole battery circuit breaker, bus tie breaker for providing interconnection with the other DC board and a two pole circuit breaker for each outgoing feeder circuit. All circuit breakers shall be designed, constructed and tested in conformity to relevant IEC standards. All circuit breakers shall be manually operated by an operating lever having three positions of "ON" "OFF" and an "INTERMEDIATE" which shall indicate auto-tripping of the circuit breaker on overload or short circuit. However, MCB shall be provided with two positions "ON" and "OFF". Battery circuit breaker and bus tie breaker shall be molded case heavy duty type. Each circuit breaker shall have thermal and instantaneous magnetic trip devices for overload and short circuit protection of the circuits. The incoming circuit from the batteries to each board shall be provided with an ammeter with a center zero scale of suitable range. All circuit breakers shall be provided with auxiliary contacts for local and remote annunciations to indicate tripping.



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### 6.17.4 A.C. System

#### 6.17.4.1 Low Tension (400 Volts) Switchgear

**a) General**

The low tension switchboard shall be indoor, totally enclosed, floor mounted type. It shall be connected to a 400/230 volts, 3 phase, 4 wire, 50 Hz AC System. The system highest voltage shall be 600V. The low tension switchboard shall comprise of two 600 Volt, 3-phase, 4 wire buses. One of these buses will be the `NORMAL' bus. The other bus will feed loads of essential nature. This bus will be named 'ESSENTIAL' bus. A Bus Tie circuit breaker shall be provided which shall couple the two buses under certain conditions only. It shall normally remain open.

**b) Incoming Supplies**

The bus A (Normal Bus) shall receive its supply from power plant source-1.

The bus B (Essential Bus) shall receive its supply from power plant source-2.

From Emergency Diesel Generating Set through Generator Breaker GB when the supply A is cut off or both sources are faulty. In this case the bus tie breaker shall remain open.

The circuit breaker MB1, MB2 and TB shall be interlocked such that TB cannot be closed when both MB1 and MB2 are closed. Conversely when TB is closed, only MB1 or MB2 can be closed.

**c) Incoming Circuits**

1) The incoming supply from source A shall comprise:

   i) One 3 pole, 415 Volt, motorized air circuit breaker MB1 with rating of 400 A, adjustable thermal overload of 60-100% and appropriate short circuit protection.

   ii) Current transformers as described in clause 6.17.4.1 c) 1) i) hereafter. The current transformation ratio shall be 400/5A.

   iii) An Ammeter with range 0-600 Amps.

   iv) An Ammeter phase selector switch.

   v) A Voltmeter with range 0-500 volts

   vi) A Voltmeter phase selector switch.

   vii) Cable and boxes as required.

2) The incoming supply from source B to Bus B comprising of incoming circuit breaker MB2 similar to MB1 and all other equipment same as described above.

   The incoming circuit from Diesel Generating Set to `Bus B shall comprise of:

   i) One 3 pole, 415 volt motorized air circuit breaker GB with current rating of 400 Amps with adjustable thermal overload for the DG set as per price schedule and appropriate short circuit protection.

   ii) Current transformers as discussed in section 6.17.4.1 c) 2) i) hereafter the current transformation ratio shall be 1600/5A.

   iii) An ammeter with range 0-400 Amps.

   iv) An ammeter phase selector switch.



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v) A voltmeter with range 0-500 volts to indicate bus voltage.

vi) A voltmeter selector switch.

vii) A wattmeter with range 0-600 kW.

**d) Bus Coupler Panel**

The bus coupler shall comprise One three pole, 415 volt, motorized air circuit breaker [hereinafter called Tie Breaker (TB)] with current rating of 400 Amps without thermal over load and short circuit protections.

**e) Outgoing Circuits**

The rating and number of outgoing circuits from the Bus A and bus B have been shown on the A.C. Station Service System single line diagram in Volume-II Part-III of Employer Requirements.

The outgoing circuits shall be comprised of three pole, molded case circuit breaker (MCCBs) suitable for the connected loads.

**f) Enclosure**

The enclosure for the low tension switch board shall be suitable for indoor installation. It shall be totally enclosed, floor mounted type.

The enclosure shall be made of high grade sheet steel of minimum thickness not less than MSG 2.5mm thick. However, in case of type tested rigid frame design, the thickness of steel sheet may be reduced but not below 2mm according to manufacturer's standard design. All live parts shall be suitably enclosed. Access to bus bars, main connections, current transformers and all other items of the equipment for all normal maintenance operations shall be through the doors at the rear of the panels, provided with locking facilities. Vents shall be provided for adequate air circulation.

Provision shall be made for grounding of the metal housing of the switchboard. Doors shall be connected to the enclosure by means of separate flexible earthing straps. The enclosure shall be connected to the station ground through 185 sq.mm copper cable from the grounding bus of the enclosure to the nearest system ground available.

All interior and exterior surfaces of the enclosures shall be thoroughly cleaned and painted with one coat of metal primer and two coats of finishing paint. Light grey paint shall be provided for on-site touch-up work.

Each item of the equipment mounted on the panels shall be provided with a nameplate of approved design.

**g) Busbars**

The busbars of the switchboard shall consist of suitable bare copper bars, of at least 98% IACS conductivity and of rectangular cross section, suitable for carrying rated currents. The buses shall have provision for future extension. The buses shall be capable of withstanding short circuit current equal to the rated short-circuit currents of breakers installed in the switchboard.

The bus bars shall be air insulated and rigidly mounted on insulators placed at suitable intervals. The insulation shall be rated at 600V. All the joints shall be tin plated and firmly jointed.



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The maximum temperature rise of the busbars and their joints, above the ambient temperature, shall not exceed 30 deg. C. under normal conditions.

**h) Main Circuit Breakers**

**1. General**

The main circuit breakers MB1 and MB2, Bus Tie Breaker TB and Generator Breaker GB shall be air-break type, 3 pole, 415 V, suitable for indoor installation. The breakers shall be connected at of 400V sides and diesel generating set. The main breaker shall be rated at 1000 A and Generator Breaker shall be rated at 400 A. MB2 breaker will be equipped with syncheck relay.

The breakers shall be manufactured in accordance with IEC 60157.1 Standard. The circuit breakers shall be suitable for installation in a three phase four wire distribution system of the following characteristics:

| | | |
|---|---|---|
| - | Nominal Station Service Voltage, V. | 400/230 |
| - | System Highest Voltage, V. | 600/345 |
| - | Frequency, Hz. | 50 |

**2. Ratings**

The standard rating of breakers shall be as under:

| | | |
|---|---|---|
| - | Rated voltage, V. | 415 |
| - | Rated nominal current, A. | As per Specifications Drawings |
| - | Rated frequency, Hz. | 50 |
| - | Rated symmetrical breaking current at 415 volts, one sec. kA. | 25 |
| - | Rated making current, kA. | 50 |

**3. Operating Mechanism**

The circuit breaker operation shall be a quick-make and quick- break mechanism which shall operate by compressing springs in the first part of the make or break operation, which shall then assist in completing the operation independently of the operator's efforts. The operation shall be continuous and the mechanism shall not hold in an intermediate position in any case. The mechanism shall be so designed that a fault on one phase, shall trip all three phases simultaneously. Linkage mechanism should be simple for ease in maintenance.

The circuit breakers shall be trip free. Breaker position indication shall be provided. Circuit breakers shall be designed for continuous duty and shall carry the rated current for indefinite period of time without exceeding the temperature rise limits. Suitable arrangement shall be provided to lock the breaker in open position.

**4. Tripping Devices**

The circuit breakers shall be equipped with two direct operating; one overcurrent and one magnetic release for each phase for overload and short circuit protection respectively.

The overload release shall be adjustable and shall have the following characteristics:

| **Operating current as multiple of rated current** | **Tripping Time** |
|---|---|
| 120% | about 1 Hr. |



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| | |
|---|---|
| 150% | 80 to 120 sec. |
| 200% | 20 to 30 sec. |

Fast operating magnetic release shall be of the instantaneous type for short circuit protection and shall have adjustable setting range from 200% to 600% of rated current.

The instantaneous and overcurrent release shall be completely independent of each other. Suitable CTs may be incorporated for overload protection, if necessary. An under voltage release to indicate loss of voltage and to operate after a suitable time lag shall be provided with incoming circuit breakers.

**5. Contacts**

The contacts shall be heavy duty spring loaded type and shall be silver plated. The breaker shall be provided filled with replaceable arcing contacts and shall be removable for inspection of contacts.

**6. Tests**

The following type and routine tests shall be carried out:

**a) Type Tests**

Making capacity, breaking capacity, short time current test, mechanical and electrical life tests, temperature rise and voltage tests to determine that the insulating parts have sufficient insulation resistance.

The test reports shall be supplied to the Employer for approval.

**b) Routine Tests**

Visual, operational, power frequency and millivolt drop tests shall be performed and test report shall be supplied to the Employer.

**i) Current Transformers**

Current transformers for measurement of current at incoming circuits from transformers and emergency diesel generator set shall be single pole, single ratio and of dry type. There shall be a circular window opening for the primary winding.

**j) Rating**

The current transformation ratios shall be as identified separately for each incoming circuits. Rated Burden shall be 15 VA. The rated short time current shall be 25 kA. The rated dynamic peak current which the CT can withstand without being damaged electrically or mechanically shall be 63 kA.

The current transformers shall be manufactured and tested in accordance with IEC Publication 60044-1 or latest equivalent International Standards.

**k) Outgoing Circuit Breakers**

1) The outgoing circuit breakers shall be molded case, 3 pole, automatic, air break type with nominal voltage of 415 V as shown in the single line diagram of AC Station Service System. The interrupting capacity of the breakers at rated nominal voltage shall be not less than 35 kA symmetrical current.

   The terminals shall be adequate for rear connections to ensure adequate and durable contact and they shall be capable of receiving aluminum or copper cables of suitable sizes.



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2) The following information shall be marked on the nameplate of each outgoing circuit breaker. This information shall also be provided with the Proposal:

   a) Rated current.
   b) Voltage.
   c) Interrupting capacity.
   d) Thermal setting.
   e) Magnetic setting.

3) All circuit breakers shall be provided with auxiliary contacts for local and remote annunciations to indicate tripping.

**l) Instruments**

The instruments shall be manufactured and tested in accordance with IEC Publication 60051 Standard.

Measuring and indicating instruments shall be flush mounted back connected, dust proof, switchboard type having transparent dust tight covers.

Scale plate will have a permanent white finish with black graduations and numerals.

The zero adjustments shall be provided outside the instrument. All instruments shall be tropicalized.

**m) Ammeters**

Ammeters shall be of specified range, moving iron, spring controlled, with a pressed steel case. One ammeter for each phase shall be provided. The ammeter shall be able to withstand the momentary large currents encountered during operation without damage or loss of accuracy.

**n) Voltmeters**

The Voltmeters shall be 0-500 V range, moving iron, spring controlled in a pressed steel case. Only one voltmeter shall be provided for measuring line and phase voltages, with a voltmeter selector switch.

**o) Wattmeters**

Wattmeters shall be capable of indicating the demand up to 1000 kW. The meters shall be suitable for 400/230 V, 3-phase, 4 wire unbalanced load service. The current coils of the meter shall be suitable for use in conjunction with secondaries of current transformers specified.

### 6.17.4.2 Remote Controls and Synchronizing Equipment for Diesel Generating Set

To facilitate the paralleling route, controls of diesel generator set consisting of the start/stop push buttons, voltage regulator and frequency (speed) control will be provided on the 'B' Bus panel as well as on Control Board to be installed in the Control Room as indicated on the relevant drawing included in Volume-II Part-III of Employer Requirements. Remote closing / tripping switch for breaker mounted in the generator cubicle will also be provided on the Bus 'B' panel as well as on Control Board to be installed in the Control Room. It shall be possible to start, load, operate, unload and stop the emergency diesel generator (EDG) from the Operator's Workstation / Station HMI. The main parameters of the EDG including speed, voltage, frequency, power, currents etc. shall be monitored at the station level. The faults in the EDG system shall also be alarmed at the Operator's Workstation.



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Synchronizing instruments consisting of synchroscope and double voltmeter and double frequency meter will be installed on the 'B' Bus panel of Low Tension Switchboard and Control Board.

### 6.17.4.3 Alarms, Indications and Controls

Visual indications and audible alarms shall be annunciated at the control board, in case of loss of voltage and shall continue to operate until acknowledged by the operator. The visual indication shall remain `ON' till the supply is restored. Audible alarm shall indicate availability of supply on restoration.

A permanent red visual indication shall be produced at the Control Board when Diesel Generating Set is in operation.

Audible and visual alarms shall be simultaneously produced at the Generator Control Cubicle and the Control Board when generator fails to start or the generator fails during normal operation. The alarms shall continue to operate until acknowledged.

Instruments/controls alarms for diesel generator required to be provided on the Control Board in the Control room are indicated on the relevant drawing included in Volume-II Part-III of Employer Requirements. Design details and schematics shall be subject to approval by the Employer.

### 6.17.4.4 Remote Metering

Voltmeters shall be installed at the Control Board for remote metering of following voltages: -

1. `NORMAL' 400V Bus A.
2. `ESSENTIAL' 400V Bus B.

The voltmeters shall be of the same ranges as installed at respective apparatus. Their design shall match with other meters installed at the Control Board.

### 6.17.4.5 Operating Sequence of A.C. Station Service System

**A) System Normal**

i) Both supplies named as 'A' and 'B' shall be available to incoming panels.
ii) Incoming breakers MB1 and MB2 shall be closed.
iii) Tie breaker TB shall be open.
iv) Generator breaker GB shall be open.

**B) 1) Loss of Voltage on One incoming panel**

i) Visual and audible alarms at the Control Board indicate loss of supply. Visual indication shall remain ON till supply is restored.
ii) No volt release, trips breaker MB1 and closes breaker TB.
iii) Breaker MB2 remains closed.
iv) Breaker GB remains open.

**2) Restoration of incoming supply A**

i) Audible alarms at the Control Board indicates restoration of supply.
ii) Breaker TB is tripped manually.
iii) Breaker MB1 is closed manually.



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iv) Breaker MB2 remains closed.

v) Breaker G.B. remains open.

**C) 1) Loss of incoming supply B**

i) Visual and audible alarms at the Control Board indicate loss of supply. Visual indication shall remain ON till supply is restored.

ii) No volt release trips breaker MB2 and closes breaker TB.

iii) Breaker MB1 remains closed.

iv) Breaker GB remains open.

**2) Restoration of incoming supply B**

i) Audible alarms at the Control Board indicates restoration of supply.

ii) Breaker TB is opened automatically and Breaker MB2 is closed simultaneously.

iii) Breaker MB1 remains closed.

iv) Breaker GB remains open.

**D) 1) Loss of Both Incoming Supply Circuits**

i) Visual and audible alarms at the Control Board indicate loss both supply. Visual indication shall remain ON till supply is restored.

ii) Breaker MB1 and MB2 are opened by under voltage release.

iii) Breaker TB trips automatically if in closed position.

iv) Diesel Generating Set starts automatically after sensing loss of voltage on both `NORMAL/A' and `ESSENTIAL/B' bus and then runs up to rated speed in a short time (less than 60 sec.).

v) Breaker GB shall close automatically to connect the generator to `ESSENTIAL' Bus.

A suitable time lag shall be provided for the operation of under voltage releases on breakers MB1 and MB2 so that sequence is not initiated due to momentary voltage dips on the system.

**2) Restoration of Supply**

i) Audible alarms at the Control Board indicate restoration of supply.

ii) Breaker MB1 is closed manually.

iii) Breaker TB remains open.

iv) Diesel Generating Set is synchronized with supply B through circuit breaker MB2.

v) Breaker GB is opened manually.

The diesel generating set will be able to start automatically in case of both supplies' failure. The generator once started will run for a minimum of one hour even if normal "A" supply is restored after a short time.

### 6.17.4.6 A.C. Sub-Distribution Panels

These panels shall be required for power and lighting distribution circuits. The actual number of outgoing circuits in different sub-distribution panels shall be determined by the Contractor



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according to actual requirements of the design and the panel shall be designed to ensure safety during operation, inspection and maintenance.

The lighting and power sub-distribution panels to be installed in the Control room, shall be indoor, wall mounting or free-standing type as required. The sub- distribution panels required in the switchyard shall be outdoor type, having weather proof enclosure and shall be mounted on galvanized metal frames in vertical position.

The general lighting and power panels shall be connected to the `NORMAL/A' bus of 400V Switchboard while the essential lighting and power panels shall be connected to the 'ESSENTIAL' bus of the 400V Switchboard.

The enclosure of the sub-distribution panels shall be made of 14 SWG sheet steel and shall be finished light grey. Necessary holes with knockouts shall be provided for conduit entries. Access to busbar clamps and fuse bases shall be through the doors at the front of the panels provided with locking facilities. Adequate vermin proofing shall be provided in the design.

All lighting and power panels shall have a set of four copper bus- bars, three for the phases and one for neutral connection. The bus bar shall be of adequate current carrying capacity. The maximum temperature rise of the busbars shall be 30 deg. C above the ambient temperature.

The single phase lighting and power loads shall be uniformly divided amongst the three phases. Cartridge fuses of required ratings shall be installed in the panels to protect each lighting and power circuit.

**6.17.5 DC / AC Inverters**

Two DC/AC inverters shall be installed to provide power supply to the following un-interruptible essential load of the switchyard:

- Motors of chart recorders.
- Transient fault data recorders.
- Sequential event recorders.
- Emergency lighting.

Each inverter shall have the following minimum ratings:

- Rated power 2000 VA
- Input 110 VDC
- Output 230 VAC, 1-phase, 50 Hz.

Under normal conditions, the essential load shall remain connected to any one inverter with the other as standby. Provisions shall be made through a selector switch to shift the load from one inverter to the other in case of failure of one inverter and to connect the same load to the normal AC supply in case both the inverters are out of service.

The Contractor shall design complete essential load requirements to finally determine the size of the inverters and provide calculations in support thereof.

Panel heating and door-operated lighting facilities shall also be provided in the inverter panels. The panel protection should fulfill the requirements specified in Clause 6.3.10.1 of these Technical Specifications.

Ample provision shall also be made to add future loads on the inverters, if required.

### 6.17.6 Drawings, Technical and Descriptive Data

Detail drawings, descriptive data and technical data of 400V Switchboard panels, sub-distribution panels, circuit breakers, relays instrument, transformers, instruments, and other components of the A.C. system as per the format of the Specific Facilities Data provided in Employer Requirements.

Detailed drawings, descriptive data and technical data of DC batteries, chargers, DC distribution boards, DC circuit breakers, instruments, and relays used in DC system.

### 6.17.7 Approval Drawings, Technical & Data

Detail dimensions drawings and technical data showing the construction, operation features, technical data rating, wiring and schematic drawings and layout of all equipment associated accessories and auxiliaries offered under AC and DC auxiliary supply systems.

### 6.17.8 Emergency Diesel Generating Set

#### 6.17.8.1 General

#### 6.17.8.1.1 Equipment Description

The emergency diesel generating set shall consist of a brushless, self-exciting, self-regulating synchronous generator directly coupled to a diesel engine complete with all the required auxiliaries including lubricating oil system, engine cooling system, fuel system, starting system, excitation system, auxiliary power system, and complete controls. The unit shall be furnished with adequate guards to protect personnel from rotating and moving parts and from hot surfaces. The engine alternator shall be direct-coupled to form a single robust mechanical unit. They shall be mounted on heavy base frame of all welded design with correct alignment, and the base frame shall be drilled for holding down bolts or anti-vibration mountings whichever is most suitable.

#### 6.17.8.1.2 Rating

The Diesel Generating Set shall have a continuous rating of 200 kVA i.e. 160 kW at the given ambient temperature. The alternator shall be designed for operation at 400 Volt phase/phase and 230 V phase/neutral, 3 phase, 4 wire 50 Hz, 0.8 power factor A.C. supply.

The diesel engine driven generating set shall be of fully automatic main failure electric start type. That is, it should have a system in its control panel containing automatic start/stop relay systems designed to accept a signal from phase failure detection equipment. Following a loss of voltage on the station service bus, the machine shall be capable of starting from a remote signal and reach synchronous speed within 60 seconds. The set shall continue to feed the load until mains supply is again available, and then it shall automatically stop and shall remain in readiness for the next emergency. This unit shall also be capable of being operated in parallel with another unit of the same rating to be installed in future by others.

In addition, this diesel generating set shall also be required to run in the operating sequences specified in Section 14 of these technical Specifications.

**Work included in the supply**

The following equipment and works shall be included in the scope covered by these specifications:

a) Sensing of loss of voltage on station service bus with automatic transfer arrangement for the electrically operated breaker.



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b) Inlet to combustion air intake system.

c) Outlet for exhaust of the set from the silencer unit to the outside of the building.

d) Exhaust for air from radiator of the set to the outside of the building with wall mounted louver arrangement.

e) DG set room ventilation in coordination with HVAC design.

f) AMF and monitoring control panels completely installed and connected.

g) Reserve fuel oil tank installed outside of the building.

#### 6.17.8.1.3 Grounding Terminals

Grounding terminals and 4/0 stranded grounding copper cable shall be furnished with copper grounding lugs complete with connectors and connected to the grid station grounding grid system.

#### 6.17.8.1.4 Finish

All metal parts shall be cleaned properly and one coat of metal primer with one coat of base paint and one coat of finish paint shall be applied. Special attention shall be given to welded seams to ensure that the rough surfaces are thoroughly protected by the proper covering of paint.

### 6.17.8.2 Diesel Engine

#### 6.17.8.2.1 Design

The engine covered by these specifications shall be able to operate on a diesel fuel oil as described by ASTM or ISO Specifications for vibration test.

The DG set shall be installed DG set room.

The engine shall be provided with required auxiliaries, guarantees of fuel consumption, parallel operation, acceptance tests, torsional vibration characteristics.

#### 6.17.8.2.2 Governing

The Contractor shall assume full responsibility for selection, design and adjustment of the governing systems for stable governing i.e. without hunting and also for parallel operation of the machine.

The speed of the unit shall be adjustable over a range of + 5% from the normal engine operating speed. The speed drop characteristic over the load range from zero load to full load shall be adjustable from 0 to 5% of rated speed at 50Hz. Means for remote speed control shall also be provided.

Means shall be provided on the engine to shut down the engine automatically in the event that the engine speed exceeds the "shutdown" speed.

#### 6.17.8.2.3 Starting

The set shall include all equipment necessary to start and run the Diesel unit without any external source of AC or DC power and shall be capable, at all ambient temperatures, of starting and assuming full load at rated frequency in 60 seconds of the receipt of a start signal.

The diesel generating set shall be supplied complete with its own lead-acid battery, battery charging equipment and trays fitted on the base frame for holding the batteries.

#### 6.17.8.2.4 Air Intake System

Combustion air for the diesel unit shall be taken from inside the building. Coordination shall be done with building architecture design for air intake requirement of DG set. All necessary pipe work, flexible couplings, fittings and supports shall be supplied to extend from the heavy duty air filter to the air inlet manifold on the Diesel engine. The filter assembly shall be constructed of non-corrosive materials.

#### 6.17.8.2.5 Exhaust System

The exhaust system shall use an industrial type silencer. The exhaust shall extend from the diesel engine and terminate outside the building. All necessary. Thermal insulations of silencers, pipe work, flexible couplings, fittings and supports shall be supplied to extend from the diesel exhaust manifolds to the silencers and then to the outside of the building.

#### 6.17.8.2.6 Cooling System

The diesel engine cooling system shall employ a radiator to cool the circulating water. All connecting pipe work shall be provided with the unit.

Exhaust air from the radiator shall be ducted to a wall opening in front of the radiator. Radiator flexible ducting, flange and all necessary ductwork, flexible connections, fittings and supports shall be supplied to extend from the radiator to the exhausts louvers so that hot air from the radiator escapes freely to the outside of the building.

#### 6.17.8.2.7 Fuel System

**A fuel oil system for the unit shall be provided. The tank shall hold fuel for the engine for 12 hours of continuous operation.**

The reserve fuel tank shall be mounted on a concrete base at a level as specified by the engine manufacturer. The tank shall comply with NFPA-31 "Installation of Oil Burning Equipment" latest edition and shall be in accordance with the rules and standards referred to therein for outside above ground tanks.

All necessary piping, flexible couplings and fittings shall be supplied to extend from the reserve fuel tank to the Diesel engine. The tank shall be complete with all necessary fittings including regulation valve, gooseneck vent, outlet fuel filter, sediment drain and safe type of fuel level indicator. All openings shall be screened to prevent entry by insects.

The system shall not require any manual or electric priming before starting.

A manual fuel pump shall be fitted so that fuel can be transferred to the set mounted fuel tank from reservoir, if required to do so.

#### 6.17.8.2.8 Lubricating Oil System

The lubricating oil system shall be of the full flow, pressure type, allowing oil to the parts of the engine. The system shall be complete with a full flow oil filter with replaceable element.

### 6.17.8.3 AC Generator

#### 6.17.8.3.1 General

The generator shall be directly coupled to the diesel engine. The generator shall conform to the applicable standards.

#### 6.17.8.3.2 Rating

**The generator shall be rated as follows:**



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| | | |
|---|---|---|
| Capacity | : | 200 kVA |
| Voltage | : | 400/230 V |
| Phases | : | 3 Phase, 4 wire, grounded neutral |
| Frequency | : | 50 Hz |
| Power Factor | : | 0.8 lagging |
| Exciter | : | Rotating, direct connected |

The generator shall be suitable for continuous operation at 10% above or below rated voltage.

**6.17.8.3.3 Enclosure**

The generator shall be self-ventilated and drip proof, Air shall be drawn in from the end opposite the engine drive so that cooling air drawn into the generator does not come from the vicinity of the driving engine where it may contain oil or other contaminants.

**6.17.8.3.4 Damper Winding**

A damper winding shall be fitted to laminated pole generator. The generator shall be fitted with inter polar damper connections. The damping characteristics shall be adjusted to provide stability for parallel operation with the station service bus or other generator of the same rating.

**6.17.8.3.5 Temperature Rise**

Generator temperature rises at continuous rating in an ambient of 50 degree C shall not exceed 70 degree C by resistance measurement on the field. The exciter temperature rise shall not exceed 50 degree C by resistance measurement on field or armature when the main generator is on continuous rating.

**6.17.8.3.6 Generator Stator Insulation and Windings**

The stator winding shall be Class B. All winding materials and slot wedges shall be non-hygroscopic and be classified as Class B also.

All connections, rings and joints shall be sized such that their temperature rises are within Class B limits and all insulation materials, varnishes and impregnates shall be fully compatible.

The winding design and insulation processes shall be such as to eliminate coil or wedge migration due to Diesel engine vibration.

**6.17.8.3.7 Generator Field Insulation And Windings**

The field winding shall be Class-B. Field coils shall be pressed at a pressure at least equal to the pressure obtained at the recommended "shut-down" speed and shall be braced to withstand engine vibration and over speed.

**6.17.8.3.8 Vibration And Balance**

The vibration level of the generator when coupled to the engine shall not exceed the ISO Specifications or equivalent.

**6.17.8.3.9 Bearings**

The bearings shall preferably be grease lubricated and anti-friction type and shall be selected to provide for long trouble free service.



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### 6.17.8.3.10 Voltage Dip and Recovery

Contractor/Manufacturer's calculations to meet the above voltage dip, voltage rise and voltage recovery performance shall take into account diesel engine steady and momentary speed changer, generator impedances and excitation system forcing characteristics at 400 V.

The generator and excitation system shall be designed to start station auxiliaries induction motors direct on line. When starting 100 H.P. motor having maximum of 500 kVA starting load, the following transient performance shall be met:

a) Minimum generator terminal voltage 75% of initial voltage.

b) Maximum voltage recovery time to 90% initial voltage, 1.5 seconds.

c) Maximum voltage recovery time to 97% initial voltage, 3.0 seconds. When suddenly removing the above motor with a base load in the range 300 to 500 kVA, the following transient performance shall be met:

   i) Maximum generator terminal voltage, 125 % of initial voltage.

   ii) Maximum voltage recovery time to 110% of initial voltage; 1.5 seconds.

   iii) Maximum voltage recovery time to 103% of initial voltage, 3.0 seconds.

The generator shall be supplied with a rotating direct connected exciter.

### 6.17.8.3.11 Generator Starting Panel

The generator starting panel shall provide sufficient indicating, regulating and control functions necessary for safe and efficient operation of the generator. Complete layout and dimensions for control panel shall be submitted with the Proposal. Requirement regarding remote controls of the diesel generator set and synchronizing facilities are specified in relevant section.

The starting panel enclosure shall conform to NEMA or equivalent General Purpose Enclosure requirements and the equipment therein shall be suitable for operation in room temperature of 50 degree C.

The panels shall include but not be limited to the following equipment:

1. Synchronized panel shall be a standard one. It shall be equipped with but not limited to the following:

   - Synchro scope
   - Frequency meters
   - Voltmeters
   - Phase angle meter

2. All relays, timers, etc. required to permit the manual or automatic start, run up to load and stopping of the engine generator set.

   The engine control system shall be supplied from the starting battery and shall be able to ride through the voltage dip during cranking.

3. A front panel mounted window type annunciator together with lamp test, acknowledge and reset push-buttons and panel mounted audible alarm device shall be provided.

Functions annunciated shall include but not limited to the following:

a) Impending trouble alarm points displayed a white illuminated window:



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i) Low oil pressure.
ii) Low fuel level.
iii) High coolant temperature.
iv) Generator over-temperature.
v) Low battery voltage.
vi) Excessive low frequency.
vii) Excessive high frequency.
viii) Excessive low voltage.
ix) Excessive high voltage.

Each annunciator trip point shall be provided with an extra auxiliary contact wired in parallel with its mates to provide a contact which closes when any alarm condition exists.

b) Shut down or lockout alarm points displayed by a red illuminated window:

i) Very low oil pressure.
ii) Extreme high coolant temperature.
iii) Protective relay trip.
iv) Failure to start (over crank).
v) Over speed trip.

Each annunciator alarm point shall be provided with an extra auxiliary contact connected as above to provide a contact which closes whenever a trip or lockout condition exists.

The annunciator shall operate from one of the 220V DC station batteries.

Spare points shall be supplied complete with relays, lamps and blank windows:

Front panel mounted devices shall include:

a) Generator output voltmeter 0-500 V.
b) Generator output frequency meter 47 to 53 Hz.
c) Generator output ammeter 0-1600 A.
d) Engine hours elapsed time meter 0-9999 hrs.
e) Battery voltmeter.
f) Battery ammeter.
g) Operation mode selector switch, four position, to permit running transfer between manual and automatic.
- Off.
- Manual (local no-load) control.
- Manual (remote) control.
- Automatic control.

h) Engine control push buttons:
- start (black).
- stop (red).
- emergency stop (red mushroom head).



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The emergency stop button circuit shall include provision for tripping the remote line circuit breaker.

i) Engine speed control switch, three position spring return to off:
   - lower.
   - off.
   - rise.

j) Generator winding temperature indicator.

**6.17.8.3.12 Voltage Regulating Equipment**

A set of static voltage regulating equipment designed to meet the requirements of this specification. The regulator shall include but not be limited to:

1) A series boost current operated device to maintain excitation under fault and over load conditions.
2) Any necessary cross-compensating circuits to permit stable, parallel operation with the other engine, while running isolated from the power system.
3) Any necessary devices to permit stable parallel operation of the engine with the power system under manual/remote control.
4) Generation winding temperature relay with alarm contact and front panel mounted indicating meter.

**6.17.8.4 Control Enclosures and Components**

**6.17.8.4.1 General**

The Manufacturer shall provide a metal clad, NEMA 12, or equivalent dust tight general purposes floor mounted vermin proof, cabinet for the diesel generator to house the indicating alarm devices, auxiliary contacts and all other necessary mechanical and electrical apparatus and accessories required for the Emergency Diesel Generating Set.

Electrical interconnection between the cabinet and the remote control shall be provided by the Contractor.

Equipment for mounting in the diesel room shall be of dust tight NEMA 12 or equivalent enclosed construction and suitable for operation at the temperature which may reach in the Generator room when the outside ambient air reaches 50 degree C and the engine is operating at full load rating.

**6.17.8.4.2 Control Panels**

All necessary sub-panels frames, supports, harnesses, etc. that may be necessary to install the equipment shall be provided.

The interior of the cabinet shall be painted white and provided with a 230V, 50Hz light and door operated switch.

There shall be wire troughs for the main grouping of wires. No equipment shall be mounted less than 150 mm (6") above the floor of the cubicle or 150 mm (6") below the roof.

Each cubicle shall be equipped with hinged door. The door shall have its edge best inwards for rigidity. There shall be a three point latch and activating handle. The handle and door shall



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have matching Projects with a 1/2" diameter hole suitable for locking the cubicle door with a pad lock.

A copper ground bus bar 6mm x 25mm (1/4" x 1") shall be provided at the lower section of all panels. The bus shall run continuously across all panels in the cubicle.

Lugs for terminating a 95mm2 bare ground conductor shall be provided at both ends of the bus.

#### 6.17.8.4.3 Nameplates and Tags

Engraved nameplates of stainless steel shall be provided on all panels for clearly identifying panels and devices mounted inside of panels.

Standard nameplate with black lettering shall be provided.

Cables and capillary tubing shall be tagged with a neoprene disc or approved equivalent, stamped with the cable number or tube function for easy identification.

#### 6.17.8.4.4 Terminal Blocks and Terminals

Terminal blocks for control wiring shall be General Electric Type Eb stud terminal blocks or approved equivalent. Terminal studs and wires shall be numbered or otherwise marked in accordance with the applicable schematic and wiring diagrams.

Terminal blocks shall be arranged with sufficient room for each connection of incoming cables. Parallel rows of terminal blocks shall be spaced at least 150mm (6") apart.

Blocks shall be mounted in vertical columns as for as possible along the sides of cubicles or on vertical panels specially provided for terminal blocks. Where vertical space is not available, horizontal space be used. 20% spare blocks distributed over the columns of terminal blocks shall be provided.

Terminals shall be suitable for screw terminals and shall be sized according to the wire being terminated.

Provisions shall be made to terminate and ground the overall copper shields of all incoming cables by a suitable method approved by the Employer.

#### 6.17.8.4.5 Component Wiring

All internal wiring shall be in accordance with IEC or VDE Standards with annealed copper conductor, thermo-plastic insulated with an overall flame- retardant braid. Wire sizes for control wiring in no case shall be smaller than 2.5 mm2. The wire ends shall be permanently fitted with compression type connectors before attaching to terminal studs.

Wiring between terminals of various devices shall be point to point. All internal wiring shall be neatly trunked in wiring troughs bound and anchored.

All groups of bundled conductors to hinged doors and panels shall use extra-flexible wire arranged so that a twisting rather than a bending motion is imparted to the moving conductor bundle. Each bundle shall be anchored to the fixed member at the opposite end of the hinge axis to the anchoring point on the moving member so that the moving bundle length is the maximum available without loops.

All wires shall be identified at both ends according to the schematic diagram.



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### 6.17.8.5 Maintenance Equipment and Tools

The Manufacturer shall bring equipment and tools in new and unused condition to install the equipment and hand over the same to the Employer for the maintenance including disassembly and assembly, of the Emergency Diesel Generating Set during its useful life. Equipment and tools shall include but not be limited to the following.

Any special tools, instruments, meters, case-hardened wrenches and any other special wrenches, if required lifting devices, steel cable slings and other equipment. The wrenches and tools for maintenance, in-so-far as practicable, shall be mounted on suitable hardwood for steel boards arranged for wall mounting and provided with means or ready identification.

#### 6.17.8.5.1 Tests

##### 6.17.8.5.1.1 General

The set furnished by the Contractor under this Contract shall be subject to tests in the shop and at site in the presence of the Employer for conformity to requirements of the Specifications.

#### 6.17.8.5.2 Diesel Engine

All mechanical parts shall be run under simulated operating conditions at the Manufacturer's works.

All tests shall be conducted in accordance with the appropriate codes for testing. The tests to be carried out shall include, but not be limited to, the following:

i) Dynamic balancing together with overspeed tests of the generator exciter and rectifiers.
ii) Bench testing of all accessories.
iii) Zero load operation of the diesel engine assemblies to test the following:

- Vibration.
- Lubricating system.
- Fuel system.
- Governor system.
- Temperature control system.
- Overspeed trip.
- Individual accessories.

The diesel engine and AC generator shall be test-run continuously for 24 hours to ensure smooth running and satisfactory operation of the machines and accessories. The above tests will be witnessed by the Employer.

The contractor shall state in his proposal the performance and reliability tests to be carried out in the Works.

Tests on the unit shall not be less than the minimum requirements of ISO standard Practices for equipment.

#### 6.17.8.5.3 Generator

1. **Shop Tests:** All test procedures shall be carried out in accordance with IEEE 11501 or UTE C51 100.



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2. **Routine Tests:** Routine tests on the generator shall be performed. Routine tests shall include:

   a) Resistance of armature and field windings.
   b) Polarity of field coils
   c) Check of mechanical balance
   d) Check of no-load field current or exciter field current.
   e) Voltage balance
   f) Phase sequence
   g) No-load saturation curve
   h) Insulation and high potential tests
   i) Over speed test at 125% speed for 1 minute

Where the generator is not completely assembled in the factory, tests (d) to (i) above inclusive may be carried out with the generator coupled to Engine Test (a) to (d) shall also apply to the exciter.

3. **Type Tests:** The generator shall have the following tests performed and certificates provided to the Employer (for the similar model and type):

   a) Short circuit saturation curve.
   b) Temperature test.
   c) Segregated losses.
   d) Voltage deviation factor.
   e) Three phase lines to line short circuit test at any convenient voltage in the 0.4 to 0.5 p.u. volts.

4. **Characteristics Test Curves:** Following completion of type tests, Manufacturer shall provide characteristics curves of the brushless excitation system. These curves shall show:

   a) Exciter field amps and volts versus generator line current at 0.80 Pf. and maximum and minimum temperature rises.
   b) Exciter field amps and volts versus generator line current at 1.0 Pf and maximum and minimum temperature rises.
   c) As for (a) above, but with one diode failed.

   The above six curves shall be plotted from no-load to maximum rated load at rated generator voltage. Following approval of curves by the Employer, they shall be incorporated by the Manufacturer into the Emergency Diesel Generating Set Maintenance Manual.

**6.17.8.5.4 Performance Tests**

At the conclusion of installation of the Emergency Diesel Generating Set at site, commissioning tests shall be carried out by the Contractor/Manufacturer to demonstrate the satisfactory operation of the equipment and to verify the guaranteed performance figures of the diesel unit. The tests shall comprise:

1. Preliminary tests on individual components.
2. Continuous one-hour heat run at 50 percent load rating in parallel with the system.
3. Continuous one-hour heat run at 75 percent load rating in parallel with the system.



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4. Continuous four-hour heat run at 100 percent load rating in parallel with the system.
5. Part load heat runs to demonstrate satisfactory operation and establish fuel consumption at the respective loads.
6. The tests shall also include:
    a) Performance of governing characteristics and protective systems.
    b) Stating characteristics of the units. The units shall start at least five (5) times in six (6) consecutive starting attempts.
    c) Starting power requirements to demonstrate the ability of the machine to start the specified number of times without need to recharge the batteries.

The instrumentation supplied as standard with the equipment will be used during the commissioning tests for measurement of voltage, frequency, temperatures, pressures, etc. normally recorded during commercial operation. Additional instruments required for the measurement of electrical output, fuel flow, vibrations, etc. shall, at no extra charge, be provided by the Contractor.

Tests to be carried out manufacturer's work and at the site shall be to the satisfaction of the Employer. Seven copies of test certificates shall be forwarded to the Employer immediately following each test. The site test report shall include a list of final settings and adjustments carried out during commissioning.

If the tests show that the set does not reasonably comply with Proposal, the Contractor/Manufacturer shall, at his own expense, make all necessary corrections to the unit. Additional tests shall then be made to demonstrate the effectiveness of these corrections. Until the necessary corrections have been made, the conditions of the contract shall not be considered fulfilled.

**6.17.8.5.5 Spare Parts**

The Contractor shall submit a list of manufacturer's recommended spare parts including prices. The list shall contain parts which are identical to the original equipment installed. Spare parts for five year or 4000 hrs. operation & maintenance of the diesel generating set shall be supplied with the set. He shall also in addition provide the following items as indicated below:

1. Four fuel oil filter elements
2. Four air filters
3. Two spare starting batteries without acid. Acid in separate containers for two fillings of batteries.
4. Two sets of each type and size of belts
5. Fifty control panel indicating lamps
6. Fifteen sets of color caps for indicating lamps
7. Fifty sets of fuses
8. Two sets of blank nameplates

**6.18 POWER TRANSFORMER (10/13 MVA, 132/11.5 KV)**

**6.18.1 Scope of Work**

The scope of work covers design, manufacture, works testing, delivery, erection, site tests and



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commissioning of one (1) number of three-phase power transformer complete with their accessories. The LV Side of transformers shall be connected to medium voltage busbar.

This shall be three-phase, 10/13 MVA, with 132/11.5kV voltage ratio, and with on-load tap changers complete with transformer purpose made supports and anti-vibration pads. The cooling type shall be ONAN/ONAF and the transformers shall be provided with fire detection, alarm and protection system.

### 6.18.2 Service Conditions

See Section “General Electrical Requirements given in Vol-II part-I”.

### 6.18.3 Standards

The transformers shall conform to the applicable requirements of the latest edition of the following international standards:

| | |
|---|---|
| • IEC Publication 60076<br>• IEEE C57.12.00<br>• IEEE C57.12.10<br>• IEEE C57.12.70<br>• IEEE C57.12.80<br>• IEEE C57.12.90<br>• IEEE C57.13<br>• IEC Publication 60076-10 | • IEC Publication 60076-7<br>• IEC Publication 60137 (Bushing)<br>• IEC Publication 61869<br>• IEC Publication 60811, 60230, 60502, 60228<br>• IEC TC37, WG-4<br>• IEC Publication 60214<br>• IEC Publication 60071 |
| • IEC 60060<br>• IEC 60085<br>• IEC 60354<br>• IEC 60529<br>• IEC 60567<br>• IEC 60814 | • IEC 61181<br>• IEC 61198<br>• IEC 60296-2003<br>• IEEE 62<br>• IEEE 637<br>• IEEE 1538<br>• NTDC P-46:2008 (Including amendments) |

### 6.18.4 Functional Specifications

Power transformer shall be oil-immersed, (ONAN/ONAF), with the oil preservation system of the constant pressure conservator type with a flexible diaphragm to preclude direct contact of oil with air, complete with accessories, and spare parts, suitable for outdoor operation. The star points of the 11 kV windings shall be solidly earthed.

The core of each transformer shall be of high grade, non-ageing electrical silicon steel of low hysteresis loss and high permeability. The Low Voltage side bushings shall be suitable for connection to 11 kV bus.

The high voltage bushings shall be condenser type, free from partial discharges up to the test voltage.

All bushings shall comply with IEC 60137. The HV bushings shall be inside an oil box adequate for HV connection. The LV bushings shall be air insulated. The neutral terminals shall be provided with outdoor type bushing insulator.

Each transformer case shall be capable of withstanding, without leakage or distortion, an internal gas pressure of 0.7 bar and essentially a full vacuum and shall be designed and constructed for vacuum filling in the field.



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Each transformer oil tank shall be provided with an approved self-resetting pressure relief device for the release of any pressure that may be generated in the tank to save it from damage. It shall operate at a static pressure lower than the hydraulic test pressure and outlets shall be arranged to face away from the bushings. The device shall be provided with two sets of normally open signaling contacts. These contacts shall be used to operate alarms/trips.

The transformer shall be equipped with bushing type current transformers for the high voltage and neutral terminals. The transformer shall be protected by a water deluge system with all the accessories i.e., piping, deluge valve, sensors, nozzles etc.

The transformers shall be equipped with a motor-operated 17 position on-load tap changer (OLTC) on the HV side, with a regulating range of ± 8 x 1.25%. The OLTC shall be manually controlled by the operator, not having an automatic voltage regulator so that when interacting with the excitation voltage regulator they do not oscillate against each other.

### 6.18.5 Key Technical Parameters

#### 6.18.5.1 Transformers

- Nominal capacity per 3-phase unit — 10/13 MVA
- Rated Voltage — 132 / 11kV
- Maximum System Voltage — 145 kV
- Rated Frequency — 50 Hz
- Vector Group — Dyn11
- Voltage Impedance — Ud ⩾ 12%
- Tap Changer — On-load
- Voltage Regulation — ± 8 x 1.25%
- Cooling Type — ONAN/ONAF
- Neutral point earthing mode — Solid earthing
- Rated short-time power frequency withstand voltage (HV) — 275 kV
- Rated lightning impulse withstand voltage (HV) — 650 kV
- Rated short circuit level — 50 kA
- Rated short-time power frequency withstand voltage (LV) — 28 kV
- Rated lightning impulse withstand voltage (LV) — 75 kV
- Noise Level — <NEMA TR-1
- Efficiency (minimum) — ⩾ 99 %
- Temperature rise at 40ºC ambient temperature
  - Coil — 65 K
  - Oil — 60 K
  - Insulating liquid — Mineral oil, IEC 60296

#### 6.18.5.2 H.V Surge Arresters

- Material type — Zinc Oxide
- MCOV (maximum continuous operating voltage) — not less than 145 kV
- Standard Nominal Discharge Current rating — 10 kA (IEC 60099)
- Insulation impulse withstand voltage — 650 kV
- Insulation wet power frequency Withstand voltage — 275 kV

### 6.18.6 Overload Requirements

The overload rating and operation shall be in accordance with IEC 60076-7. The overload



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capability of any ancillary equipment such as bushings, CTs, oil expansion tanks, leads etc. shall not be less than the transformer overloads rating. The transformers shall also be capable of withstanding momentarily, without injury, a voltage of 20% greater than the rated generator voltage, when the generator full load is rejected.

### 6.18.7 Short Circuit Capability

The transformer and its accessories shall be capable of withstanding mechanical and thermal stresses caused by short circuit fault currents without mechanical deformation or impairing electrical capabilities. The sudden pressure relay and other alarm initiating devices will not respond to the effect of the through fault short circuit currents.

### 6.18.8 Transformer Fire Protection System

Transformers shall be equipped with fire protection systems.

### 6.18.9 Tests

#### 6.18.9.1 General

Each transformer shall be subjected to the routine shop and quality control tests and all applicable tests required by IEEE C57.12.90, in addition to any special test required in accordance with this Specification. Test procedures shall be submitted to the Employer prior to any tests being performed. The Contractor shall submit test procedures and notify the Employer sufficiently in advance of tests, giving the date and place where such tests shall be made. The Contractor shall furnish to the Employer certified copies of all test results in electronic PDF format. The results of each test shall be recorded in the form of test certificates or reports as specified.

#### 6.18.9.2 Type Tests

Type tests shall be made on one unit of each type of different equipment at the Contractor's expense in presence of the Employer and the actual type test report shall be submitted to the Employer for approval. Instead of carrying out the type tests, the Contractor may submit duly certified and complete type test reports for tests carried out by an independent, accredited authority on similar equipment of the same type. However, the Employer reserves the right of accepting these certificates or to reject them partially or totally.

The Power Transformer shall be subject to the following type tests:

- Noise level test in accordance with IEC 60076-10,
- Zero phase sequence impedance measurement in accordance with IEC 60076-1
- Short-circuit test in accordance with IEC 60076-5.
- A temperature rise test, in accordance with IEC 60076-2. The test shall be conducted on the tapping corresponding to the maximum losses.
- Dielectric Type Tests in accordance with IEC 60076-3.
- Type tests shall be carried out on bushings in accordance with IEC 60137.
- Type test shall be carried out on one tap changer of each type in accordance with IEC 60214.

#### 6.18.9.3 Transformer Routine Tests

Usual non-destructive tests shall be performed on the tank welds. The tank welds shall be given a pressure test by filling the tank with dry nitrogen, dry carbon dioxide, or dry air to the highest pressure for which the tank is designed and exploring all welded seams with a suitable



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leak detector. There shall be no perceptible leaks and the transformer shall hold the test pressure for four hours without leakage. Any alternative pressure test shall be submitted to the Employer for approval.

The transformer tank shall be vacuum tested to a negative pressure of 25 mm Hg absolute or less prior to filling the tank with oil. The pressure rise shall not exceed 25 mm Hg in 30 minutes while the vacuum pump is not operating. This test may be performed as part of the filling procedure.

All test equipment shall be supplied for the specified shop tests in accordance with the latest issue of the applicable international standards. Calibration of all test equipment shall be traceable to the National Institute of Standards and Technology (NIST), and calibration certificates shall be submitted for approval. Certificates shall be renewed in accordance with the Quality Control Plan. For the loss tests, the instrumentation shall be calibrated for power factor.

Insulation resistance shall be measured at 1000 V and shall indicate a minimum resistance of 50 MΩ to ground.

The following tests shall be made at the completion of winding, at the conclusion of all other tests, and prior to shipment.

- Resistance of high voltage and low voltage windings, including all taps.
- Applied and induced voltage tests.
- Exciting current and no-load loss curves on rated voltage connections at 90%, 100% and 110% of rated voltage.
- Impedance and load loss test at rated current on the rated voltage connection and on the tap extremes of the transformer.
- Heat run on the transformer at lowest and highest MVA ratings.

Pressure tests at 25% above maximum nameplate rating shall be performed for the duration of 6 hours and shall be made immediately following the temperature rise test while the oil is hot.

On completion of all other tests and prior to shipment, the transformer shall be subjected to a one hour excitation loss run at 110% voltage. The current and power recorded at the conclusion of this test shall compare favorably with previous test results.

The following tests, described in cited sections of IEEE C57.12.90, unless otherwise indicated, shall be included:

- Resistance Measurement, Section 5.
- Polarity and Phase Relation, Section 6.
- Ratio, Section 7.
- No-Load Losses and Excitation Current, Section 8.
- Impedance Voltage and Load Losses, Section 9.
- Dielectric Tests, Section 10.
- Temperature Rise, Section 11.
- Audible Sound Emission, Section 13.
- Measurement of zero-sequence impedance.
- 1 minute power frequency separate source AC withstand voltage test on auxiliary wiring and function tests on auxiliary equipment/devices. The functional tests of all auxiliaries



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including tap changer shall be performed.

**6.18.9.4 Additional Transformer Tests per IEEE C57.12.90**

The following additional transformer tests shall be performed per IEEE C57.12.90:

- Insulation Power Factor, IEEE C57.12.90, Section 10.
- Bushing Power Factor, IEEE C57.19.00.
- Impulse Tests, IEEE C57.12.90, Section 10.3 (Full and Chopped Wave Test).
- Switching Impulse Voltage Tests, IEEE C57.12.90, Section 10.6.
- Bushing Capacitance, IEEE C57.19.00.
- Short-Circuit Tests

**6.18.9.5 Site Tests**

Following tests shall be performed on Power Transformer at site:

- Visual inspection,
- Insulation resistance,
- Winding resistance and continuity on all taps,
- Polarity,
- Dielectric test of oil, and
- Functional test of all control and protection apparatus.
- Transformer turn ratio test.
- Load tests.
- Sweep Frequency Response Analysis (SFRA) Test

**6.18.10 Spare Parts, Maintenance Equipment and Tools**

Spare Parts and Tools mentioned herein are the minimum required. Any other necessary spare parts and tools required for maintenance of the equipment shall be provided by the Contractor.

**Table 6-1: Spare Parts and Tools**

| Sr. No. | Description | Unit | Qty. |
|---|---|---|---|
| **Mandatory Spare Parts** | | | |
| 1 | 132 kV bushings, complete with gasket, terminal connector and oil. | Set | 3 |
| 2 | 11 kV bushings, complete with gaskets and terminal connectors. | Set | 3 |
| 3 | Neutral bushings, complete with gaskets and terminal connectors. | Set | 3 |
| 4 | Complete set of gaskets for 132 kV Power Transformer. Each set to consist of one of each size and type of gaskets furnished and one liter can of lubricating grease. | Set | 3 |
| 5 | Contacts and coils for each type and size of relay and contactor. | Set | 2 |
| 6 | Replacement parts for pressure relief devices. | Set | 2 |
| 7 | Pressure gauge of each type and size for the heat exchanger. | Set | 2 |



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| Sr. No. | Description | Unit | Qty. |
|---|---|---|---|
| 8 | Gas and oil actuated relay of each type, complete. | Set | 2 |
| 9 | Oil thermometer of each type, complete. | Set | 2 |
| 10 | Oil gauge of each type, complete. | Set | 2 |
| 11 | Air breather for conservator tank, complete. | Set | 2 |
| 12 | Thermal relay of each type, complete. | Set | 3 |
| 13 | Tapping switch assembly for 132 kV transformer. | Lot | 2 |
| 14 | Complete spares for oil preservation system for 132/11 kV Power Transformer. | Set | 1 |
| 15 | Winding temperature indicating device, each type. | Set | 2 |
| 16 | Current transformer, associated with temperature indicating device, each type. | Set | 2 |
| **Maintenance Equipment** | | | |
| 1 | 10% transformer oil in addition to net quantity required for filling the transformer. | Set | 1 |
| 2 | Consumable items such as filters, oils, etc. for 3-years of operation | Set | 1 |

## 6.19 HIGH TENSION SWITCHGEAR

### 6.19.1 General Requirements

The scope of work covers design, engineering, manufacture, works testing, delivery, erection, site testing and commissioning of HT switchgear for colony and power Intake and surrounding areas feeders. The switchgear shall be indoor type, metal clad and floor mounted. The switchgear shall be designed in accordance with latest revision of IEC 60298. In case the requirements laid down herein differ from those given in the standards, the switchgear shall comply with the requirements listed herein.

The HT switchgear shall be connected to 11/0.4 kV, 200 kVA Station Auxiliary Transformers, located outside the Control House Building and shall supply power to the AC Distribution Board to be placed in Control Building. The short-circuit kA rating of switchgear shall be as specified.

The 11 kV panels shall comprise a draw out type, motor operated vacuum circuit breaker and all its associated equipment. It shall be self-contained and self-supporting and shall be capable of being connected to the switchgear on either side.

In each panel the busbars, circuit breakers, voltage transformers, current transformers, instruments, meters, relays etc. and all live parts shall be enclosed and separated by ground metal barrier. Bus bars and their connections shall be covered with insulation.

The clearance between bus bars and between line and ground part shall be designed for the specified voltage levels short circuit capacity and other safety consideration during normal operation.



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All outgoing circuits shall have numerical type overcurrent and earth fault protection which shall have inverse as well as definite time and instantaneous features.

A mimic diagram indicating the single line of 11 kV circuit shall also be provided on the front of the panel using durable, non-fading material.

### 6.19.2 Ratings for 11 kV Switchgear

The switchgear shall be suitable for installation in 11 kV three phase A.C. supply system of the following characteristics:

| | | |
|---|---|---|
| - | Nominal system voltage, kV | 11 |
| - | Rated voltage, kV | 17.5 |
| - | Frequency, Hz50 | |
| - | Rated short-time (1 sec.) withstand current, kA, rms. | 25 |
| - | Rated peak withstand current, kA | 63 |
| - | Lightning impulse withstand voltage, kV, crest | 95 |
| - | One minute power frequency withstand voltage, kV, rms. | 38 |

### 6.19.3 Protection and Metering

#### 6.19.3.1 Overcurrent Protection

All panels shall have overcurrent and earth fault protection which shall be provided by means of numerical type relays with two over current elements and one earth fault element. The relay shall have three instantaneous elements.

For the 25 kA incoming panels, in addition to the DC protection scheme, a backup AC series protection scheme shall also be provided. The backup AC series protection shall be operated by a separate earth fault relay. The characteristics of earth fault relay for back up protection shall be same as for earth fault unit in the main overcurrent and earth fault relay. For AC back up protection the trip coils shall be energized directly from the CTs without requiring any external source.

### 6.19.4 Differential Protection

All incoming panels shall be provided with three additional CTs for differential protection.

The Differential protection zone of power transformer is required to trip the 11kV incoming breaker.

### 6.19.5 DC Supply and Trip Indications

Supervision relay shall be provided for continuously monitoring the healthy conditions of breaker trip circuit and presence of DC supply on all applicable panels. The presence of healthy trip circuit shall be indicated by the continuous glow of a yellow lamp. The indicating lamps shall be of neon type with screwed base. The rating shall be 5 watts at 150V or 260V DC depending on control and auxiliary supply voltage.



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One hooter and its acknowledge and cancelling arrangement shall be installed in the incoming panel to indicate failure of DC mains supply, DC supply to any panel and failure of healthy trip circuit and tripping of any breaker. This arrangement should be self-contained and securely fixed to the panel. The alarm cancelling arrangement shall be flush mounted on the front of the panel.

### 6.19.6 Metering

Arrangements for metering shall be provided. The voltage coils of all energy meters of the outgoing panels shall be connected to the voltage transformer of the corresponding bus section.

### 6.19.7 Construction

All metal parts of individual panels shall be efficiently bonded together. Hinged doors shall be connected to the panel body by means of flexible copper earthing straps. Each panel shall be provided with a copper earth strip of a minimum cross-section of 95 sq.mm to which all earth parts shall be bonded and arranged so that the bars of adjacent panels can be connected to form a common earth bus, which shall be connected to the station ground.

Each outgoing panel shall have provision for mounting one cable box suitable for copper cable as specified in relevant Section of the Technical Specifications.

### 6.19.8 Outgoing Panels

Each outgoing panel shall be of 25kA breaking capacity and shall comprise but not limited to the following:

i) A circuit breaker rated 630 Amps. 3-pole.
ii) Three single phase current transformers, ratio: 150-75/5-5 Amps.
iii) Three single phase overcurrent relays as specified.
iv) One outgoing cable box as required.
v) One ammeter, range 0-150A, with phase selector switch.
vi) One supervision relay for DC monitoring.

### 6.19.9 Incoming Panels

Each incoming panel shall be of 25kA breaking capacity and shall comprise but not limited to the following:

i) One circuit breaker rated minimum 630A, 3 poles.
ii) Three single phase current transformers, ratio: 700:350/5-5A for over-current protection and metering and three current transformers for differential protection.
iii) Three single phase metal oxide gapless type surge arresters, 15kV, 10kA. (The Contractor shall submit calculations to justify the rated voltage of the surge arrester).
iv) One three phase voltage transformer of ratio 11,000/110 volts.
v) One voltmeter 0-15kV with selector switch.
vi) Three ammeters 0-700 Amps. One in each phase.
vii) One kWh meter with MDI.
viii) One kVARH meter.
ix) One power factor meter.
x) One over-current relays.



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xi) One supervision relay.

xii) One earth fault relay.

xiii) Hooter, signalling lamps & cable termination pad.

### 6.19.10 Switchboard Enclosures

The enclosure shall be vermin proof. All live parts, including busbars, connections, circuit breaker, voltage transformer, current transformers etc. shall be suitably enclosed and designed to minimize chances of accidents to operating personnel during normal operation and maintenance.

Suitable provision shall be made for connection of switchboard copper earth bus to grounding conductor stub. The earthing sheaths of the outgoing cables shall also be properly terminated.

All interior and exterior surfaces of the enclosures shall be thoroughly cleaned and painted with one coat of metal primer and two coats of finishing paints. Light grey paint shall be used for exterior metal surfaces. The interior finish of panels shall be mat- white. A quart of paint shall be provided for on-site touch-up work.

Suitable arrangement shall be made for labelling of each circuit.

The 11 kV panels shall be installed in the 11 kV Switchgear Room of the new Control Building. The Contractor/Manufacturer shall supply drawings of the switchboard for approval of the Employer.

### 6.19.11 Bus bars

A set of three busbars made of 98% IACS electrical conductivity copper of current rating of 2500 Amps. shall be provided.

The busbars shall be air insulated and supported on epoxy cast resin insulators. The busbars shall be completely covered with insulation capable of withstanding the full line to line maximum service voltage.

All busbars at joints shall be tin plated and firmly jointed. A drawing showing clearly the details and methods of jointing shall be provided.

The busbars shall be capable of being extended without difficulty on either side and provision shall be made for expansion and contraction of the busbars and connections.

The maximum temperature rise of the busbars and their joints above the ambient temperature, shall be 30°C under normal conditions. The busbars and connections shall be so protected or screened as to permit cable jointing and other connections to be carried out safely when the busbars are alive.

### 6.19.12 Circuit Breakers

The circuit breakers shall be of vacuum type with 25 kA breaking capacity. They shall be triple pole, draw out type. They shall be manufactured and tested according to latest revision of IEC 62271-100. All the three poles shall be coupled so as to operate simultaneously. The breaker shall have the following characteristics and ratings:

1. Rated voltage, kV, rms. 17.5
2. Rated insulation levels:



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| | | |
|---|---|---|
| | a) Rated one minute power frequency withstand voltage, kV, rms. | 38 |
| | b) Rated lightning impulse withstand voltage kV, peak. | 95 |
| 3. | Rated frequency, Hz. | 50 |
| 4. | Rated normal current at 50 Hz and at an ambient temperature of 50˚C, A, rms | 630 |
| 5. | Rated short-time withstand current, kA | 25 |
| 6. | Rated peak withstand current, kA, peak | 63 |
| 7. | Rated duration of short-circuit, second | 1 |
| 8. | Rated short-circuit making current, kA, rms. | 63 |
| 9. | Rated short-circuit breaking current at rated voltage kA, rms. | 25 |
| 10. | Operating duty | O-0.3 sec.-CO-3 min-CO |
| 11. | Closing time, msec. | 130 |
| 12. | Opening time, msec. | 70 |

The circuit breaker shall be vertically or horizontally isolating and shall have mechanical interlocking devices, arc control devices and disconnecting devices, under carriage and automatic safety shutters with locking facility.

At least following mechanical interlocks shall be provided:

i) To prevent moving the circuit breaker to or from the connected position when the breaker is closed.

ii) To prevent closing the circuit breaker unless the primary disconnecting devices are in full contact or separated by a safe distance and the shutters are closed.

iii) To prevent switching when the auxiliary plug of the draw out CB is unplugged.

In addition, the Contractor/Manufacturer shall provide a sufficient number of interlocks to provide full safety for the operator when parts of the circuit breaker or its mechanism malfunction during the operation of the switchgear. A list and mode of operation of all such interlocks shall be supplied.

The breakers shall have mechanical "ON" and "OFF" position indicators.

The design shall be such that even after repeated fault interruptions, the capability of the circuit breaker to carry its rated current continuously is not impaired. The Contractor/Manufacturer shall provide literature and technical data in this regard.

The circuit breakers shall be capable of interrupting any current from zero to its rated breaking current when used on a predominantly resistive or inductive circuit. The break time at all currents less than the rated breaking current, shall not exceed the rated break time.



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The arc interrupting mechanism shall be designed with ample mechanical and electrical factors of safety in all its parts. These parts shall consist of a minimum number of assemblies arranged for convenient installation and readily removable for repair or inspection.

Silver plated; self-aligning isolating contacts shall be provided for separating the breaker from the busbars. They shall be adequately interlocked and protected by manually operated shutters with locking facility.

Silver plated plug contacts shall be provided between separable units to complete the secondary circuits. They shall be of the pressure loaded self-aligning type.

The temperature rise of the main contacts of a circuit breaker shall not exceed the value given in IEC Publication 62271-100 minus 10 K˚ to take into account specified ambient temperature of 50˚C against 40˚C ambient temperature considered in IEC.

The operating mechanism shall be spring charged power mechanism with manual push buttons for closing and opening the breaker. The closing springs shall be charged by a 220 Volt D.C. motor. The power mechanism shall be completely independent of the operator and shall consist of springs charged in readiness for closing operation.

The mechanism shall be trip-free. It shall be possible to prevent operation of the operating mechanism when maintenance is in progress on the circuit breaker.

The closing mechanism shall not prevent or delay the opening of the circuit breaker beyond the standard interrupting time.

The operating mechanism shall incorporate the following safety features:

i) The closing springs, if charged should not be capable of release while the circuit breaker is closed.
ii) Interlocks to prevent slow closing or slow opening of the circuit breaker in its service position.

The circuit breakers shall be provided with 220 volts. D.C. trip coils for operation with protection relays.

The circuit breakers shall be designed and constructed to operate without replacement of mechanical parts due to breakage, excessive wear or adjustment, for 2000 operations each consisting of a complete opening and closing operation of the circuit breaker.

Testing: The circuit breakers shall be tested in accordance with IEC 62271-100.

The circuit breakers shall be provided with a nameplate in accordance with IEC 62271-100.

**6.19.13 Current Transformers**

The current transformers shall be manufactured and tested in accordance with IEC 60044-1 and particulars listed herein.

Single pole, epoxy resin insulated, dry type, self-contained`, indoor current transformers suitable for mounting in the switchgear shall be supplied. The protective current transformers shall have the following ratings:

- Transformation ratios 150-75/5A for outgoing panels



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| | | |
|---|---|---|
| | | 700-350/5-5A for incoming |
| - | Accuracy class | 10P20 |
| - | Output, VA | 30 |

The measuring current transformers shall have the following ratings:

| | | |
|---|---|---|
| - | Transformation ratios | 150-75/5A for outgoing panels<br>700-350/5-5A for incoming |
| - | Accuracy | 0.5 |
| - | Instrument security factor | 5 |
| - | Output, VA | 15 |

The rated short time thermal current ratings of the 11 kV current transformers shall be 25 kA.

The rated dynamic peak current which the current transformers will withstand without being damaged electrically or mechanically shall be 108 kA.

Insulation Levels: The insulation levels for the current transformers shall be as given below:

| | | |
|---|---|---|
| i) | Rated Voltage, kV, rms. | 17.5 |
| ii) | One minute power frequency withstand voltage kV, rms. | 38 |
| iii) | Impulse withstand voltage, kV, peak. | 95 |

The current transformers shall be tested according to latest revision of IEC 61869-2 for all ratios and taps.

**6.19.14 Voltage Transformers**

Voltage transformers shall be manufactured and tested in accordance with IEC Publication 60044-2 and requirements listed herein.

Three single phase, self-contained, indoor draw out type voltage transformers shall be supplied per bay. The voltage transformers shall be epoxy resin insulated.

The rated frequency shall be 50Hz and all rated output, accuracies and tests shall be for this rated frequency

The voltage ratio shall be 11000/110 Volts. The tests shall be carried out for above voltage ratio.

The characteristics of the voltage transformers shall be as follows:

| | | |
|---|---|---|
| - | Accuracy classification | 0.2 |
| - | Rated burden, VA | 25 per phase |

The voltage transformers shall withstand for one second the mechanical and thermal stresses resulting from a short circuit on the secondary terminals with full voltage maintained on the primary terminals. Provisions shall be made to protect the voltage transformers from faults in secondary side.

The dielectric test voltage shall be as follows:

| | | |
|---|---|---|
| - | Rated maximum primary | 17.5 |



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| | | |
|---|---|---|
| | voltage, kV, rms. | |
| - | One minute power frequency withstand voltage, kV, rms. | 38 |
| - | Lightning impulse withstand voltage, kV, peak. | 95 |

The terminal markings shall be in accordance with IEC Publications.

Voltage transformers shall be wound type and tested in accordance with the methods of IEC Publication 61869-2.

A stainless steel diagrammatic nameplate shall be attached above the terminal box or to an alternate location if the alternate location is more readily accessible when the transformer is mounted. The nameplate shall include, as a minimum, the following information:

i) Serial number.
ii) Type and form designation.
iii) Rated primary voltage and ratio.
iv) Thermal burden rating at 50°C ambient temperature.
v) Rated insulation class.
vi) Impulse level, full wave in kV.
vii) Rated frequency.
viii) Name of manufacturer and year of manufacture.
ix) Connection diagram and polarity markings.

**6.19.15 Instruments**

The instruments shall be manufactured and tested in accordance with latest revision of IEC Publication 60051 and the requirements listed herein in Technical Specifications.

The indicating instruments shall be semi-flush mounted, back connected dust proof switchboard type, having a removable transparent, dust tight window cover with a dull black finish to match in appearance with relays and meters. Scale plates shall have a permanent white finish with black graduation and numerals and with the instrument transformer ratio for which instrument will be provided graduated prominently marked. The zero adjuster will be provided outside the instrument. All instruments shall be tropicalized.

Ammeters shall be suitable and robust enough to withstand the momentary large currents arising in the circuit during short circuit conditions without damage or loss of accuracy.

The marking of terminals of instruments should preferably be the same as those of the terminal of the instrument transformer to which they are to be connected.

A diagram of connection giving the following particulars shall be supplied with the instruments.

1. The current disposition of the connections carrying current to and from the instrument.
2. Diagram explaining internal wiring of the instrument.

The accuracy of instruments shall be of class 1.5 for ammeters and voltmeters.

The preferred full-scale value of ammeters for use with current transformers shall be as follows:

i) Ammeters:

Rated Primary Full Scale



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| Current of CT (Amps) | Value, (Amps) |
|---|---|
| 700-350 | 700-350 |
| 150-75 | 150-75 |

ii) Voltmeters: The voltmeters scale range shall be 0-15 kV.
Relevant data shall be marked on instrument to clarify the rating and make.

iii) kWh Meter and kVARH Meter: kWH meter shall be 3 phase 3 wire. It shall have maximum demand indicator to indicate in kilowatts. The potential coils shall be of 110 volts rating. The current coils shall be of 5 Amp rating. This meter shall be supplied and tested in accordance with IEC Recommendation 60043.

kVARH meter shall also be of the above-mentioned ratings for measuring the reactive energy. It shall be tested as per IEC Recommendation 60043.

The kWH and kVARH meters may be built into one case or may have independent cases and shall be mounted side by side.

The nameplates of the meters shall be in accordance with IEC Recommendation 60043.

**6.19.16 Relays**

Protective relays shall be of the back- connected dust proof, semi-flush, for operation in climatic conditions specified in Section-2 of Technical Specifications. The indicated temperatures may, however, be exceeded considerably in the immediate surroundings of the relays. Relays shall be tropicalized.

Relays shall be capable of 5000 electrical operations when tested at rated values of energizing quantities and at a rate which will not result in overheating. Withdrawable plug-in units and test plugs and sockets shall withstand 500 mechanical operations without suffering damage.

The relays shall withstand a test voltage of 2000 volts rms for 1 minute. All insulated parts and terminals shall be tested to earth. All circuits insulated from one another shall be tested with voltage applied between the circuits.

The overcurrent protection relays for 11 kV system shall be numerical type having definitive, inverse and instantaneous features.

Operation indicators shall be provided on all phases of relays and shall be designed for hand resetting. The operated position shall be clearly distinguished from the unoperated position. The color of the operation indicator flag shall be red on white background.

The relays shall incorporate test devices which shall be in front of panel mounted so that testing can be carried out from the front of the panels using test plugs. The test devices shall be so arranged that the current transformer secondary circuits cannot be open-circuited or voltage transformer circuits short-circuited at any position while test plugs or covers are being inserted or removed. A test device integral with a meter or relay is satisfactory if provision is made for testing each device. Sufficient number of test plugs shall be furnished.

The type tests listed below are specified. Certified "type test reports" on identical units shall be acceptable. The Contractor/Manufacturer shall indicate clearly the method of testing and test values for the limits of error test which shall be subject to approval. The relays shall meet the requirements of these Technical Specifications.



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**Type Tests**

i) Limits of error.
ii) Temperature rise test.
iii) Overload test.
iv) Contact rating test.
v) Mechanical durability test.
vi) Variation of characteristics with ambient conditions.

The overcurrent relays shall have a rating plate marked with the following information:

i) Make.
ii) Type of relay.
iii) Serial number.
iv) Frequency.

### 6.19.17 Control and Termination

All control wiring shall be done with 600V grade, single core PVC insulated copper wire with 90°C operating temperature. All potential connections shall be made with 2.5 sq.mm. wire and all current connections with standard 4 $mm^2$ wire.

The control wires shall be tested with an A.C. voltage of 2 kV for 1 minute.

The ends of each wire shall be identified by suitable method.

In case of hinged panels matching terminal blocks shall be provided on both sides of the hinged section.

## 6.20 ERECTION, TESTING AND MAINTENANCE EQUIPMENT AND SPARE PARTSGeneral

These Specifications cover the requirements of testing, maintenance & erection equipment and spare parts.

All testing, maintenance and erection equipment shall be new & unused and shall conform to test, maintenance and erection (including assembly and disassembly) requirements of the various equipment offered during its useful life.

Erection equipment shall be manufactured especially for use with the equipment offered.

The testing equipment shall be lightweight, portable, compact, rugged and shall provide operating convenience and reliability for field testing. The testing equipment shall include meters, operating controls, safety devices, cables, toolkit, all accessories and spare parts. Contractor shall submit instruction, operation and maintenance manuals for all the testing equipment. The Proposer shall list in the Proposal, optional features available in the testing equipment offered.

#### 6.20.1.1 Special Maintenance Equipment

SF6 Circuit Breaker Consisting of:

(1) Pipe clamping and grooving tool to obtain a good seal in the fittings of control circuit.
(2) Pipe crimping block.
(3) SF6 refilling device.

(4) Module head lifting device.

(5) SF6 leak detector with complete accessories.

(6) Sets of single-end torque wrenches to fit every type of nut and bolt head, used for the circuit breakers and erection equipment.

(7) Sets of screw drivers, pliers and other normal tools.

(8) Sets of any other special tools required in the operation of the circuit breakers.

#### 6.20.1.2 Erection and Maintenance Equipment, and Tools for Disconnectors

The Proposer shall provide erection and maintenance equipment and tools required for erection and maintenance of disconnectors.

#### 6.20.1.3 Testing Instruments

These shall be robust; state of art numerical instruments conforming to IEC standards and have proven experience.

1. Universal Relay Test Set Omicron CMC 356, Fareja-549or ISA DRTS 64with complete accessories along with dedicated latest laptop computer, laser jet colored printer or any other compatible approved set, suitable to test distance and other relays.
2. Latest Laptop Computer along with laser jet colored printer having provision of A4& A3 prints along with both sides printing facility and complete accessories as specified for uploading and downloading the setting for testing.
3. Primary Current Injection Test Set (0-3000A).
4. Three phase secondary injection test set with input voltage 400V, 3Ø, 50 Hz output range 0-50A, 110-120V.
5. Phase sequence indicator 3ø, voltage range 100 to 500V, 50 Hz.
6. Digital phase angle meter type Multiamp Model 175A or approved Equivalent.
7. High voltage insulation resistance tester.
8. Digital type Standard Multi-range, Multimeter with DC/AC current, voltage and ohm Scales, Fluke or approved equivalent.
9. Single phase Variac input 230V, Output 0-260V, 8A/2kVA.(10)
10. Three phase Variac input 400V, 50HZ, Output 0-450V, 2A/500VA.
11. Digital standard multi-range clip-on meter.
12. Contact resistance measurement set Program type Micro Ohmmeter MOM200A or approved equivalent.
13. Dielectric Test Set for Insulating Oil 90kV as per WAPDA Specification P-156:81.
14. Capacitance and Dissipation Factor (C & DF) Test Set 12 kV.
15. Battery Ground Test Set Multiamp BGL or equivalent.
16. Battery capacity/discharge test system TORKEL 900 complete with Extra Load TXL870 and software and printer or equivalent.
17. Test equipment for verification of magnetization characteristics of current transformers etc. (Omicron CT Analyzer) or approved equivalent.
18. Battery cell terminal voltage measurement and recording test set.
19. Resistance bridge for accurate measurement of low resistance such as of CT & VT windings and cables.
20. Earth resistance tester for measurement of the earth resistance, soil resistivity and ohmic resistances.



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21. Portable Circuit Breaker Analyzer/Chronograph system Program type TM1760 complete.
22. DC Hipot test set 0-80 kV as per WAPDA Spec. P-157:81.
23. AC Hipot test set 130 kV Phoenix USA Type BK130 or equivalent.

### 6.20.2 Mandatory Spare Parts for Switchyard

#### 6.20.2.1 General

All spare parts shall be new, strictly interchangeable with the parts by which they are intended to be replaced and shall conform to the relevant Specifications. In case the Proposer's estimates differ from the specified quantities, the Proposer shall furnish his own supplementary list of additional recommended spare parts for maintenance for Five (05) years under specified environments.

**a) 132kV Circuit Breaker**

| | | |
|---|---|---|
| Circuit breaker along with operating mechanism complete as specified/used type, but without supporting structure. | Set | 1 |
| Seals, gaskets, washers, O-rings and other consumable parts required for lifetime maintenance of the circuit breaker as recommended by the manufacturer. | Set | 2 |
| Contactors, switches, push buttons, indicators, relays, timers, gas density meters, MCBs etc.; one of each type used for circuit breaker control and monitoring systems. | Set | 1 |
| SF6 in standard containers | kg | 100 |

**b) 132 kV Disconnectors**

| | | |
|---|---|---|
| Three pole disconnectors along with operating mechanism complete as specified but without supporting structure. | Set | 1 |
| Three pole disconnectors with earthing switch along with operating mechanism complete as specified but without supporting structure. | Set | 1 |
| Main contacts (complete set), MCBs, contactors, relays, timers; one of each type used in control system of the disconnector/earthing switch. | Set | 2 |

**c) 132 kV Surge Arrester**

| | | |
|---|---|---|
| 132 kV surge arrester, single pole, complete with discharge counter but without steel supporting structure. | Set | 1 |

**d) 132 kV Insulators**



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| | | | |
|---|---|---|---|
| | Suspension insulator disc. | Each | 100 |
| | Station post insulator stack, complete, without supporting structure. | Set | 3 |
| **e)** | **Control Board and Metering Board** | | |
| | Switch board indicating lamps, of each type used. | Each | 20 |
| | Color caps for indicating lamps of each type used. | Each | 20 |
| | Resistor for 230V DC indicating lamp. | Each | 20 |
| | Resistor for 230V AC indicating lamp. | Each | 20 |
| | M.C.B.'s of each type used. | Each | 3 |
| | Control and instrument switches (one for each type used). | Each | 2 |
| | Terminal block with marking strip and cover (25% of the quantity installed). | Lot | 1 |
| | Test blocks and plugs of each type used. | Set | 3 |
| | Test switches. | Set | 3 |
| | Digital multimeter | Set | 2 |
| | Indicating and recording instrument set consisting of one of each type of instrument used. | Set | 1 |
| | Semaphore indicators. | Set | 1 |
| | DC annunciator relays units complete one of of each type used. | Set | 1 |
| | Indicator meter of each type | Set | 1 |
| | Energy meter of each type | Set | 1 |
| | AC annunciator unit complete including annunciator relay each type used | Set | 2 |
| **f)** | **Relay Boards and Relays** | | |
| | **Line Protection Relays** | | |
| | Distance cum differential relay of used type. | Set | 1 |
| | O/C relay and earth fault relay of used type used. | Set | 1 |
| | **Miscellaneous Protection Relays** | | |
| | Breaker failure relay one of each type used. | Set | 1 |
| | Synchronism check relay of each type used. | Set | 1 |
| | Bus bar low impedance centralized relay | Each | 1 |
| | Auxiliary relays consisting of one of each type | | |



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| | | | |
|---|---|---|---|
| | used. | Set | 1 |
| | Test plug for relays and meters, one of each type used. | Set | 2 |
| | M.C.B's of each type used in the relay panels. | Set | 2 |
| | Supervision relay for D.C. supply | Each | 2 |

**g) 132 kV Capacitor Voltage Transformer**

| | | | |
|---|---|---|---|
| | 132 kV CVT& SMS VT Complete as Specified/used without steel support structure. | Each | 1 |
| | M.C.B's one of each type used. | Set | 2 |
| | Drain coil | Each | 2 |

**h) 132kV Current Transformer**

| | | | |
|---|---|---|---|
| | Current transformer (bay & SMS), single pole as Specified/used without steel supports structure. | Each | 1 |
| | Gaskets of each type used. | Set | 2 |

**i) AC/DC Auxiliary Supplies**

| | | | |
|---|---|---|---|
| | MCB's of each type used. | Set | 1 |

### 6.20.3 Spare Parts Books

For each separate piece of equipment, the Contractor shall provide a spare parts book. This spare parts book shall contain an assembly drawing of the equipment which shall show all parts of the equipment marked and designated.

### 6.20.4 Packing

The spare parts shall be treated and packed for storage for a long time in the climatic conditions specified in other Sections of these Specifications. Each spare part shall be clearly marked or labeled on the outside of its packing with its description and purpose. When more than one spare part is packed in a single case or container, a general description of its contents shall be shown on the outside of such case or container and detailed list enclosed.

### 6.20.5 Paint

For field touch up work, 30liters of paint lacquer as used on various equipment under these Contract Documents shall be provided.

## 6.21 ERECTION, TESTING AND COMMISSIONING

### 6.21.1 General

The Contractor shall complete the erection, testing and commissioning of the switchyard and shall hand over in proper working order in accordance with the Contract Documents. All work of assembly, construction and erection shall be done in a neat, first-class workmanship manner according to the best practice applicable and as approved by the Employer



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The Contractor shall submit a detailed description of the field tests he intends to carry out on his equipment, comprising test protocols, testing and commissioning procedures etc. for Employer's review well before starting of the field tests.

The Contractor shall be responsible for satisfactory field testing and commissioning of equipment to the satisfaction of the Employer prior to the energization. Employer may also ask the Contractor to perform additional tests, which may not be listed, to prove that particular equipment is fit for commissioning and energization.

A record of all performance tests shall be embodied in a report to be submitted by the Contractor upon completion, to the satisfaction of the Employer of the tests described herein together with such other tests as may be agreed between the Contractor and the Employer, which collectively shall constitute the Commissioning Tests.

The Employer may, at his option, require that tests be made after the equipment has gone into service in order to demonstrate that all performance guarantees have been met. The Contractor will be permitted to have his representative present at his own expense and make all necessary corrections. Additional tests shall then be made under the directions of the Employer to demonstrate to his own satisfaction the effectiveness of these corrections. These additional tests shall be at the Contractor's expense. Until the necessary corrections have been satisfactorily made, the conditions of the Contract shall not be considered fulfilled.

Upon completion to the satisfaction of the Employer, of the tests specified hereafter together with such other tests as may be agreed between the Contractor and Employer shall collectively constitute the commissioning tests. The Contractor shall certify in writing to the Employer that the equipment or part of the equipment has been installed and tested to the satisfaction of the Employer and is ready for energization.

All instruments and test equipment required for complete installation, testing and commissioning of plant shall be arranged by the Contractor.

### 6.21.2 Erection and Installation

#### 6.21.2.1 High Voltage Bus-Work

##### 6.21.2.1.1 General

The Contractor shall install the conductor, insulators and the hardware for strain and tubular buses and overhead shield wire in accordance with approved drawings.

##### 6.21.2.1.2 Conductor and Buses

Buses which are used in tension shall be free of joints or splices. All bus connectors shall be clamped firmly and locked securely. The equipment and methods used for stringing the conductors shall be approved by the Employer and shall be such that the conductor will not be damaged during the stringing operation.

Tubing’s used for bus work and connections to equipment shall be shaped and formed prior to installation to reduce the possibility of damaging equipment terminals. All tubing shall be installed in such a fashion that stresses between connecting terminals will be reduced to a minimum. If connection is made to the equipment on another foundation or structure then the tubing shall have flexible connectors at one end.

The radius of tubing bends shall not be less than four times the diameter of the tubing, and such bends shall be free from kinks, indentations, or flattened surfaces. Tubing shall be utilized in such a manner as to minimize the necessity of splicing. Splicing will not be allowed unless



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unavoidable. All terminals shall be bolted securely and locked. All connections shall be thoroughly cleaned to remove oxide film. An oxide retarding compound of approved type shall be used at all connections and precautions shall be taken to seal moisture out of the joint to avoid galvanic corrosion.

#### 6.21.2.2 Circuit Breakers

The circuit breakers shall be assembled, placed, leveled, aligned and grouted on their concrete foundations and connected in accordance with approved drawings.

The circuit breaker control panels shall be factory wired. The control and power cables shall be terminated at terminal blocks. Connections to control mechanism shall be with control cables running through conduit from cable trench to mechanism cabinets.

#### 6.21.2.3 Disconnectors

The Contractor shall assemble, mount and connect all gang operated switches. Each pole of the disconnector shall be installed so that the base shall not be stressed unequally when bolted to the supporting member. The poles of the disconnector shall be aligned accurately and leveled on the supporting steel structures and shall be adjusted to permit a smooth and completely controlled movement through the entire operating cycle.

The bearing and the operating mechanism shall be lubricated properly. All contacts of the switches shall be adjusted and aligned for proper contact pressure and coated with corrosion inhibiting grease.

#### 6.21.2.4 Surge Arresters

Surge arresters shall be mounted as close as possible to the apparatus being protected.

#### 6.21.2.5 Instrument Transformers

Instrument transformers shall be mounted and connected in accordance with standard practice. Secondary connections to current transformers shall be made with minimum 6 sq.mm conductors and to voltage transformers with minimum 4 sq.mm conductors. Separate cable against each core/winding shall be provided.

All taps of each core shall be provided in CT junction box.

The connecting cables shall run in metallic conduits from trench to instrument transformers.

#### 6.21.2.6 Switchyard Protection System

Switchyard relay panels shall be erected on channel iron bases. The channel irons shall be leveled and grouted in place and the bay Contract units and relay board panels mounted thereon. The Contractor shall mount all equipment and shall make all necessary connections and interconnections to the panels in accordance with the approved standard practices.

All instruments and relays shall be properly installed, connected and tested to meet the technical specifications in the presence of the Employer.

#### 6.21.2.7 Telecommunication and SCADA Systems

Proper care shall be taken to avoid mechanical joints, shocks or vibrations to the equipment. If any soldering etc. on site is necessary, the person making these connections and tools will be properly grounded during the entire operation. Commissioning shall include operational tests to verify all possible modes of operation of SSB, protection and switching equipment.



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Signal to noise ratios will be monitored and demonstrated to be equal or better than design values.

#### 6.21.2.8 Control and Small Power Cables

Cables shall be installed on cable supports, in cable trenches or in conduits. Cables shall be installed with sufficient slack to allow for expansion and contraction and tied at each support point. If laid in trenches, the cables shall rest on cable supports suitably spaced, and shall be fastened at appropriate points, using bolted galvanized straps, which should not press tightly against the insulation nor damage the outer sheath.

Where group of cables enter or leave the trench, each shall be identified with stenciled metal tags. Each tag shall indicate the terminal location to which it is attached. At each cable termination, the cables shall be clamped below the terminal block. Cable glands of appropriate sizes shall be used at cable entrances into control panels, relay panels and marshalling boxes.

Cable runs shall be continuous from terminal to terminal to the extent permitted by available commercial lengths. Splicing shall not be permitted.

Insulated wire and cable shall be handled with care so as to avoid kinking and damage to insulation and outer jackets. Cables shall not be bent around a radius less than that recommended by the manufacturer.

Each wire terminating in a terminal block shall carry a permanent identification tag (ferrule) bearing the same identification number as given on the drawings. Slip-in type ferrules should not be used for this purpose.

The Contractor shall install all lugs, terminal blocks and terminals required and shall make all connections required to provide a complete installation ready to operate. Cable identification tags of a permanent type shall be provided and installed on both ends of each power and control cable.

Connections in lighting wires and cables shall be insulated with layers of plastic insulating tape or with high grade rubber tape over which friction tape shall be applied.

Sufficient slack shall be allowed in each run where a number of cables or wire comprising a circuit are trained through a pull box, terminal box, trench or tray and shall be neatly placed and tied together. Lacing shall also apply from the point of leaving a cable-tray or raceway to the point of attachment on the terminals of the Switchgear, switchboard or other devices unless the run is in conduit.

#### 6.21.2.9 Switchyard AC Power

The Contractor shall install all required power and auxiliary apparatus, cables and make all connections.

#### 6.21.2.10 AC and DC Auxiliary Supplies

The Contractors shall install and connect the equipment under these specifications as specified in Section 6.17.

### 6.21.3 Testing and Commissioning

#### 6.21.3.1 HV Bus-Work / Equipment Connections

1) Verification of tightness of nuts/bolts as per the recommended torque.
2) Verification of sag and tension of the overhead conductors.



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3) Measurement of contact resistance of the HV connections.
4) Thermo vision survey of the HV connections after energization at high voltage.
5) Check of visible corona after energization.
6) Voltage drop test with a minimum 100 A.

### 6.21.3.2 Circuit Breakers

a) Measurement of insulation resistance (Megger tests).

b) Measurement of air content and humidity in SF6 gas in the cylinder before its filling into the breaker.

c) Measurement of air content in SF6 at four times after filling in the breaker up to completion of maintenance period.

d) Recording of humidity content of the SF6 gas at four times after filling in the breaker up to completion of maintenance period.

e) SF6 leakage tests.

f) Verification of ac and dc auxiliary supplies in respect of magnitude and phasing/polarity.

g) Verification of pick-up and drop-off of each of the SF6 pressure switches at rising and dropping pressures.

h) Verification for each hydraulic/pneumatic pressure switch in respect of pick-up & drop-off

i) Verification of operation of pressure relief valves.

j) Verification of pressure thresholds for pump start/stop, breaker automatic tripping/ blocking/lockout of close, trip and auto reclose operations.

k) Measurement of starting and running currents, and direction of rotation of hydraulic/compressor motors.

l) Measurement of time to reach the pump cut-off pressure:
- From zero pressure
- After close operation
- After open operation
- After CO operation
- After OCO operation

m) Measurement of loss of hydraulic pressure over 24 hour period.

n) Measurement of current in the tripping/closing coils.

o) Measurement of operating times:
- Measurement of operating time at minimum, nominal and maximum dc supply voltage.
- Measurement of operating times at maximum, nominal and minimum hydraulic pressures.
- Measurement of time for "O", "C", "CO" and "OCO" operations

While performing the timing tests, in addition to the numerical printout, traces of contact travel and close/open positions i.e. graphical recording of times should be appended to the test reports.

Timing of each interrupter and each pre-insertion resistor shall be separately recorded and shall be graphically visible on the timing strips.



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p) Verification of pre-insertion time of closing resistors.
q) Verification of time variation between opening of series contacts on any one phase.
r) Verification of time variation between opening of contacts of any two phases.
s) Measurement of contact resistance.
t) Verification of functioning of auxiliary contacts.
u) Verification of setting of the hydraulic motor thermal protection relay by secondary injection.
v) Verification of functioning/calibration of every timing relay used in the control system.
w) Verification of trip free operation and pole discordance functions.
x) Functional tests in respect of local/remote controls, interlocking, anti-pumping, annunciation, fault & events recording, SCADA functions etc.
y) Functional tests of heating and lighting for the panels and cubicles.
z) Verification of grounding connections and continuity.
aa) Check of visible corona after energization.

#### 6.21.3.3 Disconnectors / Earthing Switches

a) Measurement of insulation resistance (Megger tests).
b) Verification of ac and dc auxiliary supplies in respect of magnitude and phasing/polarity.
c) Verification of mechanical adjustments. Field measurements should be compared with the manufacturer's recommended adjustments and tolerances.
d) Measurement of contact resistance of the main contacts.
e) Verification of limit switch operation.
f) Verification of operation of auxiliary switches.
g) Measurement of operating times for opening and closing operations.
h) Measurement of starting and running currents of motors of disconnecting and earthing switches at minimum. nominal and maximum auxiliary supply voltage.
i) Verification of functioning of motor protection devices by secondary injection.
j) Functional tests in respect of local/remote controls, interlocking, annunciations, fault & events recording, SCADA functions etc.
k) Functional tests of panels'/cubicles' humidity control, ventilation, internal illumination
l) Verification of grounding connections.
m) Check of visible corona after energization.

#### 6.21.3.4 Surge Arresters

a) Test of insulation resistance:
- HV-Ground/Base
- Base-Ground
b) Verification of grounding connections and continuity.
c) Measurement of ground resistance.
d) Verification of surge counter operation.
e) Functional tests of surge arrester remote signaling, annunciations, events and fault recording facilities which ever available with surge arrester.



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f) Measurement of leakage current with leakage current analyzer subsequent to energization of surge arrester.

g) Check of visible corona after energization.

#### 6.21.3.5 Current Transformers and Current Circuits

a) Verification of insulation resistance (Megger test):
- Primary to ground
- Each secondary winding to ground
- Primary to each secondary winding
- Between secondary windings

b) Measurement of winding resistance of each secondary winding.

c) Measurement of capacitance and dissipation factor.

d) Verification of winding polarities by flick test.

e) Verification of magnetization characteristics and knee-point voltages at each tap.

f) Verification of ratios.

g) Verification of current circuits:

Following checks and tests shall be made for the current circuits fed from the bay CTs and transformer bushing CTs:

- Each CT circuit shall be verified for grounding at one point.
- Phase-N loop resistance values shall be measured and recorded.
  * Loop resistance measurements shall also provide lead resistance values.
  * Resistance measurements shall be with wheat stone bridge.
- Verification of all current circuits associated with bay CTs
  * Primary injection shall be carried out for at least the following combinations:
  * Each CT:
    R-G
    Y-G
    B-G
    R-Y
    R-B
  * Busbar 1 CT and Mid CT in series:
    R-G
    Y-G
    B-G
  * Secondary current measurements at each test block shall include recording of current magnitude as well as relative phase angle.
  * Burden volts across each CT core shall be recorded during primary injection.
  * In addition to measurement of magnitude of current and its relative phase angle at each test block during primary injection, current in panels' internal wiring shall be checked.

h) Verification of operation of protective devices at the final (fault) settings during primary injection.



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i) Dissolved gas analysis (D.G.A) and measurement of moisture content of oil samples from each current transformer for future reference.

j) Functional tests of panels'/cubicles' humidity control, ventilation, internal illumination

k) Verification of grounding connections and continuity.

l) On-load tests on current transformer circuits:

- Secondary current measurements at each test block in respect of current magnitude as well as relative polarity.
- Measurement of burden volts across each CT core.
- Measurement of current magnitude in panels' internal wiring.

m) Check of visible corona after energization.

#### 6.21.3.6 Coupling Capacitor Voltage Transformers (CCVTs) / Capacitor Voltage Transformers (CVTs) and Voltage Circuits

a) Tests of insulation resistance (Megger tests):

- Primary winding-ground
- Primary to each secondary winding
- Secondary to ground and between secondary windings

b) Measurement of winding resistance at each tap

c) Verification of polarities:

- In case polarity of CCVT/CVTs/VTs windings cannot be verified with the flick test, phase angle meter shall be used to check the phase angle between the primary injected voltage and secondary output.

d) Verification of voltage ratio at each tap by primary injection.

e) Capacitance and dissipation factor measurements.

f) Verification of voltage circuits:

- Verification of grounding of each voltage circuits at one point
- If voltage circuits associated with CCVTs/CVTs/VTs cannot be verified with primary injection, secondary injection shall be made from the terminal box of the voltage transformers
- Measurement of related burden amperes for each core
- Voltage selection for synchronizing system for each combination of circuit breakers' and disconnectors positions shall be checked

g) Functional tests of panels'/cubicles' humidity control, ventilation, internal illumination

h) Dissolved gas analysis (DGA) and measurement of moisture content of oil samples from each voltage transformer for future reference.

i) Verification of grounding connections and continuity.

j) On-load/post energization tests shall be in respect of voltage magnitude, phase angle and phase rotation at the test blocks; voltage magnitude and phase rotation at the terminals of the major devices in the panels; measurement of burden current for each core.

k) Check of visible corona after energization.

##### 6.21.3.6.1 Metering Boards

a) Measurement of insulation resistance (Megger tests)

b) Verification of AC&DC auxiliary supply magnitude and polarity/phasing.

c) Verification of grounding connections.



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d) Verification of MCBs operation at settings of thermal/magnetic releases.

e) Verification of calibration of each energy meter and MW/MVAR/Voltage recorder by secondary injection:
   - Injected quantities for recorders shall correspond to at least 25%, 50%, 75%, 100%, 125% and full scale of the instrument
   - For MW and MVAR recorders and energy meters, tests shall also be carried out for at least the following combinations of magnitude and power factor of the measurands:
     * 100% Load: Angle 0, +30, +60, +90, -30, -60, -90 degrees
     * 50% Load: Angle 0, +30, +60, +90, -30, -60, -90 degrees
     * 25% Load: Angle 0, +30, +60, +90, -30, -60, -90 degrees

f) Functional tests of panels'/cubicles' humidity control, ventilation, internal illumination.

g) On-load tests:
   - Current circuits: Measurement of current magnitude, relative phase angle, burden volts
   - Voltage circuits: Measurement of voltage magnitude, phase angle, phase rotation and burden amperes
   - Directional checks of power recorders and energy meters.

**6.21.3.6.2 Outdoor Marshalling Kiosks and Cubicles**

a) Measurement of insulation resistance (Megger tests)
b) Verification of AC&DC auxiliary supply magnitude and polarity/phasing.
c) Verification of grounding connections.
d) Verification of calibration of adjustable devices such as timers
e) Verification of MCBs operation at settings of thermal/magnetic releases.
f) Functional tests to verify alarms, indications, annunciations.
g) Functional tests of humidity control, ventilation, internal illumination.

**6.21.3.6.3 Protection Boards**

a) Measurement of insulation resistance (Megger tests)
b) Verification of AC&DC auxiliary supply magnitude and polarity/phasing.
c) Verification of grounding connections.
d) General tests on each protective device including contactors, timers, auxiliary relays etc. as per the manufacturers' recommended procedures and tests protocols.
e) Verification of protective devices' calibration at the final settings.
f) Verification of protective devices' characteristics.
g) Verification of MCBs operation at settings of thermal/magnetic releases
h) Functional tests of protective devices including operation of power swing blocking relays, auto reclosers etc.
i) Functional tests of protection tele-signaling.
j) Functional tests of complete protection schemes.
k) Functional tests of indications, alarms, annunciations.
l) Functional tests of panels'/cubicles' humidity control, ventilation, internal illumination.
m) On-load tests:
   - Verification of current circuits
   - Verification of voltage circuits
   - Directional tests



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- Tests of differential protections by de-stabilizing the current circuits.

#### 6.21.3.7 Telecommunication and SCADA Equipment

Site Tests shall be performed comprising, as a minimum, the following:

##### 6.21.3.7.1 Power Line Carrier System

a) Installation checks.
b) Wiring, termination and earthing checks in accordance with interconnection drawings.
c) Return loss measurement for each PLC link.
d) Line attenuation measurement for each PLC link.
e) Functional tests on end to end DPLC/DPSE terminals. The tests shall be determined from the Factory Test Procedures.
f) Setting of system functions i.e., AF signal levels, equalization etc.
g) Interfacing to RTU, PAX, Power supply etc.
h) Local and functional tests in conjunction with protection system.
i) Functional tests of command transmit and receive counters.
j) Verification of remote tripping of circuit breakers with direct transfer trip commands.

##### 6.21.3.7.2 Telephone (PAX) System

a) Installation checks.
b) Wiring, termination and earthing checks.
c) Check all connections with the external MDF.
d) Functional tests of trunks and extensions.
e) Check of all types of tones in the system.
f) Check of BER (in case of 2 Mbit/s trunks), AF signal levels, etc.
g) Verification of trunk routes (direct & alternative).
h) Testing of all software features and facilities (local and network). Proper working of network facilities (priority cut-in, forced release, section dialling…) over analogue and digital trunks shall be successfully demonstrated.
i) Tests of system reloading and resetting capabilities in the event of occurrence of various categories of faults.
j) Tests to ensure correct receipt and logging of alarms and correct functioning of automatic diagnostic routines

##### 6.21.3.7.3 48V DC Power System

a) Installation checks.
b) Functional tests and settings on the 48v battery chargers to demonstrate that they maintain their float and boost characteristics within the power supply variations and meet the requirements of the specifications.
c) Capacity test on the batteries at a discharge rate to be approved by the Employer.

##### 6.21.3.7.4 SCADA System

##### 6.21.3.7.4.1 Remote Terminal Unit

a) Installation checks.
b) Wiring, earthing and termination checks.
c) Local testing of each tele information point between RTU and Process.
d) Test of each tele information point between RTU and SCADA/EMS at NPCC.

e) End to end test of each tele information point between the Process and SCADA/EMS (point to point test).

**6.21.3.7.4.2 Data Communication links**

a) Installation checks.

b) Functional tests, on end to end basis, to determine the quality of each data link between Rahim Yar Khan and NPCC.

**6.21.3.7.4.3 Station Direct Wire Telephone System**

a) Installation checks.

b) Wiring, earthing and termination checks.

c) Functional tests, to check the voice communication between subscribers and control room operator and between the subscribers.

**6.21.3.7.4.4 Public Address System**

a) Installation checks.

b) Wiring, earthing and termination checks.

c) Functional tests, to check the voice communication between loud speaker locations and the control room operator.

### 6.21.3.8 Test Equipment

The Contractor shall arrange the test equipment for the above tests. The Contractor shall ensure that is calibrated and suitable for these tests. Calibration certificates valid for at least one year shall be provided.

**6.21.3.8.1 Control and Power Cables**

**6.21.3.8.1.1 MV Cables**

a) Verification of insulation resistance (Megger test):
   - Core-Ground/Shield/Armor
   - Core-Core

b) Verification of core(s) continuity.

c) High voltage/Dielectric tests.

d) Verification of shield continuity and grounding.

e) Verification of armor continuity and grounding.

f) Verification of tightness of connections.

**6.21.3.8.1.2 LV Cables**

a) Verification of insulation resistance (Megger test):-core-core, core-ground/shield

b) Verification of core(s) continuity

c) Verification of shield/armor continuity.

d) Verification of shield/armor grounding

e) Dielectric tests: 2000V ac, one minute

f) Verification of tightness of connections.

### 6.21.3.9 Grounding and Lightning System

**6.21.3.9.1 Grounding System**

a) Visual verification of each grounding connection

b) Verification of tightness of grounding connections as per recommended torque.



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c) Verification of effectiveness of switchyard grounding system by an appropriate method commensurate with installations involving large mesh.
d) Continuity tests of each grounding connection
e) Ground grid integrity test
f) Measurement of grounding resistance with earth resistance tester:
   - Each neutral connection of transformer.
   - Each neutral connection of shunt reactor
   - Each surge arrester connection
   - Building grounding
   - Panels and equipment inside the buildings

#### 6.21.3.10 AC and DC Auxiliary Supplies

##### 6.21.3.10.1 DC Distribution Boards

Following tests shall be performed on MCBs in the DC distribution boards:

a) Verification of breakers'/MCBs' operation at settings of thermal/magnetic releases
b) On-load tests: Measurement of loading of each circuit.

##### 6.21.3.10.2 AC Distribution Boards

Following tests shall be performed on MCBs in the AC distribution boards:

a) Verification of voltage and phasing up to each outgoing breaker/mcb
b) Verification of breakers'/MCBs' operation at settings of thermal/magnetic releases
c) On-load tests: Measurement of loading of each circuit

#### 6.21.3.11 Temperature inside Panels, Cubicles and Marshalling Kiosks

Recording of temperatures inside the panels, cubicles and marshalling kiosks:

- Temperature to be measured after panels, cubicles, marshalling kiosks have been energized with ac and dc supplies and all devices mounted therein have been in service for sufficient time.
- Ambient temperatures i.e., room temperature for indoor equipment, yard temperature for outdoor equipment to be recorded.

#### 6.21.3.12 Coordinated Functional Tests of Control, Protection, Metering and Monitoring Systems

Functional tests shall be carried out to verify coordinated functioning of the control, protection, metering and monitoring systems.

#### 6.21.3.13 Miscellaneous

a) Performance of additional tests to verify characteristic(s) and functions peculiar to the design of an equipment or system device installed at the switchyard/utilized in the protection, control, metering and monitoring systems shall be assessed at the detailed engineering and implementation stages.
b) Visual inspections of equipment and devices shall be carried out in respect of damage, labelling, alignment, dust proofing, sealing against vermin etc.
c) Humidity and vibration recording devices are fitted to the equipment and systems for monitoring during transportation. Recordings of these devices shall be inspected upon



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arrival/installation at the site. Copies of the recordings shall be made part of the site test books.

d) High voltage tests shall be performed on the equipment in accordance with the standards.

e) Applicable tests and verifications mentioned in the above sections and sub-sections shall be applicable to all the equipment and systems not specifically mentioned herein above but may be installed at the switchyards.

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# ANNEXURE-I: TECHNICAL SCHEDULES (E&M WORKS)



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# 1. HYDRO-MECHANICAL EQUIPMENT

## 1.1 TURBINE AND AUXILIARIES

| Item | Designation | Unit | Value | Remarks |
|---|---|---|---|---|
| 1 | Manufacturer name and Country of Origin | | | |
| 2 | Place of manufacture | | | |
| 3 | Number & type of turbine | | 3 x Vertical Francis | |
| 4 | Rated speed | rpm | 375 rpm | |
| 5 | Direction of rotation viewed from generator side | | Clockwise | |
| 6 | Shaft alignment | | Vertical | |
| 7 | Guaranteed efficiency of turbine at: | | | |
| | 1. 100% rated output | % | | **Min 93%** |
| | 2. 90% rated output | % | | |
| | 3. 80% rated output | % | | |
| | 4. 70% rated output | % | | |
| | 5. 60% rated output | % | | |
| | 6. 50% rated output | % | | |
| | 7. 40% rated output | % | | |
| 8 | Guaranteed Weighted Average Efficiency (Refer to clause 1.1.15 for weighting factors of this volume) | `% | | **>92.8%** |
| 9 | Model Hill Diagram. Attachment no.: | | | |
| 10 | Prototype Performance diagram / Hill Diagram. Attachment no.: | | | |
| 11 | Prototype and/or Model test data for demonstrating the Efficiency guarantees. Attachment Nos: | | | |
| 12 | Graph showing the stable operating rage of turbine for continuous operation. Attachment no: | | | |
| 13 | Prototype and/or Model test data for demonstration of the cavitation guarantees given. Attachment Nos: | | | |
| 14 | If the sediment content will influence the cavitation guarantees, this shall be shown at attachment no: | | | |



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| Item | Designation | Unit | Value | Remarks |
|---|---|---|---|---|
| 15 | Prototype and/or Model test data for demonstration of the cavitation guarantees given. Attachment Nos: | | | |
| 16 | Maximum guaranteed output from the turbine shaft at rated head Hr and at TWL (at all unit's operation):<br>Corresponding discharge: | MW<br>$m^3/s$ | | |
| 17 | Maximum runaway speed:<br>Corresponding net head: | Rpm<br>m | | |
| 18 | Fly wheel effect of turbine rotating parts ($GD^2$) | t m² | | |
| | Quantity of required cooling water | | | |
| | Turbine guide bearing oil-cooler | l/s | | |
| 19 | Turbine governing system oil cooler (if applicable) | l/s | | |
| 20 | Maximum sound pressure level at a distance of 1 m at rated operation | | | |
| 21 | Weight of finished-machined runner complete | kg | | |
| 22 | No. of runner blades | No. | | |
| 23 | Runner reference diameter (according to IEC) | mm | | |
| 24 | Heaviest turbine part to be handled by powerhouse crane during installation | kg | | |
| 25 | Weight of shaft | kg | | |
| 26 | Turbine shaft diameter | mm | | |
| 27 | Turbine flow meter | | | |
| | Type | | | |
| | Manufacturer and Country of Origin | | | |
| | Range of flow measurement | | | |
| | Brief description | | | |

## 1.2 GOVERNORS

| Item | Designation | Unit | Value |
|---|---|---|---|
| 1 | Type designation of: | | |
| | – Control unit | | |
| | – Hydraulic unit | | |
| 2 | Manufacturer of Control unit | | |



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| Item | Designation | Unit | Value |
|---|---|---|---|
| 3 | Manufacturer of Hydraulic unit | | |
| 4 | Place of manufacture for Control unit | | |
| 5 | Place of manufacture for Hydraulic unit | | |
| 6 | Sensitivity of governor to respond to minimum speed change of rated speed (smaller 0.02% required) | % | |
| 7 | Governor operating oil pressure | | |
| | – Minimum | bar | |
| | – Maximum | bar | |
| 8 | Range of adjustment of gain control | | |
| | – Proportional gain | - | |
| | – Derivative gain | $s^{-1}$ | |
| | – Integral gain | s | |
| 9 | Governor oil pumps | | |
| | – Number of main oil pumps | - | |
| | – Type of oil pumps | - | |
| 10 | Unit governor oil pump discharge | l/min | |
| 11 | at pressure | bar | |
| 12 | Power rating of main pump motor | kW | |
| 13 | Pressurized accumulator tank | | |
| | – Total oil volume | l | |
| | – Design pressure | bar | |
| 14 | Minimum possible operating cycles of distributor (close-open) without recharging tank | | |
| 15 | Sump tank total oil volume | l | |
| 16 | Hydraulic oil | | |
| | – Total quantity of oil required for complete system including servomotors | l | |
| | – Oil quality | | |
| 17 | Nitrogen pressure system | | |
| | – Type & make of Nitrogen Cylinder | | |
| | – Rating & pressure | | |
| | – No. of cylinders | No. | |



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| Item | Designation | Unit | Value |
|---|---|---|---|
| | – Capacity of each cylinder | $m^3$ | |
| | – Dimensions of each cylinder | m | |
| 18 | Weight of complete governor actuator cabinet with pump set equipment | kg | |
| 19 | Servomotors | | |
| | – Number of servomotors | No. | |
| | – Full stroke | mm | |
| | – Bore of cylinders | mm | |
| | – Active volume | $cm^3$ | |
| | – Maximum operating pressure | bar | |
| | – Minimum operating pressure | bar | |
| | – Max. operating capacity per servomotor | kNm | |
| | – Min. operating capacity per servomotor | kNm | |

## 1.3 TURBINE MAIN INLET VALVES

| Item | Designation | Unit | Value |
|---|---|---|---|
| 1 | Manufacturer | | |
| 2 | Place of manufacture | | |
| 3 | Type designation | | |
| 4 | Applicable standards | | |
| 5 | Maximum leakage from main valve when fully closed against maximum head (with new seal) | l/min | |
| 6 | Maximum head loss through the valve at a flow required for rated turbine output at rated net head | m | |
| 7 | Main dimensions of main inlet valve | | |
| | – inside diameter | mm | |
| | – length of valve body (excluding extensions) | mm | |
| 8 | Type of by-pass valve | | |
| 9 | Valve operating oil pressure | | |
| | – minimum | bar | |
| | – maximum | bar | |
| 10 | Servomotor | | |



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| Item | Designation | Unit | Value |
|---|---|---|---|
| | – Type | | |
| | – Nominal design oil pressure | bar | |
| | – Active volume | l | |
| | – Range of opening time | s | |
| | – Range of closing time | s | |
| 11 | Oil pressure unit | | |
| | – Number of main oil pumps | | |
| | – Type of oil pumps | | |
| | – Oil pump discharge capacity | l/min | |
| 12 | at pressure | bar | |
| 13 | Power rating of pump motor | kW | |
| 14 | Sump tank Total oil volume | l | |
| 15 | Total quantity of hydraulic oil required for complete system including servomotor | l | |
| 16 | Nitrogen pressure system | | |
| | – Type & make of Nitrogen Cylinder | | |
| | – Rating & pressure | | |
| | – No. of cylinders | No. | |
| | – Capacity of each cylinder | $m^3$ | |
| | – Dimensions of each cylinder | m | |
| 17 | Weight of complete main inlet valve | kg | |
| 18 | Weight of complete oil pressure unit with pump set equipment | kg | |
| 19 | Estimated shipping weight of valve | kg | |
| 20 | Maximum weight of valve assembly to be handled by powerhouse crane | kg | |
| 21 | Dimensions | | |
| | – Width | mm | |
| | – Length | mm | |



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## 1.4 POWERHOUSE EOT CRANE

| Item | Designation | Unit | Value |
|---|---|---|---|
| 1 | Manufacturer | | |
| 2 | Country of Origin | | |
| 3 | Type | | |
| 4 | Hoist Capacities: | | |
| | Main Hook capacity | Ton | |
| | Auxiliary Hook capacity | Ton | |
| 5 | Test load (as per FEM Standard): | Ton | |
| | Static load test | Ton | |
| | Dynamic load test | Ton | |
| 6 | Speed of hook: | | |
| | Normal speed at max. capacity | m/min | |
| | Inching speed at max. capacity | m/min | |
| | Speed at reduced mode | m/min | |
| 7 | travelling speeds: | | |
| | Fast | m/min | |
| | Slow | m/min | |

## 1.5 COOLING WATER SYSTEM

| Item | Designation | Unit | Value |
|---|---|---|---|
| 1 | **Pumps** | | |
| | Manufacturer and Country of Origin | | |
| | Type of pump | | |
| | Number of identical pumps (per unit) | | |
| | Capacity of each pump | l/s | |
| | at manometric head | mWC | |
| | Electrical motor rating | kW | |
| | Max dimension of foreign bodies through pump (diameter) | mm | |
| | Total efficiency at design head | % | |
| 2 | **Heat Exchangers** | | |



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| Item | Designation | Unit | Value |
|---|---|---|---|
| | Manufacturer | | |
| | Country of Origin | | |
| | Type | | |
| | Material | | |

## 1.6 DRAINAGE AND DEWATERING SYSTEM

| Item | Designation | Unit | Value |
|---|---|---|---|
| 1 | **Drainage Pumps** | | |
| | Manufacturer and Country of Origin | | |
| | Type of pumps | | |
| | Number of identical pumps | | |
| | Capacity of each pump | l/s | |
| | at manometric head | mWC | |
| | Electrical Motor rating | kW | |
| | Max dimension of foreign bodies through pump (diameter) | mm | |
| | Total efficiency at design head | % | |
| 2 | **Dewatering Pump** | | |
| | Manufacturer and Country of Origin | | |
| | Type of pumps | | |
| | Number of identical pumps | | |
| | Capacity of each pump | l/s | |
| | at manometric head | mWC | |
| | Electrical Motor rating | kW | |
| | Max dimension of foreign bodies through pump (diameter) | mm | |
| | Total efficiency at design head | % | |

## 1.7 COMPRESSED AIR SYSTEM

| Item | Designation | Unit | Value |
|---|---|---|---|
| 1 | **Compressor Units (Include separately for high and low pressure systems)** | | |
| 1 | Manufacturer and Country of Origin | | |



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| Item | Designation | Unit | Value |
|---|---|---|---|
| 2 | Nominal discharge pressure | bar | |
| 3 | Unit discharge rate | m³/h | |
| 4 | Maximum sound pressure level at 1 m distance | dB(A) | |
| 5 | Compressor motor power | kW | |
| 6 | Weight of complete unit | kg | |
| 7 | Overall dimensions: | | |
| | Length | mm | |
| | Width | mm | |
| | Height | mm | |

## 2. HYDRAULIC STEEL STRUCTURES

### 2.1 GANTRY CRANE FOR POWER & FLUSHING INTAKES HSS

| Item | Designation | Unit | Value |
|---|---|---|---|
| 1 | Manufacturer | | |
| 2 | Country of Origin | | |
| 3 | Type | | |
| 4 | Hook capacity | Ton | |
| 5 | Test load (as per FEM Standard): | Ton | |
| | Static load test | Ton | |
| | Dynamic load test | Ton | |
| 6 | Speed of hook: | | |
| | Normal speed at max. capacity | m/min | |
| | Inching speed at max. capacity | m/min | |
| | Speed at reduced mode | m/min | |
| 7 | Crane travelling speeds: | | |
| | Fast | m/min | |
| | Slow | m/min | |

### 2.2 GANTRY CRANE FOR DRAFT TUBE GATES

| Item | Designation | Unit | Value |
|---|---|---|---|
| 1 | Manufacturer | | |



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| Item | Designation | Unit | Value |
|---|---|---|---|
| 2 | Country of Origin | | |
| 3 | Type | | |
| 4 | Hook capacity | Ton | |
| 5 | Test load (as per FEM Standard): | Ton | |
| | Static load test | Ton | |
| | Dynamic load test | Ton | |
| 6 | Speed of hook: | | |
| | Normal speed at max. capacity | m/min | |
| | Inching speed at max. capacity | m/min | |
| | Speed at reduced mode | m/min | |
| 7 | Crane travelling speeds: | | |
| | Fast | m/min | |
| | Slow | m/min | |

### 2.3 TRASH RACK CLEANING MACHINE

| Item | Designation | Unit | Value |
|---|---|---|---|
| 1 | Manufacturer | | |
| 2 | Country of Origin | | |
| 3 | Type | | |
| 4 | Capacity | Ton | |
| 5 | Travelling speeds: | | |
| | Fast | m/min | |
| | Slow | m/min | |

## 3. ELECTRICAL PLANT EQUIPMENT

### 3.1 GENERATORS

| Description | Unit | Value |
|---|---|---|
| Manufacturer | | |
| Origin of manufacturing | | |
| Type | | |



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| Description | Unit | Value |
|---|---|---|
| Applicable Design Standard | | |
| Maximum Continuous Rating at rated pf, rated voltage, rated frequency and Class B temperature rise Guarantee value | MVA | |
| Rated Output, SN | MVA | |
| Rated Power Factor, PF (lagging & leading) | | |
| Rated Voltage, UN | kV | |
| Voltage Limits | ± % | |
| Rated Current, IN | A | |
| Rated Frequency, fN | Hz | |
| Rated Speed, nN | rpm | |
| Design Runaway Speed | rpm | |
| Rotor, Moment of Inertia, J | $tm^2$ | |
| Direction of Rotation | Clockwise, Anti-clockwise | |
| Losses at Maximum Continuous Rating, Rated Voltage, Temperature 75°C and 50 Hz | | |
| Iron losses | kW | |
| Mechanical losses | kW | |
| I2 R-losses | kW | |
| Excitation and field circuit losses | kW | |
| Total Losses **Guarantee value** | kW | |
| Efficiencies: At rated output and 75 °C winding temperature. Bearing losses caused by turbine runner weight and hydraulic load shall not be included. | | |
| At PF= 0.8 - 23.20 MVA (100% load) | % | |
| - 17.40 MVA (75% load) | % | |
| - 11.60 MVA (50% load) | % | |
| At PF= 1.0 - 23.20 MVA (100% load) | % | |
| - 17.40 MVA (75% load) | % | |
| - 11.60 MVA (50% load) | % | |
| Temperature Rise provided that air temperature entering into the generator through the air coolers does not exceed 40 °C at rated load and power factor: | | |
| Stator winding, average value measured with ETD | K | |



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| Description | Unit | Value |
|---|---|---|
| Rotor winding, the entire winding measured by the resistance method | K | |
| Stator core, average value measured with ETD | K | |
| Maximum temperature rises above ambient air: | | |
| Excitation transformer windings, average measured with ETD | K | |
| Absolute temperatures | | |
| Drive End Sliding bearing temperature, measured with ETD in the Babbitt metal | °C | |
| Non-drive End Sliding bearing temperatures, measured with ETD in the Babbitt metal | °C | |
| Outlet cooling water, the inlet temperature not exceeding 25oC | °C | |
| Reactances: | | |
| Unsaturated direct axis synchronous reactance, xd | p.u. | |
| Unsaturated direct axis transient reactance, x'd | p.u. | |
| Saturated direct axis sub transient reactances, $x''_d$ | p.u. | |
| Saturated quadrature axis sub transient reactance, $x''_q$ | p.u. | |
| Short-Circuit Ratio | | |
| The ratio of excitation currents at no load and rated voltage and at short circuit and rated current, i.e. $i_{fo}/i_{fk}$ | p.u. | |
| Generator designed mechanically to withstand continuously a turbine output of not less than | MW | |
| Continuous output, overexcited, at rated speed and voltage when operated as a synchronous condenser, not less than | MVAr | |
| Continuous output, under-excited, at rated speed and voltage when charging a transmission line, without becoming completely self-excited or unstable, not less than, | MVAr | |
| Stator winding withstand voltage (rms) at rated frequency, not less than | kV | |
| Stator winding impulse withstand voltage (BIL, crest), not less than | kV | |
| Excitation System Response Ratio, not less than | | |
| Generator Monitoring System | | |



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| Description | Unit | Value |
|---|---|---|
| Generator Air Gap Monitoring System | Manufacturer / type | |
| Generator Vibration detection system | Manufacturer /type | |
| Short Circuit Currents | | |
| Stationary 3-phase short circuit current from no load and rated voltage | A | |
| Stationary 3-phase short circuit current from rated load and constant excitation | A | |
| Maximum peak phase current by 3-phase short circuit from no load | A | |
| Air Coolers | | |
| Nos. of cooling radiators | | |
| Braking System | | |
| Rot. speed when applying brakes | rpm | |
| Run-out time | min | |
| Max. temperature of brake ring | °C | |
| Air pressure for braking | bar | |
| Weights and Foundation Forces | | |
| Total weight of generator | ton | |
| Erection | | |
| Heaviest piece for lifting during erection | ton | |
| Required lifting height for erection | mm | |

### 3.2 EXCITATION SYSTEM

| Description | Units | Value |
|---|---|---|
| Manufacturer | | |
| Origin of Manufacturing | | |
| Type | | |
| Excitation at generator rated load and the field winding at steady operating temperature: | | |
| - excitation current | A | |
| - excitation voltage | V | |
| Ceiling voltage | % | |



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| | | |
|---|---|---|
| Voltage rises above nominal voltage at the generator terminals by throw-off of rated load and constant excitation. | | |
| - at rated power factor | % | |
| - at PF = 1.0 | % | |
| De-excitation time after tripping from rated load and 1.05 x $U_N$ | sec | |
| Excitation transformer: | | |
| Manufacturer | | |
| Type | | |
| - rated output | kVA | |
| - rated primary voltage | V | |
| - rated secondary voltage | V | |
| - vector group | | |
| - impedance voltage | % | |
| Field flashing: | | |
| - field flashing current (from battery) | A | |
| - estimated time for voltage build-up | S | |
| - required cooling time before repeated starting | S | |

### 3.3 SEGREGATED PHASE BUS

| Description | Units | Value |
|---|---|---|
| Manufacturer | | |
| Origin of manufacturing | | |
| Rating (50 Hz) | | |
| Current | A | |
| Voltage | V | |
| 3 Phase Short circuit withstand current rating (3sec) | kA | |
| Peak Short circuit withstand current rating | kA | |
| Protection Degree (IP Class) | | |
| Total Weight (for 01 Unit) | Kg/m | |
| Conductor | % | |
| Material | | |
| Shape | mm | |
| Cross Section | $mm^2$ | |



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| | | |
|---|---|---|
| Painting External | | |
| Enclosure | | |
| Material | | |
| Dimensions | mm | |
| Thickness | $mm^2$ | |
| Painting | | |
| Insulators | | |
| Power frequency withstand voltage rating | kV | |
| Lightening Impulse withstand voltage rating | kV | |
| Clearance min. Phase/Earth | mm | |
| Clearance min. Phase/Phase | mm | |
| Temperatures | | |
| Ambient | °C | |
| Conductor | °C | |
| Enclosure | °C | |

### 3.4 GENERATOR STEP-UP TRANSFORMERS (20/26 MVA)

| Description | Unit | Value |
|---|---|---|
| Manufacturer's name | | |
| Origin of manufacturing | | |
| Type of transformer | | |
| Applicable IEC standard | | |
| Rated frequency | | |
| Method of Neutral Grounding | | |
| Type of cooling | | |
| Cooling capacity | | |
| Rated Continuous Output **Guarantee Value** | MVA | |
| Temperature rises at continuous rated power:<br>- Top oil temperature rise<br>- Average winding temperature rise<br>- Temperature rise hot spot | <br>K<br>K<br>K | |
| Noise level | dB | |
| Rated voltage: | | |



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| Description | Unit | Value |
|---|---|---|
| - Primary (HV) winding<br>- Secondary (LV) winding | kV<br>kV | |
| Tapping on windings<br>- Number of taps<br>- Tapping range<br>- Type of tap changer | <br>No.<br>% | |
| Highest voltage for equipment:<br>- Primary (HV) winding<br>- Secondary (LV) winding | <br>kV<br>kV | |
| Lightning impulse withstand voltage:<br>- Primary (HV) winding<br>- Primary (HV) winding neutral point<br>- Secondary (LV) winding | <br>kV<br>kV<br>kV | |
| Power frequency withstand voltage (1 min.)<br>- Primary (HV) winding<br>- Primary (HV) winding neutral point<br>- Secondary (LV) winding | <br>kV<br>kV<br>kV | |
| Vector group | | |
| Auxiliary Supply:<br>- AC<br>- DC | | |
| Short circuit impedance at 100% of the rated power at principal tapping | % | |
| No load losses **Guarantee Value** | kW | |
| Load losses at principle tapping **Guarantee Value** | kW | |
| Insulation oil type | | |
| Material of ratings and name plates | | |
| Material of control/terminal box | | |
| Protection class of control/terminal box | IP | |
| Flux density in iron at rated voltage and frequency and at rated voltage ratio tap (no load):<br>- Cores<br>- Yokes | | |
| Transformer bushing | | |
| Manufacturer | | |
| Type | | |
| Current rating of the bushings:<br>- HV bushings<br>- LV bushings<br>- Neutral bushings | <br>A<br>A<br>A | |
| Voltage class:<br>- HV bushings | <br>kV | |



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| Description | Unit | Value |
|---|---|---|
| - LV bushings<br>- Neutral bushings | kV<br>kV | |
| Creepage distance in air:<br>- HV bushings<br>- Neutral bushings | <br>mm<br>mm | |
| Total weight of complete transformer | kg | |

### 3.5 SWITCHYARD POWER TRANSFORMER (10/13 MVA, 132/11.5 kV)

| Description | Unit | Value |
|---|---|---|
| Manufacturer's name | | |
| Origin of manufacturing | | |
| Type of transformer | | |
| Applicable IEC standard | | |
| Rated frequency | | |
| Method of Neutral Grounding | | |
| Type of cooling | | |
| Cooling capacity | | |
| Rated Continuous Output **Guarantee Value** | MVA | |
| Temperature rises at continuous rated power:<br>- Top oil temperature rise<br>- Average winding temperature rise<br>- Temperature rise hot spot | <br>K<br>K<br>K | |
| Noise level | dB | |
| Rated voltage:<br>- Primary (HV) winding<br>- Secondary (LV) winding | <br>kV<br>kV | |
| Tapping on windings<br>- Number of taps<br>- Tapping range<br>- Type of tap changer | <br>No.<br>% | |
| Highest voltage for equipment:<br>- Primary (HV) winding<br>- Secondary (LV) winding | <br>kV<br>kV | |
| Lightning impulse withstand voltage:<br>- Primary (HV) winding<br>- Primary (HV) winding neutral point<br>- Secondary (LV) winding | <br>kV<br>kV<br>kV | |
| Power frequency withstand voltage (1 min.)<br>- Primary (HV) winding<br>- Primary (HV) winding neutral point | <br>kV<br>kV | |



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| Description | Unit | Value |
|---|---|---|
| - Secondary (LV) winding | kV | |
| Vector group | | |
| Auxiliary Supply:<br>- AC<br>- DC | | |
| Short circuit impedance at 100% of the rated power at principal tapping | % | |
| No load losses **Guarantee Value** | kW | |
| Load losses at principle tapping **Guarantee Value** | kW | |
| Insulation oil type | | |
| Material of ratings and name plates | | |
| Material of control/terminal box | | |
| Protection class of control/terminal box | IP | |
| Flux density in iron at rated voltage and frequency and at rated voltage ratio tap (no load):<br>- Cores<br>- Yokes | | |
| Transformer bushing | | |
| Manufacturer | | |
| Type | | |
| Current rating of the bushings:<br>- HV bushings<br>- LV bushings<br>- Neutral bushings | <br>A<br>A<br>A | |
| Voltage class:<br>- HV bushings<br>- LV bushings<br>- Neutral bushings | <br>kV<br>kV<br>kV | |
| Creepage distance in air:<br>- HV bushings<br>- Neutral bushings | <br>mm<br>mm | |
| Total weight of complete transformer | kg | |

### 3.6 STATION AUXILIARY TRANSFORMERS

| Description | Unit | Value |
|---|---|---|
| **11/0.4 kV Dry Type Auxiliary Transformer** | | |
| Manufacturer's name | | |
| Origin of manufacturing | | |



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| Description | Unit | Value |
|---|---|---|
| Type | | |
| Applicable standard | | |
| Append catalogues and technical specifications for 11/0.4 kV Dry Type Auxiliary Transformer of the Vendors they intended to use. Moreover, Proposer to ensure that the supplied 11/0.4 kV Dry Type Auxiliary Transformer will be equals or better than the type specified in technical specifications. | | |
| Type of insulation | | |
| Rated frequency | Hz | |
| Cooling | | |
| Vector group | | |
| Rated Continuous Output **Guarantee Value** | kVA | |
| Temperature rises at full load:<br>- Winding<br>- Other parts | <br>$^0$C<br>$^0$C | |
| Noise Level | dB(A) | |
| Rated voltage:<br>- Primary (HV) winding<br>- Secondary (LV) winding | <br>kV<br>kV | |
| Tapping on winding:<br>- Number of taps<br>- Tapping range<br>- Type of tap changer | | |
| Highest voltage for equipment:<br>- Primary (HV) winding<br>- Secondary (LV) winding | <br>kV<br>kV | |
| Power frequency withstand voltage (1 min.):<br>- Primary (HV) winding<br>- Secondary (LV) winding | <br>kV<br>kV | |
| Lightning impulse withstand voltage (HV) | kV | |
| short circuit impedance at 100% of rated power at principle tapping | % | |
| No load losses **Guarantee Value** | kW | |
| Load losses at principle tapping **Guarantee Value** | kW | |
| Short circuit current 0.4kV side | kA | |
| Neutral grounding | | |
| Maximum flux density in core at rated voltage and frequency | Tesla | |
| Protection class of enclosure | IP | |
| Total weight | kg | |



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| Description | Unit | Value |
|---|---|---|
| **11/0.4 kV Oil Immersed Auxiliary Transformers for Outdoor Installations** | | |
| Manufacturer's name | | |
| Origin of manufacturing | | |
| Type | | |
| Applicable standard | | |
| Append catalogues and technical specifications for 11/0.4 kV Oil Type Auxiliary Transformer of the Vendors they intended to use. Moreover, Proposer to ensure that the supplied 11/0.4 kV Oil Type Auxiliary Transformer will be equals or better than the type specified in technical specifications. | | |
| Type of insulation | | |
| Rated frequency | Hz | |
| Cooling | | |
| Vector group | | |
| Rated Continuous Output **Guarantee Value** | kVA | |
| Temperature rises at full load:<br>- Winding<br>- Other parts | <br>$^0$C<br>$^0$C | |
| Noise Level | dB(A) | |
| Rated voltage:<br>- Primary (HV) winding<br>- Secondary (LV) winding | <br>kV<br>kV | |
| Tapping on winding:<br>- Number of taps<br>- Tapping range<br>- Type of tap changer | | |
| Highest voltage for equipment:<br>- Primary (HV) winding<br>- Secondary (LV) winding | <br>kV<br>kV | |
| Power frequency withstand voltage (1 min.):<br>- Primary (HV) winding<br>- Secondary (LV) winding | <br>kV<br>kV | |
| Lightning impulse withstand voltage (HV) | kV | |
| short circuit impedance at 100% of rated power at principle tapping | % | |
| No load losses **Guarantee Value** | kW | |
| Load losses at principle tapping **Guarantee Value** | kW | |
| Short circuit current 0.4KV side | kA | |



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| Description | Unit | Value |
|---|---|---|
| Neutral grounding | | |
| Maximum flux density in core at rated voltage and frequency | Tesla | |
| Protection class of enclosure | IP | |
| Total weight | kg | |

### 3.7 MV SWITCHGEAR

| Description | Unit | Value |
|---|---|---|
| **Cubicles** | | |
| Manufacturer | | |
| Origin of manufacturing | | |
| Type designation | | |
| Rated voltage | kV | |
| Rated frequency | Hz | |
| Rated current of the busbars | A | |
| Material of busbars | | |
| Cross-section of busbars | $mm^2$ | |
| Temperature rises of busbars at rated current | | |
| Power frequency withstand voltage (1 minute) | kV | |
| Impulse withstand voltage 1.2/50 µs | kV | |
| Rated short time withstand current for 3 sec. | kA | |
| Rated peak withstands current | kA | |
| Protection Class | IP | |
| **MV Circuit Breakers / Generator Circuit Breakers** | | |
| Manufacturer | | |
| Origin of manufacturing | | |
| Type designation | | |
| Arc quenching medium (Vacuum)/SF6 Breakers for GCB | | |
| Rated voltage | KV | |
| Rated frequency | Hz | |
| Rated current | A | |



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| Description | Unit | Value |
|---|---|---|
| Rated operating sequence | | |
| Rated power frequency withstands voltage (1 min). | kV | |
| Impulse withstand voltage, 1.2/50 µs | kV | |
| Rated short circuit breaking current | kA/3s | |
| Rated short circuit making current | kA | |
| Circuit breaker operating mechanism | | |
| **Rated Voltage of Auxiliary Devices** | | |
| - closing and tripping devices | V DC | |
| - drive motor | V AC | |
| Breaking capacity of capacitive current | A | |
| Rated opening time | ms | |
| Rated break time | ms | |
| Rated close time | ms | |
| Rise of temperature of the contacts with rated current passing | °C | |
| Weight of circuit breaker, complete | kg | |
| Auxiliary switches | | |
| - Power consumption | | |
| - closing coil | W | |
| - trip coil | W | |
| - Motor | | |
| - rated voltage | V | |
| - Power consumption | W | |
| - Running time for spring charging | s | |
| **Earthing Switches** | | |
| Manufacturer | | |
| Origin of manufacturing | | |
| Type designation | | |
| Rated voltage | | |
| Rated short time current 3 sec | kA | |
| Rated peak withstands current | kA | |



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| Description | Unit | Value |
|---|---|---|
| Operating mechanism | | |
| **Current Transformers** | | |
| Manufacturer | | |
| Origin of manufacturing | | |
| Type designation | | |
| Ratio | | |
| Rated voltage | kV | |
| Rated current, primary side | A | |
| Power frequency withstand voltage, 1 min | kV | |
| Impulse voltage withstand voltage, 1.2/50 µs | kV | |
| **Measuring Core** | | |
| - Rated secondary current | A | |
| - Rated burden | VA | |
| - Accuracy class | | |
| - Instrument security factor | | |
| **Protection Core** | | |
| - Rated secondary current | A | |
| - Rated output | VA | |
| - Protection class | | |
| - Accuracy limit factor | | |
| **Voltage Transformer** | | |
| Manufacturer | | |
| Origin of manufacturing | | |
| Type designation | | |
| Ratio | | |
| Rated primary voltage | kV | |
| Rated secondary voltage | V | |
| Rated frequency | Hz | |
| Power frequency withstand voltage, 1 min | | |
| - primary terminal | kV | |



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| Description | Unit | Value |
|---|---|---|
| - secondary terminals | kV | |
| Primary impulse withstand voltage, 1.2/50 µs | kV | |
| **Secondary Measuring Winding** | | |
| - Rated voltage | V | |
| - Rated burden | VA | |
| - Accuracy class | | |
| **Secondary Protection Winding** | | |
| - Rated voltage | V | |
| - Rated burden | VA | |
| - Protection class | | |
| **Surge Arresters** | | |
| Manufacturer | | |
| Origin of manufacturing | | |
| Type designation | | |
| Rated voltage | kV | |
| Maximum continuous operating voltage | kV | |
| Rated frequency | Hz | |
| Nominal discharge current | kA | |
| **Protective Relays** | | |
| Type of relay | | |
| Origin of manufacturing | | |
| For protection of | | |
| Manufacturer | | |
| Origin of manufacturing | | |
| Measuring input range | | |
| - Voltage | V | |
| - Current | A | |
| - Frequency | Hz | |
| Output from measuring transformer secondary | | |
| - Voltage transformer | VA | |



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| Description | Unit | Value |
|---|---|---|
| - Current transformer | VA | |
| Operating quantity, rated (100%) value | | |
| Time delayed tripping function | | |
| - Setting range | | |
| - Time delay setting range | ms | |
| Instantaneous tripping function: | | |
| - Setting range | | |
| - Tripping time delay | ms | |
| External power supply: | | |
| - Rated supply voltage | V | |
| - Permissible voltage variation | | |
| - Power consumption | W | |

### 3.8 LV SWITCHGEAR

| Description | Unit | Value |
|---|---|---|
| Manufacturer | | |
| Origin of manufacturing | | |
| Type | | |
| Applicable Standard | | |
| Append catalogues and technical specifications for LV Switchgear of the Vendors they intended to use. Moreover, Proposer to ensure that the supplied LV Switchgear will be equals or better than the type specified in technical specifications. | | |
| Rated voltage | V | |
| Rated frequency | Hz | |
| Rated current of the busbars | A | |
| Temperature rises of busbar at rated current | °C | |
| Power frequency withstand voltage, 1 min | kV | |
| Three phase symmetrical short circuit withstand capacity, 3 sec. | kA | |
| Heat dissipation at full load conditions | W | |
| Protection Class | IP | |



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| Description | Unit | Value |
|---|---|---|
| **Withdrawable Circuit Breakers** | | |
| Manufacturer | | |
| Origin of manufacturing | | |
| Type | | |
| Rated current | A | |
| Rated short time withstand current | kA | |
| Rated breaking current | kA | |
| Rated making current | kA | |
| Control voltage | V | |
| **Fixed Circuit Breakers** | | |
| Manufacturer | | |
| Origin of manufacturing | | |
| Type | | |
| rated current | A | |
| Rated short time withstand current | kA | |
| Rated breaking current | kA | |
| Rated making current | kA | |
| **Current Transformers** | | |
| Manufacturer | | |
| Origin of manufacturing | | |
| Type | | |
| Ratio | | |
| Rated secondary current | A | |
| Burden | VA | |
| Accuracy class | | |
| Overcurrent factor | | |
| Rated primary short time current | kA | |
| Rated primary asymmetrical fault withstand current | kA | |
| **Fuse Switches** | | |
| Manufacturer | | |



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| Description | Unit | Value |
|---|---|---|
| Origin of manufacturing | | |
| Type | | |
| Rated voltage | V | |
| Rated current | A | |
| Fuse breaking capacity | kA | |
| **Protective Relays** | | |
| Type of relay: | | |
| For protection of: | | |
| Manufacturer: | | |
| Measuring input range: | | |
| - Voltage | V | |
| - Current | A | |
| - Frequency | Hz | |
| Output from measuring transformer secondary: | | |
| - Voltage transformer | VA | |
| - Current transformer | VA | |
| Operating quantity, rated (100%) value | | |
| Time delayed tripping function: | | |
| - Setting range | | |
| - Time delay setting range | ms | |
| Instantaneous tripping function: | | |
| - Setting range | | |
| - Tripping time delay | ms | |
| External power supply: | | |
| - Rated supply voltage | V | |
| - Permissible voltage variation | | |
| - Power consumption | W | |

## 3.9 DC AND UPS SYSTEM



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| Description | Unit | Value |
|---|---|---|
| **Batteries** | | |
| Manufacturer | | |
| Origin of manufacturing | | |
| Type | | |
| Rated voltage | V | |
| Number of cells: | | |
| - In parallel | No. | |
| - In series | No. | |
| Type of cells | | |
| Rated Voltage per cell fully charged | V | |
| Float Charging Voltage | V | |
| Boost Charging Voltage | V | |
| End Voltage used for capacity calculation | V | |
| Float charging current | A | |
| Nominal charging current | A | |
| Nominal charging time | Hrs. | |
| Boost charging current | A | |
| Max. admissible charging current | A | |
| Internal resistance per cell | Ohm | |
| Rated discharge capacity/10 hours | Ah | |
| Heat dissipation at full load | kW | |
| **Battery Chargers** | | |
| Manufacturer | | |
| Origin of manufacturing | | |
| Type: | | |
| Rated ac voltage | V | |
| Input Parameters:<br>Voltage<br>Current<br>Frequency<br>p.f | <br>V<br>A<br>Hz | |
| Rated dc voltage | V | |



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| Description | Unit | Value |
|---|---|---|
| Type of cooling | | |
| Rated input at full load | VA | |
| Rated DC current at ambient temperature | A | |
| Type of load voltage control | | |
| Range of load voltage control | % | |
| Adjustable dc voltage for: | | |
| - float charging | V/cell | |
| - boost charging | V/cell | |
| Ripple value | % | |
| Heat dissipation at full load | kW | |
| Protection class of charger cubicle | IP | |
| Weight of complete Charger | kg | |
| Rated short time withstand current | kA/1sec | |
| **Inverter** | | |
| Manufacturer | | |
| Origin of manufacturing | | |
| Type | | |
| Rated input voltage | V | |
| Rated input current | A | |
| Input voltage variations | % | |
| Voltage stability from no load to full load with input voltage variations as above | % | |
| Over load capacity (1 sec) | % | |
| Over load capacity (1 min) | % | |
| Rated output | KVA | |
| Heat dissipation at full load | kW | |
| **Battery Fuse Box** | | |
| Manufacturer | | |
| Origin of manufacturing | | |
| Protection class | IP | |
| Fuse rating | A | |



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## 3.10 PROTECTION AND RELAY EQUIPMENT

| Description | Unit | Value |
|---|---|---|
| Type of relay: | | |
| Protection Function: | | |
| Manufacturer: | | |
| Current Input:<br>- Number of CTs<br>- Nominal Current<br>- Nominal Frequency<br>- Burden for each phase | <br>No.<br>A<br>Hz<br>VA | |
| Voltage circuit input:<br>- Number of VTs<br>- Nominal voltage<br>- Nominal frequency<br>- Burden for each phase | <br>No.<br>V<br>Hz<br>VA | |
| Time delay tripping function:<br>- Setting range<br>- Operating time range | <br>ms | |
| Instantaneous tripping function:<br>- Setting range<br>- Operating time range | <br>ms | |
| Relay contacts:<br>- Number of contacts<br>- Permissible making current at 110VDC | <br>NO/NC<br>A | |
| Auxiliary power supply<br>- Rated supply voltage<br>- Permissible voltage variation<br>- Power consumption | <br>V<br>%<br>W | |
| Protection class | IP | |

## 3.11 CABLES

| Description | Unit | Value |
|---|---|---|
| **Medium Voltage Power Cables** | | |
| Manufacturer: | | |
| Origin of manufacturing | | |



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| Description | Unit | Value |
|---|---|---|
| Type of cable | | |
| Rated voltage | kV | |
| Number of cores | | |
| Nominal cross section | $mm^2$ | |
| Applied standards | | |
| Append the following information: Append catalogues of the Vendors Proposer intended to use. Moreover, Proposer to ensure that the supplied cables will be equals or better than the type specified in technical specifications | | |
| Ampacity at rated air temperature | A | |
| **Considering cable configuration** | | |
| Distance between two phases | | |
| Distance between two system | | |
| Rated short time withstand current (1 sec) | kA | |
| Max. Permissible fault duration at 90 °C conductor temperature and at max. fault current | kA/sec | |
| Conductor material | | |
| Number of strands | | |
| Max. continuous conductor temperature | °C | |
| Max. conductor temperature under short circuit condition | °C | |
| Material of insulation | | |
| Material of semi conducting layer | | |
| Material of screen | | |
| Cross section of screen | $mm^2$ | |
| Material of outer jacket/sheath | | |
| Material of filling sheath | | |
| Material of armoring | | |
| Outer diameter of the cable | $mm^2$ | |
| Min. bending radius | mm | |
| Cable length in drum | Meter | |
| Dimension of drum | mm x mm x mm | |
| Weight of drum | Kg | |



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| Description | Unit | Value |
|---|---|---|
| **Low Voltage Power Cables** | | |
| Manufacturer | | |
| Origin of manufacturing | | |
| Type | | |
| Applied standards | | |
| Rated voltage | V | |
| Number of cores per cable | | |
| Nominal cross section | $mm^2$ | |
| Ampacity at rated air temperature | A | |
| **Considering cable configuration** | | |
| Distance between two phases | | |
| Distance between two system | | |
| Rated short time current (1 sec) | kA | |
| Max. permissible fault duration at 90 oC conductor temperature and at max. fault current | kA/sec | |
| Conductor material | | |
| Number of strands | | |
| Max. continuous conductor temperature | °C | |
| Max. conductor temperature under short circuit condition | °C | |
| Material of insulation | | |
| Material of semi conducting layer | | |
| Material of screen | | |
| Cross section of screen | | |
| Material of outer jacket/sheath | °C | |
| Material of filling sheath | °C | |
| Material of armoring | mm | |
| Outer diameter of the cable | mm | |
| Min. bending radius | mm | |
| Cable length in drum | Meter | |
| Dimension of drum | mm x mm x mm | |



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| Description | Unit | Value |
|---|---|---|
| Weight of drum | Kg | |
| **Control & Measuring Cables** | | |
| Manufacturer | | |
| Origin of manufacturing | | |
| Type | | |
| Applied standards | | |
| Rated voltage | V | |
| Conductor material | | |
| Screen material | | |
| Insulation material | | |
| Max. conductor temperature: | | |
| - at rated current | °C | |
| - at short circuit conditions | °C | |
| Cable length in drum | Meter | |
| Weight of drum | Kg | |
| **Fire Alarms Cables** | | |
| Type | | |
| Applied standards | | |
| Rated voltage | V | |
| Conductor material | | |
| Screen material | | |
| Insulation material | | |
| Max. conductor temperature: | | |
| - at rated current | °C | |
| - at short circuit conditions | °C | |
| Cable length in drum | Meter | |
| Dimension of drum | mm x mm x mm | |
| Weight of drum | Kg | |
| **Cable Trays / Racks** | | |
| Manufacturer | | |



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| Description | Unit | Value |
|---|---|---|
| Origin of manufacturing | | |
| Type | | |
| Material | | |
| Corrosion protection | | |
| Loading capacity | kg/m | |

### 3.12 EARTHING SYSTEM (FOR EQUIPMENT)

| Description | Unit | Value |
|---|---|---|
| **Conductor** | | |
| Manufacturer | | |
| Origin of manufacturing | | |
| Catalogue attached | Yes/No | |
| Standard | | |
| Material | | |
| Cross Section of | | |
| Earthing Cable | $mm^2$ | |
| Earthing Conductor | | |
| Risers | $mm^2$ | |
| Pigtail | $mm^2$ | |
| Joint weld method | | |

### 3.13 EMERGENCY DIESEL GENERATING UNITS (EDG)

| Description | Unit | Value |
|---|---|---|
| **Diesel Engine** | | |
| Manufacturer | | |
| Origin of manufacturing | | |
| Model/type | | |
| Nominal speed | rpm | |
| Output | kW | |
| Fuel consumption at rated output | L/h | |
| Oil consumption | L/h | |
| **Generator** | | |



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| Description | Unit | Value |
|---|---|---|
| Manufacturer | | |
| Origin of manufacturing | | |
| Type | | |
| Rated continuous output | kVA | |
| Frequency | Hz | |
| Rated power factor | | |
| Rated terminal voltage | kV | |
| Rated speed | rpm | |
| EDG Audible noise level | dB | |
| Total weight | T | |
| Protection class | IP | |

## 4. CONTROL AND INSTRUMENTATION

### 4.1 LOCAL CONTROL SYSTEM

| Description | Unit | Value |
|---|---|---|
| **Local Control Panels Indicating Instruments** (to be filled in for each different instrument) | | |
| Manufacturer | | |
| Origin of manufacturing | | |
| Type | | |
| Applicable standards | | |
| Local indication and scale range | | |
| **For Direct Measuring Instruments** | | |
| - Ratio of connected voltage transformer | | |
| - Ratio of connected current transformer | | |
| Instrument accuracy class | | |
| Max. permissible ambient temperature | °C | |
| **Alarm Annunciators** | | |
| Manufacturer | | |
| Origin of manufacturing | | |
| Type/series | | |



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| Description | Unit | Value |
|---|---|---|
| Signal input/output | | |
| Alarms per card | | |
| Power supply voltage and - tolerance | V/± | |
| Max permissible ambient temperature | °C | |
| **Measuring Converter / Transducers** | | |
| Manufacturer | | |
| Origin of manufacturing | | |
| Type designation | | |
| Converter / transducer type | | |
| Current input range | A | |
| - Permissible continuous overload | % | |
| Voltage input range | V | |
| - Permissible continuous overload | % | |
| Output signal for rated input | mA | |
| Accuracy | % | |
| Linearity | % | |
| Max. permissible ambient temperature | °C | |
| **Water Level Transducers** | | |
| Manufacturer | | |
| Origin of manufacturing | | |
| Type designation | | |
| Water level measuring range | m | |
| Accuracy | ± % | |
| Linearity | % | |
| Operating temperature range | °C | |
| **Transmitters (to be filled in for each type)** | | |
| Manufacturer | | |
| Origin of manufacturing | | |
| Type | | |



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| Description | Unit | Value |
|---|---|---|
| Accuracy | ±% | |
| **Indicators (to be filled in for each type)** | | |
| Manufacturer | | |
| Origin of manufacturing | | |
| Type/Model no: | | |
| Accuracy | ±% | |
| **Local Control Units Data**<br>(To be filled in for each LCU) | | |
| Maker's Name | | |
| Programming system and language | | |
| Number of LCU Cubicles | | |
| Memory Capacity | MB | |
| **Programmable Logic Controllers (PLCs)** | | |
| Maker's Name | | |
| PLC Software | | |
| Model Number | | |
| Memory size | MB | |
| Specified Options | Please list | |
| Communications Interfaces/protocols Supported | Please list | |
| Communications Interfaces/protocols Used | Please list | |
| Engineering Software Used/version | Please list | |
| **Local HMI** | | |
| Maker's Name | | |
| Model Number | | |

### 4.2 Plant Control System (PCS)

| Description | Unit | Value |
|---|---|---|
| **Plant Control System (PCS)** | | |
| Manufacturer | | |
| Origin of manufacturing | | |
| Model Or Generic Name | | |



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| Description | Unit | Value |
|---|---|---|
| Communications Interfaces/protocols Supported | Please list | |
| Resolution Of Time Stamp for Sequence of Events (SOE) Recording | ms | |
| Type And Data Rate of Terminal Network | baud | |
| Type And Data Rate of Controller Network | | |
| **Operator Workstation / Engineering Workstation** | | |
| Maker's Name | | |
| Origin of manufacturing | | |
| Quantity | | |
| Model Number | | |
| Software Supplier/ Product Name / Version | | |
| **PCS Servers** | | |
| Maker's Name | | |
| Origin of manufacturing | | |
| Equipment Range / Model Number | | |
| Software Supplier/ Product Name / Version | | |
| Interfaces Provided/Used | | |
| **Data Historian and Archiving System** | | |
| Maker's Name | | |
| Origin of manufacturing | | |
| Model Number | | |
| Type | | |
| **Redundant Data Highway (Bus System)** | | |
| Maker's Name | | |
| Origin of manufacturing | | |
| Model Number | | |
| Type | | |
| Ethernet Switch | | |
| Data transmission rate | | |
| **Portable Service Station (Laptop)** | | |
| Maker's name | | |
| Origin of manufacturing | | |
| Model number | | |
| Operating system | | |



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| Description | Unit | Value |
|---|---|---|
| Quantity | No. | |
| Memory size (RAM) | GB | |
| Processor manufacturer | | |
| Processor type | | |
| HDD type | | |
| HDD capacity | TB | |
| Clock frequency | MHz | |
| Optical super drive | Yes/No | |
| **Large Screen Displays with Controller** | | |
| Manufacturer | | |
| Origin of manufacturing | | |
| Type | | |
| Resolution | Pixels | |
| Quantity | No. | |
| Size | Inch | |
| **LED type Monitors** | | |
| Manufacturer | | |
| Resolution | Pixels | |
| Quantity | No. | |

## 5. PLANT TELECOMMUNICATION EQUIPMENT

### 5.1 TELEPHONE SYSTEM (EPABX)

(All items to be filled in for each type / size used)

| Description | Unit | Value |
|---|---|---|
| **PABX Equipment Cubicle** | | |
| Manufacturer | | |
| Origin of manufacture | | |
| Model/type | | |
| Protection class | | |
| Cubicle is floor mounted (Yes) | | |
| Accessible from both front/rear (Yes/No) | | |
| Material of sheet | | |
| Thickness of sheet | $mm^2$ | |

| Description | Unit | Value |
|---|---|---|
| Dimensions (W x H x D) | mm | |
| **Digital Exchange** | | |
| Manufacturer | | |
| Origin of manufacture | | |
| Model number | | |
| Type of modulation | | |
| Type of multiplexing | | |
| Back-up memory provided (Yes) | | |
| **Desk Telephone Sets** | | |
| Manufacturer | | |
| Origin of manufacture | | |
| Model number | | |
| Instruments are push-button type (Yes) | | |
| Type of signaling | | |
| **Executive Telephone Sets** | | |
| Manufacturer | | |
| Origin of manufacture | | |
| Model number | | |
| Instruments are push-button type (Yes) | | |
| Type of signaling | | |
| **Wall Mounted Telephone Sets** | | |
| Manufacturer | | |
| Origin of manufacture | | |
| Model number | | |
| Instruments are push-button type (Yes) | | |
| Type of signaling | | |
| **Main Distribution Frame (MDF)** | | |
| Manufacturer | | |
| Origin of manufacture | | |
| Model number | | |



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| Description | Unit | Value |
|---|---|---|
| Protection class is IP54 | | |
| Dimensions of MDF Equipment Cabinet (W x H x D) | | |
| Maximum capacity of cabinet | | |
| Number of blocks | | |
| Number of pairs in each block | | |
| Number of pairs that can be terminated per frame | | |

## 5.2 PUBLIC ADDRESS SYSTEM (PAS)

| Description | Unit | Value |
|---|---|---|
| **Public Address System Equipment** | | |
| Manufacturer | | |
| Country of manufacture | | |
| Model number | | |
| Model and make of Microphone | | |
| Model and make of Amplifier | | |
| Model and make of Indoor Loudspeakers | | |
| Model and make of Indoor Loudspeakers (horns) | | |

## 5.3 CCTV SYSTEM

| Description | Unit | Value |
|---|---|---|
| **CCTV System** | | |
| Manufacturer | | |
| Country of manufacture | | |
| Model / type | | |
| **Network Video Recording Equipment** | | |
| Manufacturer | | |
| Country of manufacture | | |
| Model number | | |
| Data Storage | TB | |
| DVD Writer Support (Yes/No) | | |



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| Description | Unit | Value |
|---|---|---|
| **Cameras**<br>(to be filled in for each type of camera) | | |
| Type of Camera | | |
| Manufacturer | | |
| Country of manufacture | | |
| Model number | | |
| Optical Zoom Size | | |
| Digital Zoom Size | | |
| IP Rating of Casing | | |
| Minimum Illumination | | |
| Memory | | |
| Resolution | | |
| Frame Rate | | |
| Number of Alarm Inputs | | |
| IP Rating of Casing | | |

## 6. 132kV SWITCHYARD

| | Description | Units | Value |
|---|---|---|---|
| **6.1** | **SUBSTATION AUTOMATION SYSTEM EQUIPMENT (Control, Indications & Monitoring)** | | |
| | a) Manufacturer | | |
| | b) Country of Manufacture. | | |
| | c) Type. | | |
| | d) Manufacturing ordering code | | |
| **6.1.1** | **Bay Control Unit (BCU) Cabinet** | | |
| | 1. Manufacturer | | |
| | 2. Model number | | |
| | 3. Cubicle is swing rack type (Yes/No) | | |
| | 4. Cubicle is dust & vermin-proof (Yes) | | |
| | 5. Protection class is IP54 (Yes) | | |
| | 6. Cubicle is floor mounted (Yes) | | |
| | 7. Accessible from both front/rear (Yes) | | |
| | 8. Material of sheet | | |



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| | Description | Units | Value |
|---|---|---|---|
| | 9. Thickness of sheet: | | |
| | a. Front door (2 mm) | | |
| | b. Rear and side doors (1.5 mm) | | |
| | 10. Dimensions: | | |
| | a) Height (2200 mm) | | |
| | b) Width (800 mm) | | |
| | c) Depth (600 mm) | | |
| | 11. Weight (kg) | | |
| **6.1.2** | **Bay Control Unit (BCU)** | | |
| **(A)** | **General** | | |
| | 1. Manufacturer | | |
| | 2. Country of manufacture | | |
| | 3. Model number | | |
| | 4. Applicable standards | | |
| | 5. Type test: | | |
| | a) Carried out (Yes/No) | | |
| | b) Date | | |
| | c) Testing laboratory: | | |
| | i. name | | |
| | ii. country | | |
| | 6. Date of first commercial operation of BCU | | |
| **(B)** | **Equipment Design and Performance:** | | |
| | 1. Word length of BCU processor (bits) | | |
| | 2. Time of power interruption which will not cause break in normal operation (ms) | | |
| | 3. Are telemetered values checked for alarm limits in RTU? (Yes/No) | | |
| | 4. Is time stamping of indications / alarms provided? (Yes/No) | | |
| | 5. Resolution of time stamping (ms) | | |
| | 6. List of internal indications and alarms related to the system operation provided (Yes/No) | | |
| | 7. MTBF | | |
| **(C)** | **Working Principle:** | | |
| | 1. Request/response principle | | |
| | 2. Time-division multiplex code | | |



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| | Description | Units | Value |
|---|---|---|---|
| | 3. Series transmission with PCM | | |
| **(D)** | **BCU Capacity:** | | |
| | 1. Capacity of one digital input (DI) module | | |
| | 2. Capacity of one digital output (DO) module | | |
| | 3. Capacity of one analogue input (AI) module | | |
| | 4. Equipped capacity for SCADA signals (Specify reference of Proposal) | | |
| | 5. Number of input and output modules in BCU (Specify reference of Proposal) | | |
| **(E)** | **Status Indications:** | | |
| | 1. Signal level to activate input device (mA) | | |
| | 2. Signal duration to assure recognition (ms) | | |
| | 3. Input filtering time (10-20 ms) | | |
| | 4. Delay mechanism incorporated to eliminate spurious indications. (Yes) | | |
| | 5. Limits of adjustment of above delay (50ms…20s) | | |
| | 6. Surge and insulation limits (kV) | | |
| | 7. Galvanic isolation provided (Yes) | | |
| **(F)** | **Alarm Indications:** | | |
| | 1. Signal level to activate input device (mA) | | |
| | 2. Signal duration to assure recognition (ms) | | |
| | 3. Surge and insulation limits (kV) | | |
| | 4. Galvanic isolation provided (Yes) | | |
| **(G)** | **Analog Inputs:** | | |
| | 1. Input signal (mA) | | |
| | 2. A/D converter resolution (12+sig. bits) | | |
| | 3. Accuracy (0.03 %) | | |
| | 4. Common mode voltage (V) | | |
| | 5. Common mode rejection (dB) | | |
| | 6. Serial mode rejection at 60 Hz (dB) | | |
| | 7. Galvanic isolation provided (Yes) | | |
| **(H)** | **Control Outputs:** | | |
| | 1. Control board output (make / break contact or other) | | |
| | 2. Signal duration | | |
| | 3. Contact rating (V, A, W) | | |



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| | Description | Units | Value |
|---|---|---|---|
| | 4. Contact operating time (100ms…30s) | | |
| | 5. Control outputs options | | |
| | 6. Surge insulation limits (kN) | | |
| | 7. Galvanic isolation provided (Yes) | | |
| **(I)** | **General Digital Outputs:** | | |
| | 1. With relay outputs: | | |
| | a) Contact type (make/break) | | |
| | b) Contact rating (V, A, W) | | |
| | c) Contact operating time (ms) | | |
| **(J)** | **Set Point Outputs:** | | |
| | 1. Output type (make/break contacts or others) | | |
| | 2. Output code | | |
| **(K)** | **Analog Outputs:** | | |
| | 1. Output (mA) | | |
| | 2. Output impedance (ohm) | | |
| | 3. Resolution binary bits (12+sig.) | | |
| | 4. Accuracy (± %) | | |
| **(L)** | **Maintenance and Administration:** | | |
| | 1. Maintenance laptop PC available, software functions shall be detailed. | | |
| | 2. Laptop PC operating system | | |
| | 3. Downloading process available for database and RTU software release. (Yes) | | |
| | 4. Documents and manual (YES) | | |
| **(M)** | **Communication Interfaces:** | | |
| | 1. Redundant communication ports provided? (Yes) | | |
| | a) List all types of communication interfaces | | |
| | b) List all types of protocols supported (IEC60870) | | |
| | 2. Transmission times: | | |
| | a) Collection of 8 analog values at 4800bps (ms) | | |
| | b) Collection of a change of state or 1 digital value at 4800bps (ms) | | |
| | c) Transfer of 1 check-back-before-execute command at 4800bps operator check time (ms) | | |
| | 3. Line output: | | |



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| | Description | Units | Value |
|---|---|---|---|
| | a) Adjustable output level range (dBm) | | |
| | b) Continuous adjustment (Yes/No) | | |
| | 4. Input from line: | | |
| | a) Range of acceptable input signal level (dB) | | |
| | b) Line impedance matching facilities provided (Yes/No) | | |
| | c) Surge and insulation limits (kV) | | |
| | d) List of all LED indications provided (Specify reference of Proposal) | | |
| **(N)** | **Climatic Conditions:** | | |
| | 1. Temperature range for guaranteed operation (0-55°C) | | |
| | 2. Maximum relative humidity at 35°C (%) | | |
| **(O)** | **Power Supply Requirements:** | | |
| | 1. Power consumption (W) | | |
| | 2. Power supply voltage range (V) | | |
| **(P)** | **Electrical and Electromagnetic Environment:** | | |
| | 1. Electrostatic discharge immunity test: IEC 61000-4-2 (8 kV peak) | | |
| | 2. Radiated, radio-frequency, electromagnetic field immunity test: IEC 61000-4-3 (10 V/m) | | |
| | 3. Electrical fast transient/burst immunity test: IEC 61000-4-4 (2 kV peak) | | |
| | 4. Surge immunity test: IEC 61000-4-5 | | |
| | 5. Insulation tests for electrical relays: IEC 60255-5 (5 kV, 1.2/50) | | |
| **6.1.3** | **SCADA Interface Cabinet (SIC)** | | |
| | 1. Manufacturer | | |
| | 2. Country of manufacture | | |
| | 3. Model number | | |
| | 4. Cubicle is swing rack type (Yes) | | |
| | 5. Cubicle is dust and vermin-proof (Yes) | | |
| | 6. Protection class is IP54 (Yes) | | |
| | 7. Cubicle is floor mounted (Yes) | | |
| | 8. Accessible from both front/rear | | |
| | 9. Material of sheet | | |
| | 10. Thickness of sheet: | | |
| | a) Front door (2 mm) | | |



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| | Description | Units | Value |
|---|---|---|---|
| | b) Rear and back doors (1.5 mm) | | |
| | 11. Dimensions: | | |
| | a) Height (2200mm) | | |
| | b) Width (≥ 800mm) | | |
| | c) Depth (600mm) | | |
| | 12. Weight (kg) | | |
| **6.1.4** | **Operator Workstation** | | |
| | a) Manufacturer / Model. | | |
| | b) Type. | | |
| | c) AC Voltage Working Range. Volts | | |
| | d) Service Conditions (Temperature & RH). | | |
| | e) Power Consumption. Watt | | |
| | f) Architecture. | | |
| | g) Operating system software. | | |
| | h) VGA controller type | | |
| | i) Ambient temperature | | |
| | j) Method of Processor Expansion (e.g. number of free slots when supplied). | | |
| | **Main (Semi-Conductor) Memory** | | |
| | a) Type. | | |
| | b) Supplied Size. | | |
| | c) Maximum expandable size. | | |
| | d) Battery backup system. | | |
| | **Hard Disc Storage** | | |
| | a) Type. | | |
| | b) Supplied Size. | | |
| | c) Maximum size. | | |
| | **Clock.** | | |
| | a) Type. | | |
| | b) Drift per day (when not synchronized to master clock). | | |
| | c) Method of synchronization with master clock. | | |
| | **Processing system Intercommunications Interface.** | | |
| | a) Number supported. | | |
| | b) Type (e.g. LAN etc.) | | |



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| | Description | Units | Value |
|---|---|---|---|
| | c) Speed. | | |
| | **Video Display Unit** | | |
| | a) Type & size. | | |
| | b) Number to be supplied at a workstation. | | |
| | c) Screen size. | | |
| | d) Screen pixel resolution. | | |
| | e) Compliance with recognized EMC and safety Standards | | |
| | f) Type of Interface. | | |
| | **Keyboard.** | | |
| | a) Type. | | |
| | b) Number to be supplied. | | |
| | c) Total number of keys. | | |
| | d) Alphanumeric character key set. | | |
| | e) Control keys provided. | | |
| | f) Number of special function keys. | | |
| | g) Type of Interface. | | |
| | **Cursor Control Device/Mouse.** | | |
| | a) Number to be supplied. | | |
| | b) Number of buttons. | | |
| | c) Type (e.g. optical). | | |
| | d) Mat | | |
| | e) Type of interface. | | |
| **6.1.5** | **Engineering Workstation** | | |
| | a) Manufacturer / Model. | | |
| | b) Type. | | |
| | c) AC Voltage Working Range. Volts | | |
| | d) Service Conditions (Temperature & RH). | | |
| | e) Power Consumption. Watt | | |
| | f) Architecture. | | |
| | g) Operating system software. | | |
| | h) VGA controller type | | |
| | i) Ambient temperature | | |
| | j) Method of Processor Expansion (e.g. number of free slots when supplied). | | |



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| | Description | Units | Value |
|---|---|---|---|
| | **Main (Semi-Conductor) Memory** | | |
| | a) Type. | | |
| | b) Supplied Size. | | |
| | c) Maximum expandable size. | | |
| | d) Battery backup system. | | |
| | **Hard Disc Storage.** | | |
| | a) Type. | | |
| | b) Supplied Size. | | |
| | c) Maximum size. | | |
| | **Clock.** | | |
| | a) Type. | | |
| | b) Drift per day (when not synchronized to master clock). | | |
| | c) Method of synchronization with master clock. | | |
| | **Processing system Intercommunications Interface.** | | |
| | a) Number supported. | | |
| | b) Type (e.g., LAN etc.) | | |
| | c) Speed. | | |
| | **Video Display Unit** | | |
| | a) Type & size. | | |
| | b) Number to be supplied at a workstation. | | |
| | c) Screen size. | | |
| | d) Screen pixel resolution. | | |
| | e) Compliance with recognized EMC and safety Standards | | |
| | f) Type of Interface. | | |
| | **Keyboard.** | | |
| | a) Type. | | |
| | b) Number to be supplied. | | |
| | c) Total number of keys. | | |
| | d) Alphanumeric character key set. | | |
| | e) Control keys provided. | | |
| | f) Number of special function keys. | | |
| | g) Type of Interface. | | |
| | **Cursor Control Device/Mouse.** | | |



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| | Description | Units | Value |
|---|---|---|---|
| | a) Number to be supplied. | | |
| | b) Number of buttons. | | |
| | c) Type (e.g. optical). | | |
| | d) Mat | | |
| | e) Type of interface. | | |
| **6.1.6** | **GPS MASTER CLOCK SYSTEM** | | |
| | a) Manufacturer / Model. | | |
| | b) Type. | | |
| | c) AC / DC Voltage Working Range. | | |
| | d) Power Consumption. | | |
| | e) Service conditions (temperature & RH). | | |
| | f) Battery Standby capacity. | | |
| | g) Type, speed and No: of output interfaces. | | |
| | h) Time and date facility. | | |
| | i) Seasonal changeover / automatic. | | |
| | j) Local display. | | |
| | k) Day – Date: Month: Year | | |
| | l) HH: MM: SS: | | |
| | m) Drift per day (when not synchronized to radio signal) | | |
| | n) Receiver for UT from NAVSTAR satellites. | | |
| | o) Loss of radio synch alarm. | | |
| | p) other alarms. | | |
| | q) Local alarms and contacts for alarms to SCMS. | | |
| **6.1.7** | **Alarm and Event Printer** | | |
| | a) Manufacturer / Model | | |
| | b) Colored Laser - Type. | | |
| | c) AC Voltage Working Range Volts. | | |
| | d) Power Consumption watt. | | |
| | e) Service Conditions (Temperature & RH). | | |
| | f) Print Speed PPm. | | |
| | g) Print Pitch / Width. | | |
| | h) No. of print pins / jets or resolution. | | |
| | i) No. of fonts / character sets. | | |



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| | Description | Units | Value |
|---|---|---|---|
| | j) Paper feed proposed / width. | | |
| | k) Self test facility. | | |
| | l) No. of colors. | | |
| | m) Type of interface. | | |
| | n) Stand / Trays. | | |
| | o) Acoustic noise at one meter. | | |
| | p) Alarms local and Remote. | | |
| | q) Configuration / dual network connection. | | |
| **6.1.8** | **HARD COPY COLOR LASER PRINTER.** | | |
| | a) Manufacturer / Model | | |
| | b) Type. | | |
| | c) AC Voltage Working Range Volts. | | |
| | d) Power Consumption watt. | | |
| | e) Service Conditions (Temperature & RH). | | |
| | f) Print Speed for Color Graphics Printing (PPM). | | |
| | g) No. of colors / toners. | | |
| | h) Resolution. | | |
| | i) Paper Handling. | | |
| | j) Paper Size. | | |
| | k) Type of Interface. | | |
| | l) Stand / Trays. | | |
| | m) Acoustic noise at one meter db. | | |
| | n) Alarms local and remote. | | |
| | o) Configuration / dual network connection. | | |
| **6.1.9** | **GATEWAY** | | |
| | a) Type | | |
| | b) Speed | | |
| | c) Protocol | | |
| | d) Power supply voltage range (V) | | |
| | e) Power consumption (W) | | |
| | f) Temperature range for guaranteed operation (°C) | | |
| | g) Temperature changing rate (°/hour) | | |
| | h) Relative humidity at maximum ambient temperature (%) | | |



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| | Description | Units | Value |
|---|---|---|---|
| | i) MTBF (hours) | | |
| **6.1.10** | **SWITCHED ETHERNET LAN INFRASTRUCTURE** | | |
| | a) Manufacturer | | |
| | b) Type | | |
| | c) Network Interfaces | | |
| | d) Simple Network Management Protocol (SNMP) | | |
| | e) Switch Properties | | |
| | f) Input voltage | | |
| | g) Power consumption | | |
| | h) Ambient temperature | | |
| | i) Physical dimension | | |
| **6.1.11** | **UNINTERRUPTED POWER SUPPLY (UPS)** | | |
| | a) Nominal input voltage | | |
| | b) Input voltage range | | |
| | c) Input frequency range | | |
| | d) Nominal output voltage | | |
| | e) Nominal power | | |
| | f) Efficiency at full load | | |
| | g) Dimensions | | |
| **6.1.12** | **FURNITURE** | | |
| | a) Operator desk. | | |
| | b) Engineer desk. | | |
| | c) Material of desk. | | |
| | d) Durable desk top surface. | | |
| | e) Writing area. | | |
| | f) Drawers / shelves. | | |
| | g) Support for VDUs. | | |
| | h) Size. | | |
| | i) Height. | | |
| | j) Operator chair. | | |
| | k) Material. | | |
| | l) Swivel and castor action. | | |
| | m) Arm rests. | | |



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| | Description | Units | Value |
|---|---|---|---|
| | n) Engineer Chair. | | |
| | o) Material. | | |
| | p) Swivel and castor action. | | |
| | q) High backed design. | | |
| | r) Arm rests. | | |
| | s) Desk lighting. | | |
| | t) Window blinds. | | |

## 6.2 SUBSTATION TELECOMMUNICATION AND SCADA SYSTEMS

| Item | Description | Units | Value |
|---|---|---|---|
| **6.2.1** | **Digital Power Line Carrier Equipment** | | |
| **6.2.1.1** | **DPLC Equipment Cubicle** | | |
| | 1. Manufacturer | | |
| | 2. Country of manufacture | | |
| | 3. Model number | | |
| | 4. Cubicle is swing rack type (Yes) | | |
| | 5. Cubicle is dust and vermin-proof (Yes) | | |
| | 6. Protection class is IP55 (Yes) | | |
| | 7. Cubicle is floor mounted (Yes) | | |
| | 8. Accessible from both front/rear (Yes/No) | | |
| | 9. Material of sheet | | |
| | 10. Thickness of sheet: | | |
| | a. Front door (2 mm) | | |
| | b. Rear and side doors (1.5 mm) | | |
| | 11. Dimensions: | | |
| | a) Height (2200 mm) | | |
| | b) Width (800 mm) | | |
| | c) Depth (600 mm) | | |
| | 12. Weight (kg) | | |
| **6.2.1.2** | **Digital Power Line Carrier Terminal** | | |
| | 1. Manufacturer | | |
| | 2. Country of manufacture | | |
| | 3. Model number | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | 4. Applicable standard is IEC60495 (Yes) | | |
| | 5. Type test: | | |
| | a) Carried out (Yes/No) | | |
| | b) Date | | |
| | c) Testing laboratory: | | |
| | i. name | | |
| | ii. country | | |
| | 6. Date of first commercial operation of PLC terminal | | |
| | 7. Type of modulation is SSB-SC (Yes) | | |
| | 8. Full duplex operation (Yes) | | |
| | 9. HF transmitter power (40W) | | |
| | 10. Nominal HF bandwidth (kHz) | | |
| | 11. HF carrier range (40-500 kHz) | | |
| | 12. Transmit and receive frequencies programmable | | |
| | 13. Frequency separation: | | |
| | a) Tx to own Rx (kHz) | | |
| | b) Tx to adjacent Rx (kHz) | | |
| | c) Tx to adjacent Tx (kHz) | | |
| | d) Rx to adjacent Rx (kHz) | | |
| | 14. Loss due to parallel operation of two PLC (dB) | | |
| | 15. Return loss: | | |
| | a) transmit direction (dB) | | |
| | b) receive direction (dB) | | |
| | 16. Signal to noise ratio (without compandor): | | |
| | a) fair weather (dB) | | |
| | b) adverse weather (dB) | | |
| | 17. HF output impedance (ohm) | | |
| | 18. Receiver sensitivity (≤ 30dBm) | | |
| | 19. AGC range (± dB) | | |
| | 20 AF interface: | | |
| | a) module name | | |
| | b) AF bandwidth (Hz) | | |
| | c) speech possible on both 2/4-wire (Yes) | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | d) nominal impedance of AF signals (ohm) | | |
| | 21. Teleoperation interface: | | |
| | a) module name | | |
| | b) max. teleoperation inputs/outputs | | |
| | 22. Frequency of pilot signal (Hz) | | |
| | Is frequency programmable? (Yes/No) | | |
| | 23. VF channel allocation for each PLC link will be provided during detailed design (Yes) | | |
| | 24. Service telephone equipment provided with each PLC terminal (Yes) | | |
| | 25. Frequency response of speech channel (±1 dB referred to 800 Hz) (kHz) | | |
| | 26. Frequency response of VF signaling channel referred to 3.0 kHz (kHz) | | |
| | 27. Facility for transmission of Tele protection signals with boosted power available | | |
| | 28. Compandors required on PLC links (Yes/No) | | |
| | 29. Idle noise (dBm0p) | | |
| | 30. Crosstalk attenuation (dB) | | |
| | 31. Line side equipment withstand voltage (kV) | | |
| | 32. Alarms: | | |
| | a) transmitter alarm | | |
| | b) receiver alarm | | |
| | 33. Alarm outputs in form of potential free contacts available (Yes) | | |
| | 34. Power supply voltage range (V DC) | | |
| | 35. Power consumption of fully equipped terminal (W) | | |
| | 36. Operation temperature | | |
| | a) maximum (55°C) | | |
| | b) minimum (-5°C) | | |
| | 37. Relative humidity | | |
| | a) maximum (95%) | | |
| | b) minimum (5%) | | |
| | 38. Type test reports enclosed (Yes/No) | | |
| | 39. Reference list enclosed (Yes) | | |
| | 40. Technical literature enclosed (Yes) | | |
| **6.2.1.3** | **Digital Protection Signaling Equipment** | | |
| | 1. Manufacturer | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | 2. Country of manufacture | | |
| | 3. Model number | | |
| | 4. Applicable standard is IEC 60834-1 (Yes) | | |
| | 5. Type test: | | |
| | a) Carried out (Yes/No) | | |
| | b) Date | | |
| | c) Testing laboratory: | | |
| | i. name | | |
| | ii. country | | |
| | 6. Date of first commercial operation of DPSE | | |
| | 7. Integrated with DPLC (Yes) | | |
| | 8. Number of independent commands (≥ 4 No.) | | |
| | 9. Transmitter output level, adjustable on Z = 600 Ohms (balanced) (dBm) | | |
| | 10. Power boosting (6 dB) | | |
| | 11. Receiver input level on Z = 600 Ohms (balanced) (dBm) | | |
| | 12. Permissible input level variation (dB) | | |
| | 13. Trip signal blocking in case of event | | |
| | of excessive line noise (Yes) | | |
| | 14. Permissible white noise input level within the transmission band (dB) | | |
| | 15. Return loss in 0.3-3.6 KHz band (≥ 14dB) | | |
| | 16. SNR for blocking (< 6dB) | | |
| | 17. Signal level fluctuation from the nominal that causes receiver output blocking (± 6dB) | | |
| | 18. External trip counters provided (Yes) | | |
| | 19. Signal delay time including transmission channel time mode, including input/output relays: | | |
| | a) directional comparison relays (< 20ms) | | |
| | b) distance/BFP relays (< 30ms) | | |
| | 20. Command duration (min. 60ms) | | |
| | 21. Command prolongation up to (ms) | | |
| | 22. Self-supervising in case of equipment failure (Yes/No) | | |
| | 23. LED indication for normal operation (Yes) | | |
| | 24. LED indication for failure of equipment (Yes) | | |
| | 25. Switching capacity of contacts (AC) (100/0.5 V/A) | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | 26. Loop test facility (Yes/No) | | |
| | 27. Maximum requirements for transmitter input contacts (24-250V dc) | | |
| | 28. False trip probability: | | |
| | a) permissive trip (10E-2) | | |
| | b) direct trip (10E-5) | | |
| | 29. Receiver output relay contacts: | | |
| | a) continuous (2 potential free A/V dc) | | |
| | b) for 1 minute (changeover A/V dc) | | |
| | 30. Signaling transmission during test (Yes/No) | | |
| | 31. Power supply voltage range (-40 to -58V DC) | | |
| | 32. Power consumption (W) | | |
| | 33. Power ON/OFF switch with protection (Yes/No) | | |
| | 34. Operation temperature: | | |
| | a) maximum (55°C) | | |
| | b) minimum (-5°C) | | |
| | 35. Relative humidity: | | |
| | a) maximum (95%) | | |
| | b) minimum (5%) | | |
| | 36. Type test reports enclosed (Yes/No) | | |
| | 37. Reference list enclosed (Yes) | | |
| | 38. Technical literature enclosed (Yes) | | |
| **6.2.1.4** | **Line Matching Units** | | |
| | 1. Manufacturer | | |
| | 2. Country of manufacture | | |
| | 3. Model number | | |
| | 4. Applicable standards IEC60481 (Yes) | | |
| | 5. Type test: | | |
| | a) Carried out (Yes/No) | | |
| | b) Date | | |
| | c) Testing laboratory (name/country) | | |
| | 6 Date of first commercial operation of LMU | | |
| | 7. Units are broad-band type (Yes) | | |
| | 8. Tuning frequency range is field programmable (Yes) | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | 9. Composite loss over tuning range (dB) | | |
| | 10. Return loss: | | |
| | a) equipment side (dB) | | |
| | b) line side (dB) | | |
| | 11. Line side impedance (ohm) | | |
| | 12. Equipment side impedance (75/150 ohm) | | |
| | 13. Peak envelope power rating (W) | | |
| | 14. Main arrester nominal discharge current (kA) | | |
| | 15. Drain Coil: | | |
| | a) impedance at 50 Hz (ohm) | | |
| | b) for nominal temperature rise (A,rms) | | |
| | c) current carrying capacity at 50 Hz for 0.2 sec. (A,rms) | | |
| | 16. Unit withstand voltage for shock-wave 1.2/50 µsec applied on power line side (kV) | | |
| | 17 Insulation level for 1 minute applied between: | | |
| | a) coil and earth (kV,rms) | | |
| | b) coil and screen (kV,rms) | | |
| | 18. Cubicle is dust and vermin-proof (Yes) | | |
| | 19. Protection class is IP55 or better (Yes) | | |
| | 20. Cable input and door seals provided (Yes) | | |
| | 21. Rating plate provided (Yes) | | |
| | 22. Arrangement diagram pasted on door (Yes) | | |
| | 23. Operation temperature: | | |
| | a) maximum (55°C) | | |
| | b) minimum (-5°C) | | |
| | 24. Relative humidity: | | |
| | a) maximum (95%) | | |
| | b) minimum (5%) | | |
| | 25. Type test reports enclosed (Yes/No) | | |
| | 26. Reference list enclosed (Yes) | | |
| | 27. Technical literature enclosed (Yes) | | |
| **6.2.1.5** | **Coaxial Cable** | | |
| | 1. Manufacturer | | |
| | 2. Country of manufacture | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | 3. Model number | | |
| | 4. Applicable standards | | |
| | 5. Date of first commercial operation of HF cable | | |
| | 6. Inner conductor: | | |
| | a) material (bare copper) | | |
| | b) type of conductor (solid) | | |
| | c) diameter (1-2mm) | | |
| | 7. Insulation between inner and outer conductor: | | |
| | a) material (solid PE) | | |
| | b) diameter (mm) | | |
| | 8. Outer conductor: | | |
| | a) material (bare copper braid) | | |
| | b) diameter (mm) | | |
| | 9 Inner sheath: | | |
| | a) material (PE black) | | |
| | b) thickness (mm) | | |
| | 10. Armor: | | |
| | a) material (galvanized steel tape) | | |
| | b) Number of layers (2 No.) | | |
| | c) tape thickness (mm) | | |
| | 11. Outer sheath: | | |
| | a) material (HDPE black) | | |
| | b) thickness (mm) | | |
| | 12. Structural layout of cable enclosed (Yes) | | |
| | 13. Minimum bending radius (mm) | | |
| | 14. Delivery length per drum (m) | | |
| | 15. Cable weight (kg/km) | | |
| | 16. Maximum permissible pulling force (kN) | | |
| | 17. Nominal impedance (75/150 ohm) | | |
| | 18. Resistance of inner conductor at 20°C (ohm/km) | | |
| | 19. Resistance of outer conductor at 20°C (ohm/km) | | |
| | 20. Insulation resistance between inner and outer conductors (min.), measured at 500V DC (Mohm.km) | | |
| | 21. Capacitance between inner and outer conductors at 800 Hz (≤66 nF/km) | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | 22. Attenuation at: | | |
| | a) 100 kHz (≤ 1.8 dB/km) | | |
| | b) 300 kHz (≤ 2.8 dB/km) | | |
| | c) 500 kHz (≤ 4.1 dB/km) | | |
| | 23. Operation temperature: | | |
| | a) maximum (70°C) | | |
| | b) minimum (-10°C) | | |
| | 24. Relative humidity: | | |
| | a) Maximum (95%) | | |
| | b) Minimum (5%) | | |
| | 25. Reference list enclosed (Yes) | | |
| | 26. Technical literature enclosed (Yes) | | |
| **6.2.1.6** | **Line Traps** | | |
| | 1. Manufacturer | | |
| | 2. Country of manufacture | | |
| | 3. Model number | | |
| | 4. Applicable standards IEC60353 (Yes) | | |
| | 5. Type test: | | |
| | a) Carried out (Yes/No) | | |
| | b) Date | | |
| | c) Testing laboratory (name/country) | | |
| | 6. Date of first commercial operation of Line Trap | | |
| | 7. Coil inductance | | |
| | 8. Blocking impedance | | |
| | 9. Rated continuous current (A) | | |
| | 10. Temperature rise at rated continuous current (°C) | | |
| | 11. Short-time current rating: | | |
| | a) Thermal (kA) | | |
| | b) Dynamic (kA) | | |
| | 12. Temperature rise at rated short-time current (°C) | | |
| | 13. Over-load for 20 minutes (%) | | |
| | 14. Overall radius (mm) | | |
| | 15. Overall length (mm) | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | 16. Lightning arrester discharge current (kA) | | |
| | 17. Mounting method is pedestal (Yes) | | |
| | 18. Down droppers and jumper clamps included (Yes) | | |
| | 19. Pedestals and bird barriers included (Yes) | | |
| | 20. Corona rings included (Yes) | | |
| | 21. Net weight (kg) | | |
| | 22. Tuning device: | | |
| | a) Manufacturer | | |
| | b) Model number | | |
| | c) Broad band type (Yes) | | |
| | d) Tuning pack frequency range (kHz) | | |
| | 23. Surge Arrester: | | |
| | a) Manufacturer | | |
| | b) Model number | | |
| | c) Voltage (kV) | | |
| | 24. Operation temperature: | | |
| | a) maximum (50°C) | | |
| | b) minimum (-5°C) | | |
| | 25. Relative humidity: | | |
| | a) maximum (95%) | | |
| | b) minimum (5%) | | |
| | 26. Type test reports on same type enclosed (Yes/No) | | |
| | a) Material | | |
| **6.2.2** | **FIBER OPTIC EQUIPMENT** | | |
| **6.2.2.1** | **OLTE/Multiplexer Cubicle** | | |
| | 1. Manufacturer | | |
| | 2. Country of manufacture | | |
| | 3. Model number | | |
| | 4. Cubicle is swing rack type (Yes) | | |
| | 5. Cubicle is dust & vermin-proof (Yes) | | |
| | 6. Protection class is IP55 (Yes) | | |
| | 7. Cubicle is floor mounted (Yes) | | |
| | 8. Accessible from both front/rear (Yes/No) | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | 9. Material of sheet | | |
| | 10. Thickness of sheet: | | |
| | a. Front door (2 mm) | | |
| | b. Rear and side doors (1.5 mm) | | |
| | 11. Dimensions: | | |
| | a) Height (2200 mm) | | |
| | b) Width (600/800 mm) | | |
| | c) Depth (600 mm) | | |
| | 12. Weight (kg) | | |
| **6.2.2.2** | **SDH Optical Line Terminal Equipment** | | |
| | 1. Manufacturer | | |
| | 2. Country of manufacture | | |
| | 3. Model number | | |
| | 4. Applicable standards | | |
| | 5. Type test: | | |
| | a) Carried out (Yes/No) | | |
| | b) Date | | |
| | c) Testing laboratory: | | |
| | i. name | | |
| | ii. country | | |
| | 6. Date of first commercial operation of the offered SDH OLTE | | |
| | 7. System configuration is point to point with MSP 1+1 protection scheme (Yes) | | |
| | 8. Duplicated control/cross-connect modules provided (Yes) | | |
| | 9. Duplicated power supply modules provided (Yes) | | |
| | 10. Electrical interface: | | |
| | a) Input/output interface as per ITU-T G703 and G957 (Yes) | | |
| | b) Line code | | |
| | c) Number of ports | | |
| | d) Line impedance | | |
| | 11. Optical interface: | | |
| | a) Operation technique (SDH) | | |
| | b) Transmission rate (STM-1) | | |
| | c) Transmission mode (single mode) | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | d) Expandable to higher order STM levels (Yes) | | |
| | e) Number of optical STM-1 input/output (≥ 4) | | |
| | f) Optical transmitter element (laser diode) | | |
| | g) Mean transmitted optical power | | |
| | h) Optical connector type | | |
| | i) Wavelength (nm) | | |
| | j) Optical code format | | |
| | k) Optical receiver element | | |
| | l) Optical receiver sensitivity at BER=10 -10 (dBm) | | |
| | m) Dynamic range (dB) | | |
| | 12. EOW service channel provided (Yes) | | |
| | 13. Jitter and wander of equipment as per G.783 (Yes) | | |
| | 14. Protection switching characteristics: | | |
| | a) Automatic switching criteria (BER, AIS, LIS) | | |
| | b) Maximum switching time (<5 ms) | | |
| | c) Manual and auto switching mode (Yes) | | |
| | 15. Maintenance tools: | | |
| | a) AIS (Yes) | | |
| | b) LIS alarm (Yes) | | |
| | c) Order channel (Yes) | | |
| | d) Service data channel (Yes) | | |
| | e) Craft channel (Yes) | | |
| | 16. Alarm conditions: | | |
| | a) Loss of transmitted signal (Yes) | | |
| | b) Loss of received signal (Yes) | | |
| | c) BER > 10 -6 (Yes) | | |
| | d) BER > 10 -3 (Yes) | | |
| | e) Loss of STM-1 signal (Yes) | | |
| | f) Laser failure (Yes) | | |
| | g) Power supply failure (Yes) | | |
| | 17. LEDs on front of the panel for normal operation (Yes) | | |
| | 18. LEDs on front of the panel for major alarms (Yes) | | |
| | 19. EMC compatibility (Yes) | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | 20. Operating voltage range (-40 to - 58 Vdc) | | |
| | 21. Power consumption of full rack (W) | | |
| | 22. Operation temperature range (0 to 50°C) | | |
| | 23. Relative humidity range (to 95%) | | |
| | 24. MTBF of complete shelf (hours) | | |
| | 25. Type test reports enclosed (Yes/No) | | |
| | 26. Reference list enclosed (Yes) | | |
| | 27. Technical literature enclosed (Yes) | | |
| | 28. Relevant drawings enclosed | | |
| | 29. Other documents required under Specifications | | |
| **6.2.2.3** | **Optical Distribution Frame** | | |
| | 1. Manufacturer | | |
| | 2. Country of manufacture | | |
| | 3. Model number | | |
| | 4. Applicable standards | | |
| | 5. Maximum number of optical fibers that can be terminated (24/48) | | |
| | 6. Number of optical connectors including the auxiliary connectors | | |
| | 7. Patch cords provided between the ODF and the OLTE (Yes) | | |
| | 8. Maximum loss of connector (<0.3 dB) | | |
| | 9. EMC compatibility as per IEC (Yes) | | |
| | 10. Installed in separate cabinet/OLTE cabinet | | |
| | 11. Dimension of ODF: | | |
| | a) Height (mm) | | |
| | b) Width (mm) | | |
| | c) Depth (mm) | | |
| | 12. Reference list enclosed (Yes) | | |
| | 13. Technical literature enclosed (Yes) | | |
| **6.2.2.4** | **Digital Multiplexer** | | |
| | 1. Manufacturer | | |
| | 2. Country of manufacture | | |
| | 3. Model number | | |
| | 4. Applicable standards | | |
| | 5. Type test: | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | a) Carried out (Yes/No) | | |
| | b) Date | | |
| | c) Testing laboratory: | | |
| | i. name | | |
| | ii. country | | |
| | 6. Date of first commercial operation of the offered Digital Multiplexer (dd-mm-yy) | | |
| | 7. Type of modulation is PCM (Yes) | | |
| | 8. Duplicated control/cross-connect modules provided (Yes) | | |
| | 9. Duplicated power supply modules provided | | |
| | 10. Transmission characteristics: | | |
| | a) Number of channels, voice or data | | |
| | b) Sampling rate (8 kHz) | | |
| | c) Binary digits/sample (8 bits/sample) | | |
| | d) Encoding law (A-law) | | |
| | e) Number of time slots per frame (32) | | |
| | f) Number of bits per time slot (8) | | |
| | g) Frame length (256) | | |
| | h) Crosstalk attenuation (min) (65 dB) | | |
| | 11. Equipment performance as per ITU-T G712 (Yes) | | |
| | 12. EMC compatibility according to IEC (Yes) | | |
| | 13. 2 Mbits/s input/output interfaces: | | |
| | a) Bit rate (2048 kb/s) | | |
| | b) Code format (HDB3) | | |
| | c) Signal waveform acc. to ITU-T G.703, G.708 (Yes) | | |
| | d) Frame structure acc. to ITU-T G.732, G.704 (Yes) | | |
| | e) Jitter acc. To ITU-T G.780, G.825 (Yes) | | |
| | f) Input attenuation range at 1024kHz (0-6 dB) | | |
| | g) Impedance (75Ω coax. /120Ω symm.) | | |
| | 14. Audio frequency interface: | | |
| | a) Frequency bandwidth (300-3400 Hz) | | |
| | b) Audio frequency termination (4-W & 2-W) | | |
| | c) Signaling interface (E&M) | | |
| | d) Input & output impedance (600Ω balanced) | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | e) Return loss (dB) | | |
| | f) Input level range (dBm) | | |
| | g) Output level range (dBm) | | |
| | h) Attenuation/frequency distortion as per ITU-T G.712 (Yes) | | |
| | i) Group delay distortion as per ITU-T G.712 (Yes) | | |
| | j) Send receive crosstalk as per ITU-T (Yes) | | |
| | k) Inter channel crosstalk as per ITU-T (Yes) | | |
| | l) Variation of gain with input level in compliance with ITU-T G.712 (Yes) | | |
| | m) Signal to total distortion in compliance with ITU-T G.712 (Yes) | | |
| | n) Spurious in-band signals in compliance with ITU-T G.712 (Yes) | | |
| | o) Intermodulation in compliance with ITU-T G.712 (Yes) | | |
| | 15. Digital interface: | | |
| | a) Bit rate (synchronous operation) (64 kbit/s) | | |
| | b) Bit rate tolerance (± 5 x 10-5) | | |
| | c) Encoding format as per ITU-T G.703, G.704 (Yes) | | |
| | d) Pulse shape as per ITU-T G.703, G.705 (Yes) | | |
| | e) Impedance (120Ω balanced) | | |
| | f) Return loss (16 dB) | | |
| | 16. Signaling multiplex: | | |
| | a) Allocation of time slot#16 in acc. with ITU-T G.704 (Yes) | | |
| | b) Multi frame structure | | |
| | 17. Compandor A-law with A=87.6: | | |
| | a) Frame structure as per ITU-T G.712 (Yes) | | |
| | 18. Maintenance tools: | | |
| | a) AIS (Yes) | | |
| | b) LIS alarm (Yes) | | |
| | c) Service data channel (Yes) | | |
| | 19. Alarm conditions: | | |
| | a) BER > 10 -3 (Yes) | | |
| | b) Loss of 2Mbps signal (Yes) | | |
| | c) Loss of VF frequency (Yes) | | |
| | d) Power supply failure (Yes) | | |
| | 20. LEDs on front panel for normal operation (Yes) | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | 21. LEDs on front panel for each alarm (Yes) | | |
| | 22. Operating voltage range ( -40 to - 58 V) | | |
| | 23. Power consumption of fully equipped shelf (W) | | |
| | 24. Operation temperature range (0 to 50°C) | | |
| | 25. Relative humidity range (5 to 95%) | | |
| | 26. MTBF of complete shelf (hours) | | |
| | 27. Type test reports enclosed (Yes/No) | | |
| | 28. Reference list enclosed (Yes) | | |
| | 29. Technical literature enclosed (Yes) | | |
| | 30. Relevant drawings enclosed | | |
| | 31. Other documents required under Specifications | | |
| **6.2.2.5** | **Approach Fiber Optic Cable** | | |
| | 1. Manufacturer | | |
| | 2. Country of manufacture | | |
| | 3. Model number | | |
| | 4. Applicable standards for: | | |
| | a) Optical fiber (ITU-T G.652) | | |
| | b) Fiber optic cable (IEC 60793, IEC 60794) | | |
| | 5. Type test: | | |
| | a) Carried out on same design (Yes/No) | | |
| | b) Date | | |
| | c) Testing laboratory: | | |
| | i. name | | |
| | ii. country | | |
| | 6. Date of first commercial operation of the offered Digital multiplexer (dd-mm-yy) | | |
| | 7. Optical fibers: | | |
| | a) Number of fibers (≥ 24) | | |
| | b) Single mode (Yes) | | |
| | c) Material (High grade silica) | | |
| | d) Mode field diameter at 1310nm (µm) | | |
| | e) Mode field concentricity error (<1) | | |
| | f) Cladding diameter (125±2) | | |
| | g) Cladding non-circularity (<2) | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | h) Material of coating above cladding (UV cured acrylate) | | |
| | i) Coating diameter (250±5) | | |
| | 8. Central strength member: | | |
| | a) Material | | |
| | b) Material is dielectric (Yes) | | |
| | c) Diameter (minimum) (mm) | | |
| | 9. Buffer tube: | | |
| | a) Loose tubes with loose fiber protection (Yes) | | |
| | b) Number of tubes (≥3) | | |
| | c) Number of fibers per tube (≤8) | | |
| | d) Material of tube | | |
| | e) Inner diameter (mm) | | |
| | f) Thickness (0.4 mm) | | |
| | g) Tube filling compound (moisture-proof gel) | | |
| | 10. Interstices between tubes filled with jelly compound (Yes) | | |
| | 11. Moisture-resistant wrapping around tubes (Yes) | | |
| | 12. Inner sheath: | | |
| | a) Material (Thermoplastic) | | |
| | b) Nominal thickness (1.5 mm) | | |
| | 13. Strength member reinforcing layer: | | |
| | a) Material (Aramid or glass yarn) | | |
| | b) Nominal thickness (mm) | | |
| | 14. Anti-rodent protection: | | |
| | a) Material (Glass tape) | | |
| | b) Thickness (mm) | | |
| | 15. Outer jacket: | | |
| | a) Material (HDPE) | | |
| | b) Thickness (1.5 mm) | | |
| | 16. Anti-termite coating over outer jacket (Yes) | | |
| | 17. Overall diameter of cable (mm) | | |
| | 18. Transmission mode (Single mode) | | |
| | 19. Wavelength (1310 & 1550 nm) | | |
| | 20. Cable cut-off wavelength<1270) | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | 21. Max. attenuation at 1310 nm (0.35 dB) | | |
| | 22. Max. attenuation at 1550 nm (0.22 dB) | | |
| | 23. Chromatic dispersion at 1310 nm (< 4 ps/nm.km) | | |
| | 24. Chromatic dispersion at 1550 nm (< 20 ps/nm.km) | | |
| | 25. Zero dispersion wavelength (1300-1330 nm) | | |
| | 26. Zero dispersion slope (≤0.1 ps/nm².km) | | |
| | 27. Operation temperature range (-10 to 70°C) | | |
| | 28. Relative humidity range (5 to 95%) | | |
| | 29. Minimum permissible bending radius (12 x cable dia.) | | |
| | 30. Maximum permissible pulling force (> 3 kN) | | |
| | 31. Ultimate breaking force (kN) | | |
| | 32. Delivery length per drum (2000m) | | |
| | 33. Cable installed in 50mm PVC duct from tower base to grid station control building (Yes) | | |
| | 34. Cable installed in flexible ducts on cable trays within grid station control building (Yes) | | |
| | 35. Material of cable drum (wooden/steel with screwed lagging) | | |
| | 36. Overall dimensions: | | |
| | a) Flange diameter (mm) | | |
| | b) Core diameter (mm) | | |
| | c) Width (mm) | | |
| | 37. Reel spindle hole diameter (mm) | | |
| | 38. Weights: | | |
| | a) Maximum gross weight of a full drum (kg) | | |
| | b) Empty drum (kg) | | |
| | 39. Type test reports of same type of FOC enclosed (Yes/No) | | |
| | 40. Technical literature for FOC enclosed (Yes) | | |
| | 41. Reference list for FOC enclosed (Yes) | | |
| **6.2.3** | **TELEPHONE (PAX) EQUIPMENT** | | |
| **6.2.3.1** | **PAX Equipment Cubicle** | | |
| | 1. Manufacturer | | |
| | 2. Country of manufacture | | |
| | 3. Model number | | |
| | 4. Cubicle is swing rack type (Yes) | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | 5. Cubicle is dust & vermin-proof (Yes) | | |
| | 6. Protection class is IP54 (Yes) | | |
| | 7. Cubicle is floor mounted (Yes) | | |
| | 8. Accessible from both front/rear (Yes/No) | | |
| | 9. Material of sheet | | |
| | 10. Thickness of sheet: | | |
| | a. Front door (2 mm) | | |
| | b. Rear and side doors (1.5 mm) | | |
| | 11. Dimensions: | | |
| | a) Height (2200 mm) | | |
| | b) Width (600/800 mm) | | |
| | c) Depth (600 mm) | | |
| | 12. Weight (kg) | | |
| **6.2.3.2** | **Digital Exchange** | | |
| | 1. Manufacturer | | |
| | 2. Country of manufacture | | |
| | 3. Model number | | |
| | 4. Exchange is SPC type (Yes) | | |
| | 5. Type of modulation | | |
| | 6. Type of multiplexing | | |
| | 7. Back-up memory provided (Yes) If yes, specify time taken to reload the software and customer files on restoration of AC mains (s) | | |
| | 8. Interface circuit for extension is according to ITU-T Q23 (Yes) | | |
| | 9. Interface circuit for trunk line is according to: | | |
| | a) DTMF/ITU-TR2 signaling for 4-wire E&M | | |
| | b) Q-signaling for 2 Mb/s digital trunk (Yes) | | |
| | 10. Equipped number of subscribers: | | |
| | a) Analog | | |
| | b) Digital | | |
| | 11. Equipped number of trunk lines | | |
| | a) Analog | | |
| | b) Digital | | |
| | 12. Maximum capacity of subscribers | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | 13. Maximum capacity of trunk lines | | |
| | 14. Subscriber lines 2-wire/4-wire: | | |
| | a) Input speech level (4-wire) (dBm) | | |
| | b) Output speech level (4-wire) (dBm) | | |
| | c) Input speech level (2-wire) (dBm) | | |
| | d) Output speech level (2-wire) (dBm) | | |
| | 15. Ringing voltage (V,rms) | | |
| | 16. Numbering scheme is software programmable in field (Yes) | | |
| | 17. Software features, as specified, provided (Yes) | | |
| | 18. Priority intrusion, forced release, section dialing facilities available over the network analog and digital trunk lines (Yes) | | |
| | 19. Power supply voltage range (-40 to -58 V) | | |
| | 20. Power consumption of full rack (W) | | |
| | 21. MTBF of full rack (hours) | | |
| | 22. Details of maintenance facilities given (Yes) (Specify volume/section of Tender) | | |
| | 23. Exchange has been in operation for five years operation in power utilities (Yes) | | |
| | 24. Type test reports attached (Yes/No) | | |
| | 25. Reference list attached (Yes) | | |
| | 26. Technical literature enclosed (Yes) | | |
| **6.2.3.3** | **Normal Telephone Sets** | | |
| | 1. Manufacturer | | |
| | 2. Country of manufacture | | |
| | 3. Model number | | |
| | 4. Instruments are push-button type (Yes) | | |
| | 5. Type of signaling (decadic/DTMF) | | |
| | 6. If DTMF, receivers operate at frequencies acc. to ITU-T Q23 (Yes) | | |
| **6.2.3.4** | **Executive Telephone Sets** | | |
| | 1. Manufacturer | | |
| | 2. Country of manufacture | | |
| | 3. Model number | | |
| | 4. Units are desk mounted type (Yes) | | |
| | 5. Type of dial | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | 6. If DTMF, receivers operate at frequencies acc. to ITU-T Q23 (Yes) | | |
| | 7. Features, as specified, provided (Yes) | | |
| **6.2.4** | **MAIN DISTRIBUTION FRAME (MDF)** | | |
| **6.2.4.1** | **Equipment Cabinet** | | |
| | 1. Manufacturer | | |
| | 2. Country of manufacture | | |
| | 3. Model number | | |
| | 4. Protection class is IP54 (Yes) | | |
| | 5. Color | | |
| | 6. Cabinet is self-standing type (Yes) | | |
| | 7. Dimensions: | | |
| | a) Height (2200 mm) | | |
| | b) Width (600/800 mm) | | |
| | c) Depth (600 mm) | | |
| | 8. Number of cable entries: | | |
| | a) From bottom | | |
| | b) From top | | |
| | 9. Gland plate: | | |
| | a) Stainless steel material (Yes/No) | | |
| | b) Grade | | |
| | c) Length (mm) | | |
| | d) Width (mm) | | |
| | e) Thickness (mm) | | |
| | 10. Gland: | | |
| | a) Brass material (Yes/No) | | |
| | b) Grade | | |
| | 11. Weight of cabinet (kg) | | |
| **6.2.4.2** | **MDF equipment** | | |
| | 1. Manufacturer | | |
| | 2. Country of manufacture | | |
| | 3. Model number of frame | | |
| | 4. Terminating blocks are quick connect type (Yes) | | |
| | 5. Type number of disconnecting block | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | 6. Type number of connecting block | | |
| | 7. Type number of block with surge protection | | |
| | 8. Insulation voltage of surge arrester (V) | | |
| | 9. Number of pairs that can be terminated per frame | | |
| | 10. Number of pairs in each block | | |
| | 11. Cabinet equipped for 600 pairs termination (Yes) | | |
| | 12. Number of blocks: | | |
| | a) Disconnection | | |
| | b) Connection | | |
| | c) Surge protection | | |
| | 13. Maximum capacity of cabinet (1200 pairs) | | |
| **6.2.5** | **SCADA SYSTEM** | | |
| **6.2.5.1** | **Transducers** | | |
| **(A)** | **General:** | | |
| | 1. State standards for design and tests | | |
| | IEC, EN, IEEE) | | |
| | 2. Power supply voltage range (V) | | |
| | 3. Temperature range for guaranteed operation (°C) | | |
| | 4. Maximum relative humidity at 35°C (%) | | |
| **(B)** | **Active power transducer:** | | |
| | 1. Manufacturer | | |
| | 2. Type number | | |
| | 3. Type of load (balanced/unbalanced)<br>(3 phase 3 wire/3 phase 4 wire) | | |
| | 4. Output signal (±10 mA, 4-20 mA) | | |
| | 5. Accuracy class (0.5 %) | | |
| | 6. External resistance load (ohm) | | |
| | 7. Input voltage (V) | | |
| | 8. Input current (mA) | | |
| | 9. Input consumption (burden) (VA) | | |
| | 10. Input frequency (50 Hz) | | |
| | 11. Input overload capacity (current circuits): | | |
| | a) continuous | | |
| | b) for 10 sec. | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | c) for 1 sec. | | |
| | 12 Galvanic separations between input and output (Yes) | | |
| | 13. Test voltage (≥4 kV/50Hz/1 min.) | | |
| | 14. Measuring range (± MW) | | |
| | 15. Type of mounting (surface/rack) | | |
| **(C)** | **Reactive power transducer:** | | |
| | 1. Manufacturer | | |
| | 2. Type number | | |
| | 3. Type of load (balanced/unbalanced) | | |
| | (3 phase 3 wire/3 phase 4 wire) | | |
| | 4. Output signal (±10 mA, 4-20 mA) | | |
| | 5. Accuracy class (0.5 %) | | |
| | 6. External resistance load (ohm) | | |
| | 7. Input voltage (V) | | |
| | 8. Input current (mA) | | |
| | 9. Input consumption (burden) (VA per phase) | | |
| | 10. Input frequency (50 Hz) | | |
| | 11. Input overload capacity (current circuits): | | |
| | a) continuous | | |
| | b) for 10 sec. | | |
| | c) for 1 sec. | | |
| | 12. Galvanic separation between input and output (Yes) | | |
| | 13. Test voltage (≥4 kV/50Hz/1 min.) | | |
| | 14. Measuring range (± MVAr) | | |
| | 15. Type of mounting (surface/rack) | | |
| **(D)** | **Voltage transducer:** | | |
| | 1. Manufacturer | | |
| | 2. Type number | | |
| | 3. Output signal (0-10 mA, 4-20 mA) | | |
| | 4. Accuracy class (0.5 %) | | |
| | 5. External resistance load (ohm) | | |
| | 6. Input voltage measuring range (V) | | |
| | 7. Input current (mA) | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | 8. Input consumption (burden) (VA) | | |
| | 9. Input frequency (45-55 Hz) | | |
| | 10. Input overload capacity (current circuits): | | |
| | a) continuous | | |
| | b) for 10 sec. | | |
| | 11. Galvanic separation between input and output (Yes) | | |
| | 12. Test voltage (≥4 kV/50Hz/1 min.) | | |
| | 13. Measuring range (V) | | |
| | 14. Type of mounting (surface/rack) | | |
| **(E)** | **Frequency transducer:** | | |
| | 1. Manufacturer | | |
| | 2. Type number | | |
| | 3. Output signal (0-10 mA, 4-20 mA) | | |
| | 4. Accuracy class: | | |
| | a) of nominal frequency (<0.05%) | | |
| | b) of measured span (<0.5%) | | |
| | 5. External resistance load (ohm) | | |
| | 6. Input voltage (V) | | |
| | 7. Tolerance on input voltage (%) | | |
| | 8. Input consumption (burden) (VA) | | |
| | 9. Input frequency (45-55 Hz) | | |
| | 10. Input overload capacity (current circuits): | | |
| | a) continuous | | |
| | b) for 10 sec. | | |
| | 11. Galvanic separation between input and output (Yes) | | |
| | 12. Test voltage (≥4 kV/50Hz/1 min.) | | |
| | 13. Measuring range (Hz) | | |
| | 14. Type of mounting (surface/rack) | | |
| **6.2.6** | **Supporting Documents** | | |
| | 1. Supporting documents, as specified, provided (Yes) | | |
| | 2. Give reference of each document in the Proposal (Volume #, Page # of Proposal) | | |
| | 3. Type test reports enclosed (Yes) | | |
| | 4. Relevant drawings enclosed (Yes) | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | 5. Reference lists attached (Yes) | | |
| **6.2.7** | **48V DC POWER SUPPLY SYSTEM** | | |
| **6.2.7.1** | **General** | | |
| | 1. Nominal system voltage (V) | | |
| **6.2.7.2** | **Battery Chargers** | | |
| | 1. Manufacturer | | |
| | 2. Country of manufacture | | |
| | 3. Model number | | |
| | 4. Duplicated configuration (Yes/No) | | |
| | 5. Rated current of each charger, A. | | |
| | 6. Type of rectifier bridge | | |
| | 7. Operation mode | | |
| | 8. Duty class | | |
| | 9. AC mains voltage/tolerance (V±%) | | |
| | 10. Input frequency/tolerance (Hz±%) | | |
| | 11. Rated output DC voltage (V) | | |
| | 12. Output voltage variation for specified fluctuation in AC mains and ± 5% frequency change (± %) | | |
| | 13. Audible noise (dB) | | |
| | 14. Insulation resistance (Mohm) | | |
| | 15. Time to 100% charge a fully discharged battery (hours) | | |
| | 16. Input power factor at: | | |
| | a) lightly loaded condition | | |
| | b) full load | | |
| | 17. Charger efficiency at 100% load (%) | | |
| | 18. Operating temperature range for guaranteed operation (deg. C) | | |
| | 19. Relative humidity at maximum ambient temperature (%) | | |
| | 20. Controls and alarms, as specified, provided (Yes/No) | | |
| **6.2.7.3** | **Charger Cabinet** | | |
| | 1. Manufacturer | | |
| | 2. Country of manufacture | | |
| | 3. Model number | | |
| | 4. Material of cabinet | | |
| | 5. Cabinet is dust & vermin-proof (Yes/No) | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | 6. Protection class is IP54 (Yes/No) | | |
| | 7. Cabinet is floor mounted (Yes/No) | | |
| | 8. ON/OFF main switches with green LEDs provided (Yes/No) | | |
| | 9. Red LED to indicate manual boost operation provided (Yes/No) | | |
| | 10. Specified DC and AC ammeters and voltmeters provided (Yes/No) | | |
| | 11. Protection equipment, as specified, provided (Yes/No) | | |
| | 12. Weight (kg) | | |
| **6.2.7.4** | **Instrumentation and DC Distribution Cabinet** | | |
| | 1. Instrumentation: | | |
| | a) Instruments, as specified, provided (Yes/No) | | |
| | b) Manufacturer | | |
| | c) Country of manufacture | | |
| | d) Tolerance of meters (± %) | | |
| | 2. DC distribution cabinet: | | |
| | a) Manufacturer | | |
| | b) Model number | | |
| | c) Design according to IEC 60439, 60146, 60478 and 60896 (Yes/No) | | |
| | d) Material of cubicle | | |
| | e) Cubicle is vermin-proof (Yes/No) | | |
| | f) Type of arrangement within cabinet for connection to common grounding system | | |
| | g) Weight (kg) | | |
| | h) Installation mode | | |
| | i) Number of outgoing circuits | | |
| | j) Battery DC voltmeter installed (Yes/No) | | |
| | k) Battery DC contactor installed (Yes/No) | | |
| | l) Battery DC contactor disconnect voltage (V) | | |
| | m) Battery DC contactor reconnect voltage (V) | | |
| | n) Manufacturer of MCBs | | |
| | o) Type number of MCBs | | |
| | p) Ratings of breakers provided (A) | | |
| | q) Alarms, as specified, provided (Yes/No) | | |
| **6.2.7.5** | **Batteries** | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | 1. Manufacturer | | |
| | 2. Country of manufacture | | |
| | 3. Model number | | |
| | 4. Duplicated configuration (Yes/No) | | |
| | 5. Rated capacity of each battery, AH. | | |
| | 6. Battery is single cell type (Yes/No) | | |
| | 7. Number of cells in each battery | | |
| | 8. Positive plate is planet type (Yes/No) | | |
| | 9. Float voltage per cell (V) | | |
| | 10. Boost voltage per cell (V) | | |
| | 11. End voltage per cell (V) | | |
| | 12. Minimum aging factor | | |
| | 13. Self-discharge at 25°C (%) | | |
| | 14. Name of electrolyte | | |
| | 15. Material of cell terminals | | |
| | 16. Material of intercell connectors | | |
| | 17. Material of battery racks | | |
| | 18. Racks are treated with acid-resistant paint (Yes/No) | | |
| | 19. Mode of installation of cells | | |
| | 20. List of accessories provided (Yes/No) | | |
| | 21. List of similar installations provided with Proposal (Yes/No) | | |
| | 22. Operating temperature range for guaranteed operation (°C) | | |
| | 23. Relative humidity at maximum ambient temperature (%) | | |
| | 24. Guaranteed life (years) | | |

### 6.3 132 KV SWITCHYARD EQUIPMENT

| Item | Description | Units | Value |
|---|---|---|---|
| **6.3.1** | **CIRCUIT BREAKERS: 132kV** | | |
| **6.3.1.1** | Reference Data | | |
| | 1. Nominal voltage class, kV, rms | | |
| | 2. Type designation | | |
| | 3. Manufacturer's name and country | | |
| | 4. Catalog No. | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | 5. Is Proposal in accordance with the Specifications? (If not, list deviations in an attachment to this Schedule.) | | |
| **6.3.1.2** | Voltage Data: | | |
| | 1. Nominal system voltage, kV, rms. | | |
| | 2. (a) Rated voltage kV, rms. | | |
| | 2. (b) Steady state max. sustained voltage. | | |
| | 3. Visible or audible corona at steady state, maximum sustained voltage. | | |
| | 4. Rated insulation level: | | |
| | (a) Rated one minute power frequency | | |
| | -withstand voltage, kV, rms. | | |
| | -Phase to earth and between phases. | | |
| | -Across open breaker. | | |
| | (b) Rated switching impulse | | |
| | -withstand voltage, kV, peak. | | |
| | -Phase to earth. | | |
| | -Between phases. | | |
| | -Across open breaker. | | |
| | (c) Rated lightning impulse | | |
| | -withstand voltage, kV, peak. | | |
| | -Phase to earth and between phases. | | |
| | -Across open breaker. | | |
| | 5. Rated frequency. | | |
| | 6. Max. rate of rise of recovery voltage the breaker is designed to handle at rated interrupting MVA, kV/usec. | | |
| | 7. Maximum RIV at 1.1xUr//3 line to ground when tested as per IEC 694, micro volt. | | |
| **6.3.1.3** | Current Ratings: | | |
| | 1. Rated current at 50 Hz and 50 deg. C not less than, A, rms: | | |
| | a) Bay circuit breaker. | | |
| | b) Shunt reactor circuit breaker. | | |
| | 2. Rated short time withstand current, kA, rms. | | |
| | 3. Rated peak withstand current, kA, peak. | | |
| | 4. Rated duration of short circuit, sec. | | |
| **6.3.1.4** | **Breaking/Making:** | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | 1. Rated short circuit breaking current at rated voltage and 50 deg. C, not less than kA, rms. | | |
| | 2. Percentage of DC component | | |
| | 3. Rated short-circuit making current, kA, peak. | | |
| | 4. Rated out of phase breaking current, kA, rms. | | |
| | 5. Rated line charging breaking current at rated voltage. | | |
| | 6. Rated cable charging breaking current, A at rated voltage. | | |
| | 7. Transient recovery overvoltage for terminal faults according to IEC standards: | | |
| | u1= first reference voltage, kV. | | |
| | t1 = time to reach u1, usec. | | |
| | uc =second reference voltage (TRV peak value), kV. | | |
| | t2 = time to reach uc, usec. | | |
| | td = time delay, usec. | | |
| | u' = reference voltage, kV | | |
| | t' = time to reach u', u sec. | | |
| | u1/t1 = rate of rise of voltage, kV/usec. | | |
| | 8. First pole to clear factor. | | |
| | 9. Are short line fault rated characteristics according to IEC (Yes/No). | | |
| **6.3.1.5** | **Time Characteristics at Rated Control Voltage and Operating Pressure:** | | |
| | 1. Rated operating sequence. | | |
| | 2. Maximum time interval between the complete closing of the first and the last pole, msec. | | |
| | 3. Maximum closing time (from energization of closing coil to the completion of closing stroke), msec. | | |
| | 4. Maximum operating time from energization of tripcoiltocontact parting, msec. | | |
| | 5. Minimum time from arc extinguishing to contact remake for auto reclosing, msec. | | |
| | 6. Maximum arc duration, msec. | | |
| | 7. Dead time adjustment for three phase auto reclosing, msec. | | |
| | 8. Additional time for interrupting the resistor currents. | | |
| | 9. Time from contact touch to contact part on Close Open operation, upon which interrupting rating is based, msec. | | |
| | 10. Rate of rise of recovery voltage at: | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | a) 100% fault duty, V/usec. | | |
| | b) 60% fault duty, V/usec. | | |
| | c) 30% fault duty, V/usec. | | |
| | d) 10% fault duty, V/usec. | | |
| | 11. Rate of rise of recovery voltage (line side) at rated interrupting current with fault at critical distance, V/usec. | | |
| | 12. Critical impedance to fault,km. | | |
| | 13. Rated break time, msec. | | |
| | 14. Breaking time (with rated control voltage based on 50 Hz) at: | | |
| | a) 100% fault duty, msec. | | |
| | b) 25% fault duty, mesc. | | |
| | c) Less than 25% duty, msec. | | |
| | 15. Maximum time variation between: | | |
| | a) The opening of series contacts on, any one `phase, msec. | | |
| | b) The closing of contact on any two phases, msec. | | |
| | c) The opening of contacts on any two phases, msec. | | |
| | 16. Closing resistors: | | |
| | Resistance, ohms. | | |
| | insertion time, msec. | | |
| | 17. Opening resistors: | | |
| | resistance, ohms. | | |
| | insertion time, msec. | | |
| | 18. Time interval between two maintenances (for infrequent operation). | | |
| | 19. Number of operations after which a maintenance is necessary (for frequent operations). | | |
| | 20. Total number of possible operations (the lifetime of the operating mechanisms if stipulated maintenance is performed). | | |
| **6.3.1.6** | **Design:** | | |
| | 1. Resistive drop across main contacts at rated current, mili volts. | | |
| | 2. Type of main arcing contacts. | | |
| | 3. Contact material, how adjusted and method of extinguishing arc. | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | 4. Type of auxiliary arcing contacts, contact material, how adjusted, and method of extinguishing arc. | | |
| | 5. Number of series breaks in main contacts. | | |
| | 6. Voltage distribution between breaks. | | |
| | 7. Does magnetic effect of local current increase contact pressure. | | |
| | 8. Minimum electrical clearance between stationary and moving conducting parts when breaker is open, mm. | | |
| | 9. Type of terminals and connectors. | | |
| | 10. Is breaker suited for independent pole operation. | | |
| | 11. Is breaker suited for high speed, 3phase and single-phase auto reclosing. | | |
| | 12. Maximum noise level at distance of 1 meter horizontal distance at the perimeter of circuit breaker during opening and closing operations, dB(A). | | |
| | 13. Permissible loading of breaker terminals: | | |
| | a) Horizontal, kg. | | |
| | b) Vertical ,kg. | | |
| | c) Longitudinal, kg. | | |
| **6.3.1.7** | **Insulating Porcelains:** | | |
| | (a) Insulator Columns: | | |
| | 1. Type | | |
| | 2. Manufacturer | | |
| | 3. Number of units per column | | |
| | 4. Maximum diameter of insulators | | |
| | 5. Clearance, phase to phase, mm. | | |
| | 6. External creepage distance, phase to ground, mm. | | |
| | 7. Protected creepage distance (90 deg. shadow) mm. | | |
| | 8. External striking distance: | | |
| | phase to ground, mm. | | |
| | phase to phase, mm. | | |
| | 9. Ultimate strength of columns: | | |
| | . cantilever, N. | | |
| | . tension, N. | | |
| | . torsion, Nm. | | |
| | . compression, N. | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | 10. Rated Voltage, kV. | | |
| | 11. 1 minute power frequency wet withstand voltage, kV. rms. | | |
| | 12. 1 minute power frequency dry withstand voltage, kV, rms. | | |
| | 13. Lightning impulse withstand voltage, kV, peak. | | |
| | 14. Wet switching impulse withstand, kV, peak. | | |
| | 15. Creepage distance, mm. | | |
| **6.3.1.8** | **Operating Mechanism:** | | |
| | 1. Type of mechanism | | |
| | . Method of closing. | | |
| | . Method of tripping. | | |
| | 2. Operating pressure of interrupting medium, bars | | |
| | 3. Number of phases and voltage of: | | |
| | . motors, V, DC/AC | | |
| | . heaters, V, rms. | | |
| | 4. Power demand of: | | |
| | . motors, W. | | |
| | . heaters, W. | | |
| | 5. Number of trip coils per phase. | | |
| | 6. Closing control current (total for three phase): | | |
| | a) initial, A. | | |
| | b) holding, A. | | |
| | 7. Closing control voltage, V. | | |
| | 8. Tripping control current per trip coil, A. | | |
| | 9. Opening control voltage, V. | | |
| | 10. Locked rotor and maximum running current required by motor operated mechanism at rated voltage, A. | | |
| **6.3.1.9** | **Auxiliary Switches:** | | |
| | 1. Number of normally open contacts. | | |
| | a) Total | | |
| | b) Spare | | |
| | 2. Number of normally closed contacts. | | |
| | a) Total | | |
| | b) Spare | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | 3. Number of reversible contacts. | | |
| | a) Total | | |
| | b) Spare | | |
| | 4. Number of adjustable contacts. | | |
| | a) Total | | |
| | b) Spare | | |
| | 5. Voltage rating, V dc. | | |
| | 6. Current rating of auxiliary contacts: | | |
| | a) Make and hold, Amps. | | |
| | b) Interrupting, resistive, Amps. | | |
| **6.3.1.10** | **Other Data:** | | |
| | 1. Nominal operating pressure of circuit breaker, bars. | | |
| | 2. Normal operating pressure range of circuit breaker: | | |
| | a) Minimum, bars | | |
| | b) Maximum, bars. | | |
| | 3. Total volume of SF6 gas per pole, m3. | | |
| | 4. Total weight of SF6 gas per pole, kg. | | |
| | 5. No. of operations from SF6 stored at circuit breaker without recycling. | | |
| | 6. No. of operations after which circuit breaker is to be overhauled: | | |
| | a) Short-circuit operations. | | |
| | b) Operations in normal service. | | |
| | 7. Maximum leakage of SF6 gas per year per circuit breaker. | | |
| | 8. SF6 pressure at which: | | |
| | (a) closing is blocked, bars | | |
| | (b) tripping is blocked, bars. | | |
| | 9. No. and description of safety alarms provided for: | | |
| | a) _____ | | |
| | b) _____ | | |
| | c) _____ | | |
| **6.3.1.11** | **Hydraulically Operated Circuit Breaker:(N.A)** | | |
| | 1. Number of Close Open operations which can be performed by the stored energy in each circuit breaker | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | operating device starting at the normal working pressure and without replenishing. | | |
| | 2. Normal value of pressure and range of pressure within which the circuit breaker will operate satisfactorily, bars. | | |
| | 3. Append description of stored energy system to be furnished with circuit breaker. (Yes/No) | | |
| | 4. Time required to pump from lockout pressure to normal pressure, minutes. | | |
| **6.3.1.12** | **Spring Charge Mechanism:** | | |
| | 1. No. of operating mechanisms for 3pole circuit breaker. | | |
| | 2. Time required for the motor to recharge the closing spring at min. dc supply voltage, sec. | | |
| **6.3.1.13** | **Weights, Dimensions and Miscellaneous:** | | |
| | 1. Overall length, mm | | |
| | 2. Overall width, mm | | |
| | 3. Overall height, mm | | |
| | 4. Phase spacing, mm | | |
| | 5. Terminal height above foundation, mm. | | |
| | 6. Maximum shipping dimension (largest item), m x m x m. | | |
| | 7. Total weight of single pole breaker unit, kg. | | |
| | 8. Total weight of complete circuit breaker, kg. | | |
| | 9. Total weight of support structure, kg. | | |
| | 10. Maximum shipping weight (heaviest item),kg. | | |
| | 11. Withstand to earthquake shocks. Horizontal and vertical ground acceleration, g. | | |
| | 12. Append drawing of support structure (Yes/No) | | |
| | 13. Append drawing of mechanism details (Yes/No) | | |
| | 14. Append list of type and routine tests to be performed by the Manufacturer and details of test procedure that will be used to prove breaker performance in accordance with the proposed IEC standards (Yes/No) | | |
| | 15. Append list of attached drawings, design briefs and documentation (Yes/No) | | |
| | | | |
| | 16. Additional clear space required for removal of bushings and/or interrupters, m x m x m. | | |
| | 17. Additional height or width required for use of manual closing mechanism, mm. | | |
| | 18. Append description of facilities for handling and lifting: | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | interrupter. (Yes/No) | | |
| | interrupter assembly. (Yes/No) | | |
| | insulator supporting columns. (Yes/No) | | |
| | 19. Append a description of measures incorporated for tropicalization and dust proofing of breaker components including control relays and contacts. (Yes/No) | | |
| | 20. Append copy of type tests required by the documents and performed on the breaker. (Yes/No) | | |
| | 21. Submit diagram showing how main contacts of the breaker are shunted with resistors and capacitors (Yes/No) | | |
| | 22. Where are resistors and capacitors located? Supply drawing showing this information (Yes/No) | | |
| | 23. Submit a travel diagram plotted in msec with the following points shown thereon for one opening operation: (Yes/No) | | |
| | a) Trip coil energized. | | |
| | b) Resistor switch closes. | | |
| | c) Main contact's part. | | |
| | d) Arc extinguished (maximum interruption time). | | |
| | e) Main contacts fully open. | | |
| | f) Resistor switch starts opening. | | |
| | g) Resistor switch fully open. | | |
| | 24. Submit a similar diagram for a closing operation with the following points shown thereon: (Yes/No) | | |
| | a) Closing relay energized. | | |
| | b) Preinsertion resistor switch closes. | | |
| | c) Main contact's touch. | | |
| | d) Main contacts fully closed. | | |
| | e) Preinserted resistor switch opens. | | |
| | 25. Submit a similar diagram for an opening operation and unsuccessful instantaneous reclosing operation into a fault. This too consist of an open zero time close open (Yes/No) | | |
| **6.3.2** | **DISCONNECTORS AND EARTHING SWITCHES** | **132kV** | |
| **6.3.2.1** | **Reference Data:** | | |
| | 1. Nominal voltage class, kV | | |
| | 2. Type designation | | |
| | 3. Break type (Vertical/Horizontal) | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | 4. Manufacturer's name and country | | |
| | 5. Catalog No. | | |
| | 6. Is Proposal in accordance with the Specifications? (If not, list deviations in an attachment to this Schedule) | | |
| **6.3.2.2** | **Voltage Data:** | | |
| | 1. Nominal system voltage, kV, rms. | | |
| | 2. Rated voltage, kV, rms. | | |
| | 3. Rated insulation level: | | |
| | (a) Rated 1 min. power frequency withstand voltage: | | |
| | Phase to earth and between phases, kV, rms. | | |
| | Across the isolating distance, kV, rms. | | |
| | (b) Rated switching impulse withstand voltage: | | |
| | Phase to earth kV, peak. | | |
| | Between phases, kV, peak | | |
| | Across the isolating distance, kV, peak. | | |
| | (c) Rated lightning impulse withstand voltage: | | |
| | Phase to earth and between | | |
| | phases, kV, peak. | | |
| | Across the isolating distance, kV, peak. | | |
| | 4. Frequency, Hz. | | |
| | 5. Max. RIV at 1.1xUr//3 rms line to ground voltage when tested as per IEC 694, microvolts | | |
| **6.3.2.3** | **Current Data:** | | |
| | 1. Rated current at 50 deg. C, not less than, A, rms: | | |
| | a) Bay disconnectors. | | |
| | b) Shunt reactor disconnectors. | | |
| | c) Transformer disconnectors. | | |
| | 2. Rated short time withstand current for disconnectors and earthing switches, kA, rms. | | |
| | 3. Rated duration of short circuit for disconnectors and earthing switches, sec. | | |
| | 4. Rated peak withstand current for disconnectors and earthing switches, kA, peak. | | |
| **6.3.2.4** | **Operating Mechanism:** | | |
| **6.3.2.4 .1** | **Motor Operated Mechanism for Disconnectors and Earthing Switches:** | | |
| | 1. Manufacturer's name and country | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | 2. Type and catalog No. | | |
| | 3. Max. opening time, sec. | | |
| | 4. Max. closing time, sec. | | |
| | 5. Number of phases and voltage of: | | |
| | (a) motor, V, dc. | | |
| | (b) heater, V, rms. | | |
| | 6. Power demand of : | | |
| | (a) motor, W. | | |
| | (b) heater, W. | | |
| | 7. Maximum current during: At 220V DC | | |
| | (a) start, A, rms. | | |
| | (b) running, A, rms. | | |
| | (c) stall, A, rms. | | |
| | Maximum time required to open or close the disconnector, sec. | | |
| | Number of operations (Close Open) disconnector is capable to perform. | | |
| **6.3.2.4.2** | **Manually Operated Mechanism:** | | |
| **I.** | **For Disconnectors:** | | |
| | 1. Maximum Torque required to open (operation effort and point of application shall be indicated on an outline drawing) Kgm. | | |
| | 2. Method of manual operation. | | |
| | 3. Number of revolutions of crank required for full stroke of disconnector. | | |
| **II.** | **For Earthing Switches** | | |
| | 1. Maximum Torque required to open (operation effort and point of application shall be indicated on an outline drawing) Kgm. | | |
| | 2. Method of manual operation. | | |
| | 3. Number of revolutions of crank required for full stroke of disconnector. | | |
| **6.3.2.5** | **Contact Data:** | | |
| | 1. Normal contact pressure (disconnector in fully closed position), kg. | | |
| | 2. Maximum wiping contact pressure, kg | | |
| | 3. Material of contact surfaces | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| **6.3.2.6** | **Switch Materials:** | | |
| | 1. Disconnector | | |
| | 2. Earthing switch | | |
| | 3. Other live parts | | |
| **6.3.2.7** | **Dimensions:** | | |
| | 1. Maximum opening from closed position. | | |
| | 2. Height from base to center line of terminal connectors, mm. | | |
| | 3. Length of disconnector base, mm | | |
| | 4. Length from jaw end terminal pad to hinge end terminal pad, mm | | |
| | 5. Length of open gap, metal to metal, mm | | |
| | 6. Live part, phase clearance disconnector (centerline to centerline spacing) based on (5) above, mm. | | |
| | 7. Overall length, mm | | |
| | 8. Overall width, mm | | |
| | 9. Overall height, mm | | |
| **6.3.2.8** | **Insulator Stacks:** | | |
| | 1. Type | | |
| | 2. Manufacturer's name and country | | |
| | 3. IEC Designation | | |
| | 4. No. of units per stack | | |
| | 5. Lighting impulse withstand voltage, kV, peak. | | |
| | 6. Switching impulse withstand voltage, wet, kV, peak. | | |
| | 7. Power frequency 1 min. wet withstand, voltage, kV. rms. | | |
| | 8. Radio interference voltage: | | |
| | (a) Test voltage, kV rms to ground. | | |
| | (b) Max. RIV, at 1.1xUr//3kV line to ground when tested as per IEC 694, micro volts. | | |
| | 9. Minimum creepage distance, mm. | | |
| | 10. Ultimate strength at top of insulator stack: | | |
| | (a) Cantilever, N | | |
| | (b) Tension, N | | |
| | (c) Torsion, Nm | | |
| | (d) Compression, N | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | 11. Maximum cantilever load on any insulator at points of contact resulting from disconnectors operation, N | | |
| | 12 a) Top metal fitting pitch circle diameter | | |
| | b) Bottom metal fitting pitch circle diameter | | |
| | 13 Material and color | | |
| **6.3.2.9** | **Auxiliary Switches:** | | |
| | 1. Number of normally open contacts. | | |
| | a) Total | | |
| | b) Spare | | |
| | 2. Number of normally closed contacts. | | |
| | a) Total | | |
| | b) Spare | | |
| | 3. Number of reversible contacts: | | |
| | a) Total | | |
| | b) Spare | | |
| | 4. Number of adjustable contacts. | | |
| | a) Total | | |
| | b) Spare | | |
| | 5. Voltage rating, V, dc. | | |
| | 6. Continuous current rating, A, dc | | |
| | 7. Contact material. | | |
| **6.3.2.10** | **Terminals and Connectors:** | | |
| | 1. Rated Mechanical Terminal Load: | | |
| | a) Static mechanical terminal loads: | | |
| | i) Straight load, N | | |
| | ii) Cross load, N | | |
| | b) External dynamic mechanical load, N | | |
| | c) Do the offered loads meet the specified requirements of Clause 6.3.3 of the Technical Specifications (Yes/No). | | |
| | 2. Manufacturer and type of terminal connectors. | | |
| | 3. Terminal connectors current rating, A. | | |
| | 4. Material of conducting parts. | | |
| | 5. Standard or streamlined connectors. | | |
| **6.3.2.11** | **Support Structures:** | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | Lattice type or Tubular | | |
| **6.3.2.12** | **Weights:** | | |
| | 1. Switch, single pole weights: | | |
| | (a) Live parts, kg. | | |
| | (b) Switch base with operating linkage, kg. | | |
| | (c) Net weight of power operated mechanism, kg: | | |
| | i) For disconnectors | | |
| | ii) For earthing switches | | |
| | (d) Net weight of manual operated mechanism, kg: | | |
| | i) For disconnectors | | |
| | ii) For earthing switches | | |
| | (e) Net weight of earthing switch, kg | | |
| | 2. Maximum shipping weight (heaviest item), kg | | |
| **6.3.2.13** | **Foundation Loading:** | | |
| | 1. Load that foundation should be designed for: (this figure is the sum of disconnector and earthing switch (where applicable) weight, plus impact, expressed in terms of static force). | | |
| | 2. Uplift that foundation should be designed for, kg. foundation, including those | | |
| **6.3.2.14** | **Miscellaneous:** | | |
| | 1. Append drawing of supports. (Yes/No) | | |
| | 2. Append construction detail drawing (Yes/No) | | |
| | 3. Append mechanism detailed drawing. (Yes/No) | | |
| | 4. Append list of type and routine tests to be performed at the factory. (Yes/No) | | |
| | 5. Append list of attached drawings, and documentation. (Yes/No) | | |
| **6.3.3** | **STEEL STRUCTURES:** | | |
| **6.3.3.1** | Structural Steel: | | |
| | 1. Type and standard specification number. | | |
| | 2. Manufacturer's name and country | | |
| | 3. Minimum yield strength, kg/mm2. | | |
| | 4. Ultimate tensile strength, kg/mm2. | | |
| **6.3.3.2** | **Bolts and Nuts:** | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | 1. Type and standard specification number. | | |
| | 2. Manufacturer's name and country | | |
| | 3. Minimum tensile strength of bolt and proof load on nuts of 16 mm diameter, kg. | | |
| | 4. Hardness of bolt material. | | |
| | a) Minimum | | |
| | b) Maximum. | | |
| **6.3.4** | **HIGH VOLTAGE BUS WORK:** | **132kV** | |
| **6.3.4.1** | **Switchyard Conductor:** | | |
| **6.3.4.1 .1** | **Tubular Conductors:** | | |
| | 1. Manufacturer's name and country | | |
| | 2. Type designation. | | |
| | 3. Inner dia, mm. | | |
| | 4. Outer dia, mm. | | |
| | 5. Rated continuous current, at 30 degree C temperature rise above an ambient temperature of 50 deg.C, A, rms. | | |
| | 6. Rated short time (1 sec.) current, A, rms. | | |
| | 7. Weight kg/m. | | |
| | 8. Moment of inertia, kgm2. | | |
| **6.3.4.1 .2** | **All Aluminum Conductor:** | | |
| | 1. Manufacturer's name and country | | |
| | 2. Conductor Type. | | |
| | 3. Conductor size, kilo circular mils (KCM). | | |
| | 4. Stranding: | | |
| | (a) Number of AL. wires. | | |
| | (b) Dia. of each wire, mm. | | |
| | 5. Overall conductor dia, mm. | | |
| | 6. Cross-sectional area, sq.mm. | | |
| | 7. Rated continuous current, A, rms. | | |
| | 8. Rated short time (1 sec.) current, A, rms. | | |
| | 9. Rated ultimate tensile strength, kN. | | |
| | 10. Mass, nominal, kg/m. | | |
| | 11. No. of conductors per bundle. | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | 12. Bundle configuration. | | |
| | 13. Bundle spacing. | | |
| **6.3.4.1 .3** | **Shield Wire:** | | |
| | 1. Manufacturer's name and country | | |
| | 2. Diameter of galvanized steel wire, mm. | | |
| | 3. Stranding: | | |
| | (a) Number of strands of wire. | | |
| | (b) Diameter of each strand, mm. | | |
| | 4. Grade of wire. | | |
| | 5. Weight of wire, kg/km. | | |
| | 6. Minimum breaking strength of wire, kN. | | |
| | 7. Weight of zinc coating, kg/sq.m of uncoated strand surface. | | |
| **6.3.4.2** | **Insulators:** | | |
| **6.3.4.2 .1** | **Station Post Type:** | | |
| | 1. Type | | |
| | 2. (a) Manufacturer's name and country | | |
| | (b) IEC Designation. | | |
| | 3. Insulator unit, length/height, mm. | | |
| | 4. No. of units in each insulator | | |
| | 5. Power frequency flashover, voltage, kV: | | |
| | (a) Dry. | | |
| | (b) Wet. | | |
| | 6. Impulse flashover, kV. | | |
| | (a) Positive. | | |
| | (b) Negative. | | |
| | 7. Power frequency withstand voltage, kV. | | |
| | (a) One minute dry. | | |
| | (b) 10 sec. wet. | | |
| | 8. Power frequency puncture voltage, kV. | | |
| | 9. Switching impulse withstand voltage, wet, kV, peak | | |
| | 10. Lightning impulse withstand voltage, kV, peak. | | |
| | 11. Radio interference voltage. | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | (a) Test, kV, rms. to ground. | | |
| | (b) Max. RIV at 1.1 x Ur//3 line to ground voltage, when tested as per IEC 694, micro volts | | |
| | 12. Leakage distance, mm | | |
| | 13. Mechanical values, Failing Load (minimum): | | |
| | (a) Cantilever strength, N | | |
| | (b) Tensile strength, N | | |
| | (c) Torsional strength Nm | | |
| | (d) Compressional strength, N | | |
| | (e) Impact strength Nm | | |
| **6.3.4.2.2** | **Suspension Type:** | | |
| | 1. Type. | | |
| | 2. Manufacturer's name and country | | |
| | 3. ANSI Class | | |
| | 4. Insulator unit, length, mm | | |
| | 5. No. of units in each string. | | |
| | 6. No. of insulator strings per conductor (at each end). | | |
| | 7. Dia of disc, mm. | | |
| | 8. Disc spacing, mm. | | |
| | 9. Power frequency flashover voltage, kV. | | |
| | (a) Dry. | | |
| | (b) Wet. | | |
| | 10. Critical impulse flashover 1.2x50 micro sec wave: | | |
| | (a) Positive, kV peak. | | |
| | (b) Negative, kV peak. | | |
| | 11. Power frequency withstand voltage, kV. | | |
| | (a) One minute dry. | | |
| | (b) 10 sec. wet. | | |
| | 12. Power frequency puncture voltage, kV. | | |
| | 13. Lightning impulse withstand voltage, kV. | | |
| | 14. Dry arcing distance, mm | | |
| | 15. Radio interference voltage: | | |
| | (a) Test, kV rms, to ground. | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | (b) Max. RIV at 1000 kHz, micro volts | | |
| | 16. Leakage distance, mm. | | |
| | 17. Mechanical values: 132kV | | |
| | (a) Tensile strength, N | | |
| | (b) Torsional strength, Nm | | |
| | (c) Compressional strength, N | | |
| | (d) Combined electrical and mechanical strength, N. | | |
| | (e) Impact strength, Nm | | |
| **6.3.4.3** | **Switchyard Connectors and Hardware:** | | |
| | 1. Manufacturer's name and country | | |
| | 2. Cast aluminum connectors: | | |
| | (a) Type/Grade of Alloy. | | |
| | (b) Specification No. | | |
| | 3. Bolts, nuts and washers' item (2) above: | | |
| | (a) Type/Grade of Alloy. | | |
| | (b) Specification No. | | |
| | 4. Cast aluminum bus clamps: | | |
| | (a) Type/Grade of Alloy. | | |
| | (b) Specification No. | | |
| | 5. Bolts, nuts and washers for item (3) above: | | |
| | (a) Type/Grade of Alloy. | | |
| | (b) Specification No. | | |
| | 6. Nonferrous (other than aluminum) connectors and bus clamps: | | |
| | (a) Type/Grade of Alloy. | | |
| | (b) Specification No. | | |
| | 7. Bolts, nuts and washers for item (5) above: | | |
| | (a) Type/Grade of Alloy. | | |
| | (b) Specification No. | | |
| | 8. AAC compression type dead end terminals: | | |
| | (a) Type/Grade of Alloy. | | |
| | (b) Specification No. | | |
| | 9. AAC conductor hardware, high strength cast aluminum: | | |
| | (a) Type/Grade of Alloy. | | |



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| Item | Description | Units | Value |
|---|---|---|---|
| | (b) Specification No. | | |
| | 10. Bolts, nuts and washers for AAC conductor hardware, high strength cast aluminum: | | |
| | (a) Type/Grade of Alloy. | | |
| | (b) Specification No. | | |
| | 11. AAC conductor hardware galvanized steel and malleable iron: | | |
| | (a) Type/Grade of Alloy. | | |
| | (b) Specification No. | | |
| | 12. Strain clamp for overhead shield wire: | | |
| | a) Type/material | | |
| | b) Ultimate strength, kg. | | |

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

| Item | Description | 132kV | |
|---|---|---|---|
| 6.3.5 | **CURRENT TRANSFORMERS** | **CT** | **SMS CT** |
| | 1. Type designation. | | |
| | 2. Manufacturer's name and country | | |
| | 3. Nominal system voltage, kV, rms. | | |
| | 4. Rated voltage for the equipment kV, rms. | | |
| | 5. Rated continuous overvoltage, kV, rms. | | |
| | 6. Rated frequency, Hz. | | |
| | 7. Rated primary current, A, rms. | | |
| | 8. Rated secondary current, A, rms. | | |
| | 9. Rated transformation ratios. | | |
| | 10. Rated output, VA of each secondary winding at the lowest taps. | | |
| | 11. Number of secondary cores and windings. | | |
| | 12. Protective Cores: | | |
| | (a) Rated equivalent limiting secondary e.m.f.(Ea1) [IEC, 446) | | |
| | (b) Accuracy class. | | |
| | (c) Accuracy limit factor | | |
| | 13. Measuring Core: | | |
| | (a) Accuracy class. | | |
| | (b) Instrument security factor | | |
| | 14. Short time (1 second) current rating: | | |
| | (a) Thermal, kA. | | |
| | (b) Dynamic, kA. | | |
| | 15. Rated lightning impulse withstand voltage, kV peak. | | |
| | 16. Rated switching impulse withstand voltage, kV peak. | | |
| | 17. Rated primary power frequency short time withstand voltage kV, rms. | | |
| | 18. Maximum temperature rise 132kV under specified service conditions above ambient of 50-degree C. | | |
| | 19. Design test certificate: | | |
| | (a) Issuing institute. | | |
| | (b) Number and date. | | |
| | 20. Earthquake withstand, g. | | |
| | 21. Creepage distance, mm. | | |



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| Item | Description | 132kV | |
|---|---|---|---|
| | 22. Max. RIV. at 1.1x Ur//3 line to ground, micro volts. | | |
| | 23. Weight per pole, kg. | | |
| **6.3.6** | **CAPACITOR VOLTAGE TRANSFORMERS:** | **CVT** | **SMS CVT** |
| | 1. Manufacturer's name and country | | |
| | 2. Type designation. | | |
| | 3. Nominal system voltage, kV, rms. | | |
| | 4. Rated voltage for the equipment kV, rms. | | |
| | 5. Rated continuous overvoltage, kV, rms. | | |
| | 6. Rated frequency, Hz. | | |
| | 7. Rated secondary voltage, V. | | |
| | 8. Rated transformation ratios. | | |
| | 9. Rated output at a power factor of 0.8 lagging, VA: | | |
| | a) Ist winding. | | |
| | b) 2nd winding. | | |
| | c) Total simultaneous burden. | | |
| | 10. Rated voltage factor | | |
| | 11. IEC accuracy class: | | |
| | a) Ist winding. | | |
| | b) 2nd winding. | | |
| | 12. Rated coupling capacitance, pf. | | |
| | 13. Rated lightning impulse withstand voltage, kV peak. | | |
| | 14. One minute, power frequency withstands voltage kV, rms. | | |
| | 15. Rated switching impulse withstand voltage, kV peak. | | |
| | 16. Variation of capacitance, + %. | | |
| | 17. Low terminal: | | |
| | a) Stray capacitance at any frequency in the carrier frequency range 30 kHz 500 kHz, pF. | | |
| | b) Stray conductance at any frequency in the carrier frequency range 30 kHz 500 132 kV 132 kV kHz, micromhos. | | |
| | 18. Insertion loss of the carrier drain coil over the carrier frequency range 30 kHz 500 kHz with Z = 300 ohms, dB. | | |
| | 19. Voltage drop across the carrier drain coil at 50 Hz and 550 kV, rms. | | |



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| Item | Description | 132kV | |
|---|---|---|---|
| | 20. Minimum rated lightning impulse insulation level of the carrier drain coil, kV, peak. | | |
| | 21. Carrier protective gap sparkover, kV peak. | | |
| | 22. Drain coil: | | |
| | a) Inductance, mH. | | |
| | b) D.C. resistance, ohms. | | |
| | c) Impedance in the range 30 kHz 500 kHz, kohms. | | |
| | d) Maximum continuous current at 50 Hz, Amps, rms. | | |
| | 23. Design test certificate: | | |
| | a) Issuing institute. | | |
| | b) Number and date. | | |
| | 24. Creepage distance, mm. | | |
| | 25. Maximum temperature rise under specified service conditions above an ambient of 50, deg. C. | | |
| | 26. Maximum RIV, at 1.1 x Ur//3 line to ground voltage and 1 MHz, micro volts. | | |
| | 27. Weight per pole, Kg. | | |
| **6.3.7** | **SURGE ARRESTERS:** | **132kV (198kV)** | |
| **6.3.7.1** | **General** | | |
| | 1. Type designation | | |
| | 2. Manufacturer's name and country | | |
| | 3. Catalog number. | | |
| | 4. Classification | | |
| **6.3.7.2** | **Main Ratings:** | | |
| | 1. Nominal System Voltage, kV, rms. | | |
| | 2. Rated frequency, Hz. | | |
| | 3. Arrester rated voltage (Ur) kV, rms. | | |
| | 4. Maximum continuous operating voltage, kV, rms | | |
| | 5. Standard nominal discharge current kA, peak | | |
| | 6. Maximum ambient temperature | | |
| | 7. 7. maximum residual voltage, kV, peak:<br>At 20 KA discharge for:<br>(a) Steep current impulse (1x20 micro sec.) at 20kA/10kA.<br>(b) Lightning current impulse (8x20 micro sec.) | | |



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| Item | Description | 132kV |
|---|---|---|
| | i) at 2.5 kA<br>ii) at 5 kA<br>iii) at 10 kA<br>iv) at 20 kA<br>(c) Switching current impulse (30/60 microsec.) at A | |
| | 8. Energy dissipation capability, kJ/kV. | |
| | 9. Maximum external (RIV) at 1.1x Ur//3 line to ground voltage including connectors, micro V. | |
| | 1. 10. Maximum internal partial discharges at, 50Hz voltage, PC at:<br>(a) 1.05 x continuous operating voltage.<br>(b) 1.234 x continuous operating voltage. | |
| | 11. Thermal capability to discharge a line of km, With a surge impedance of ohms (With a 2.77 p.u. charge voltage). | |
| | 12. Line discharge class | |
| **6.3.7.3** | **External Insulation** | |
| | 1. Lightning impulse voltage withstand, kV, peak. | |
| | 2. Switching impulse voltage, withstand, kV, peak. | |
| | 3. Power frequency voltage withstand, kV, rms. | |
| | 4. Minimum creepage distance, mm. | |
| **6.3.8** | **Protective Relays** | |
| **6.3.8.1** | **Transmission Line Protection:** | |
| **6.3.8.1.1** | Line Distance Protection Set-I (132kV) | |
| | 1. Type | |
| | 2. Manufacturer's name and country | |
| | 3. Test certificate | |
| | (a) Issuing Institution | |
| | (b) Number and date | |
| | 4. Rated voltage, V | |
| | 5. Rated current, A | |
| | 6. Frequency, Hz | |
| | 7. Permissible continuous current, A | |
| | 8. Thermal short time (1 sec.) current rating, A. | |
| | 9. Burden of current circuit, VA | |
| | 10. Burden of voltage circuit, VA | |
| | 11. Auxiliary voltage, (D.C),V | |



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| Item | Description | 132kV |
|---|---|---|
| | 12. Tolerance in auxiliary, voltage %, (+). | |
| | 13. Consumption of D.C. auxiliary circuits: | |
| | (a) During normal conditions, watts. | |
| | (b) During short circuit, watts | |
| | 14. Settings, range available for starting, unit: | |
| | (a) Ground faults, ohms/phase | |
| | (b) Phase faults ohms/phase | |
| | 15. Setting range available for measuring unit: | |
| | (a) Ground faults, ohms/phase | |
| | (b) Phase faults ohms/phase | |
| | 16. Directional Sensitivity: | |
| | (a) For two phase and earth faults, mV | |
| | (b) For three phase faults when memory has expired, mV | |
| | 17. Time Steps: | |
| | (a) Number of steps. | |
| | (b) Basic step (minimum time), msec. | |
| | (c) Setting ranges: | |
| | 2nd step, msec. | |
| | 3rd step, msec. | |
| | 4th step, msec. | |
| | 18. Contact data, append complete contact data for signaling and tripping. | |
| | 19. Are the following modules included in the scheme offered? | |
| | (a)Power swing blocking module,(Yes/No) | |
| | (b) Carrier interface module, yes/No? | |
| | (c) Any additional module for starting or measuring systems. | |
| | 20. List any module additional to the main scheme offered by the tenderer to provide the characteristics as specified. | |
| | 21. Operating temperature range, °C. | |
| | 22. Insulation test voltage and duration. | |
| | 23. Tele protection: | |
| | Relay able to work with, and equipment included for following schemes. | |



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| Item | Description | 132kV |
|---|---|---|
| | (a) Permissive underreach (Yes/No) | |
| | (b) Permissive overreach (Yes/No) | |
| | (c) Permissive transferred acceleration blocking. (Yes/No) | |
| | (d) Blocking (Yes/No) | |
| | (e) Unblocking (Yes/No) | |
| **6.3.8.1.2** | **Auto Reclosing Scheme:** | |
| | 1. Manufacturer's name and country | |
| | 2. Type | |
| | 3. Able to Perform: | |
| | (a) Single pole, reclosing (Yes/No) | |
| | (b) Three pole, reclosing (Yes/No) | |
| | (c) Single and three pole reclosing (Yes/No) | |
| | (d) Multi shot reclosing (Yes/No) | |
| | 4. Time delay range for dead time: | |
| | (a) Single pole, reclosing (Yes/No) | |
| | (b) Three pole, reclosing (Yes/No) | |
| | 5. Reclaim time range, sec. | |
| | 6. Counter included. (Yes/No) | |
| **6.3.8.1.3** | **Fault Locator**: | |
| | 1. Type | |
| | 2. Manufacturer's name and country | |
| | 3. Measurement system | |
| | 4. Display | |
| | 5. Printer (Yes/No) | |
| | 6. Recording method | |
| | 7. Accuracy | |
| | 8. Remote Output type. | |
| **6.3.8.1.4** | **Differential Protection set- II (132kV):** | |
| | 1. Type | |
| | 2. Manufacturer's name and country | |
| | 3. Test certificate: | |
| | i) Issuing Institution | |
| | ii) Number and date | |



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| Item | Description | 132kV |
|---|---|---|
| | 4. Rated voltage, V | |
| | 5. Rated current, A | |
| | 6. Frequency, Hz | |
| | 7. Permissible continuous current, A | |
| | 8. Thermal short time (1 sec.) current rating, A. | |
| | 9. Burden of current circuit, VA | |
| | 10. Burden of voltage circuit, VA | |
| | 11. Auxiliary voltage, (D.C), V | |
| | 12. Tolerance in auxiliary, voltage %, (+). | |
| | 13. Consumption of D.C. auxiliary circuits: | |
| | (a) During normal conditions, watts. | |
| | (b) During short circuit, watts. | |
| | 14. Settings, range available for starting unit: | |
| | (a) Ground faults, ohms/phase | |
| | (b) Phase faults ohms/phase | |
| | 15. Setting range available for measuring unit: | |
| | (a) Ground fault, ohms/phase | |
| | (b) Phase fault, ohms/phase | |
| | 16. Directional Sensitivity: | |
| | (a) For two phase and earth faults, mV | |
| | (b) For three phase faults when memory has expired, mV | |
| | 17. Time Steps: | |
| | (a) Number | |
| | (b) Setting ranges. | |
| | Basic step (minimum time), msec. | |
| | 2nd step, msec. | |
| | 3rd step, msec. | |
| | 4th step, msec. | |
| | 18. Contact data, append complete contact data for signaling and tripping. | |
| | 19. Are the following modules included in the scheme offered:<br>(a) Power swing blocking module, (Yes/No)<br>(b) Carrier interface module, (Yes/No) | |



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| Item | Description | 132kV |
|---|---|---|
| | (c) Any additional module for starting or measuring systems. | |
| | 20. List any module additional to the main scheme offered by the tenderer to provide the characteristics as specified. | |
| | 21. Operating temperature range, deg. C. | |
| | 22. Insulation test voltage and duration | |
| | 23. Available modes of operation:<br>(a) Directional comparison blocking, (Yes/No)<br>(b) Permissive underreach transfer tripping, (Yes/No)<br>(c) Permissive overreach transfer tripping, (Yes/No)<br>(d) Stage acceleration (Yes/No) | |
| **6.3.8.1.5** | **Line Overcurrent Protection:** | |
| | 1. Manufacturer's name and country | |
| | 2. Type designation | |
| | 3. DC infeed. | |
| | . Independent DC/DC converter | |
| | included. (Yes/No) | |
| | . Tolerances Idc%. | |
| | . Rated voltage. V. | |
| | . Overload protection (Yes/No) | |
| | . Short circuit Protection (Yes/No) | |
| | . Power consumption at: | |
| | (a) Normal operation VA | |
| | (b) Fault VA | |
| | 4. Relay burden at 3 times minimum operating current, VA | |
| | 5. Operating characteristics | |
| | . Definite time (Yes/No) | |
| | . IDMT (Yes/No) | |
| | 6. Instantaneous element (Yes/No) | |
| | included. | |
| | 7. Current setting range: | |



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| Item | Description | 132kV |
|---|---|---|
| | . Phase elements. | |
| | . Earth element. | |
| | . Instantaneous element. | |
| | 8. Operating time: | |
| | . Minimum operating time sec. | |
| | . Time setting range. | |
| | 9. Pickup to drop-off ratio. | |
| **6.3.8.1.6** | **Voltage Relays:(if used)** | |
| | (a) Definite time over voltage relays: | |
| | Manufacturer's name and country | |
| | Type | |
| | Setting range, volts | |
| | Minimum pick up, time, ms | |
| | Maximum reset, time, ms. | |
| | pickup to drop-off ratio % | |
| | (b) Inverse time over voltage relays: | |
| | Manufacturer's name and country | |
| | Type | |
| | Setting range, volts. | |
| | Voltage/time Setting range % | |
| | Pickup drop of ratio % | |
| **6.3.8.2** | **Power Transformer Protection** | |
| **6.3.8.2.1** | **Numerical Differential Relay Main- I:** | |
| | a) Manufacturer's name and country | |
| | b) Type designation | |
| | c) Setting range, A. | |
| | d) Bias setting range, % or time setting range, sec. | |
| **6.3.8.2.2** | **Restricted Earth Fault** | |
| | a) Manufacturer's name and country | |
| | b) Type designation | |
| | c) Setting range | |
| **6.3.8.2.3** | **IDMT Over Current Protection** | |
| | a) For phase faults complete, HV and LV sides. | |



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| Item | Description | 132kV |
|---|---|---|
| | 1. Manufacturer's name and country | |
| | 2. Type designation | |
| | b) For ground faults complete, HV and LV sides. | |
| | 1. Manufacturer's name and country | |
| | 2. Type designation | |
| | c) For ground faults complete, neutral: | |
| | 1. Manufacturer's name and country | |
| | 2. Type designation | |
| **6.3.8.3** | **Busbar Protection as Specified Protection Complete:** | |
| | 1. Manufacturer's name and country | |
| | 2. Type designation | |
| **6.3.8.4** | **Breaker Failure Protection Complete:** | |
| | 1. Manufacturer's name and country | |
| | 2. Type designation | |
| **6.3.8.5** | **Synchronizing Check Scheme Complete:** | |
| | 1. Manufacturer's name and country | |
| | 2. Type designation | |
| **6.3.8.6** | **Lockout Relays:** | |
| | 1. Manufacturer's name and country | |
| | 2. Type designation | |
| **6.3.8.7** | **Tripping Relays:** | |
| | 1. Manufacturer's name and country | |
| | 2. Type designation | |
| | 3. Pickup time, m sec | |
| **6.3.8.8** | **Panel Wiring:** | |
| | 1. Voltage rating | |
| | 2. Size | |
| | 3. Type of insulation | |
| **6.3.8.9** | **Auxiliary Relays & Contactors:** | |
| | 1. Self-reset | |
| | (a) Manufacturer's name and country | |
| | (b) Type designation | |
| | 2. Manual reset | |



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| Item | Description | 132kV |
|---|---|---|
| | (a) Manufacturer's name and country | |
| | (b) Type designation | |
| | 3. Time Delay | |
| | (a) Manufacturer's name and country | |
| | (b) Type designation | |
| | 4. Tripping | |
| | (a) Manufacturer's name and country | |
| | (b) Type designation | |
| **6.3.8.10** | **Other Miscellaneous Relays: (Proposer to provide list)** | |

| Item | Description | | |
|---|---|---|---|
| **6.3.9** | **CONTROL AND POWER CABLES:** | **132kV** | |
| **6.3.9.1** | **Control cables (600/1000V) for Protection, Control, Measurement and Annunciations:** | | |
| | 1. Type designation. | | |
| | 2. Manufacturer's name and country | | |
| | 3. Standard to which manufactured. | | |
| | 4. Test certificate. | | |
| | (a) Issuing Institute. | | |
| | (b) Number and date. | | |
| | 5. Conductor material. | | |
| | 6. Insulation material. | | |
| | 7. Shielding material and thickness. | | |
| | 8. Armoring material and thickness | | |
| | 9. Maximum operating temperature, deg C. | | |
| | 10. A.C. test withstand voltage level for 5 minutes, kV. | | |
| | 11. D.C.test withstand voltage level for 5 minutes, kV. | | |
| | 12. Cable identification tag material. | | |
| | 13. Wire identification tag type/material. | | |
| **6.3.9.2** | **Power Cables** | **8.7/15kV Power Cables** | **600/1000V Small Power Cables** |



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| Item | Description | | |
|---|---|---|---|
| | 1. Type designation | | |
| | 2. Manufacturer's name and country | | |
| | 3. Standard to which manufactured | | |
| | 4. Test certificates: | | |
| | (a) Issuing Institute. | | |
| | (b) Number and date. | | |
| | 5. Maximum allowable conductor temperature. | | |
| | (a) At continuous operation. | | |
| | (b) Under short circuit conditions. | | |
| | 6. Conductor material (No of strands/diameter of each strands) | | |
| | 7. Insulation material. | | |
| | 8. Sheath material | | |
| | 9. Screening material | | |
| | 10. Armoring material and thickness | | |
| | 11. A.C. test withstand voltage level for 5 minutes, kV. | | |
| | 12. D.C. test withstand voltage level for 4 minutes, kV. | | |
| | 13. Cable identification tag material. | | |
| | 14. Wire identification tag type/material. | | |
| | 15. D.C resistance at 20 deg C | | |
| | 16. A.C resistance at 80 deg C | | |
| **6.3.10** | **Grounding System:** | | |
| **6.3.10.1** | 1. Earthing Conductor/Cable: | | |
| | (a) Type and specification number. | | |
| | (b) Manufacturer's name and country | | |
| | (c) Size, sq.mm. | | |
| | (d) Dia of conductor, mm. | | |
| | (e) Total length of the conductor used. | | |
| | 3. Connectors: | | |
| | (a) Type and specification number. | | |
| | (b) Manufacturer's name and country | | |
| | (c) Alloy. | | |
| | (d) Material of bolts. | | |



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| Item | Description | |
|---|---|---|
| **6.3.11** | **A.C/D.C AUXILIARY SUPPLIES:** | **132kV** |
| **6.3.11.1** | **220 Volts D.C. System: 220V DC** | **220V DC** |
| **6.3.11.1.1** | **General:** | |
| | 1. Nominal system voltage. | |
| | 2. System voltage under float charge conditions. | |
| | 3. System voltage under boost charge conditions. | |
| **6.3.11.1.2** | **Batteries:** | |
| | 1. Type. | |
| | 2. Manufacturer's name and country | |
| | 3. Cells. | |
| | a) Type | |
| | b) Number | |
| | 4. Rated capacity at 10 hour rate and 25 deg. C. ambient temperature, AH. | |
| | 5. Percentage of rated capacity available, AH. | |
| | a) at 0 deg. C ambient temp. | |
| | b) at 50 deg. C. ambient temp. | |
| | 6. Cell voltage, V. | |
| | a) Nominal. | |
| | b) On floating charge. | |
| | c) On boost charge. | |
| | 7. Short circuit current, amp. dc. | |
| | 8. Recommended range of temperature for normal operation, deg. C. | |
| | 9. Type of anode. | |
| | 10. Type of cathode. | |
| | 11. Type of container. | |
| | 12. Weight of cell with electrolyte, Kg. | |
| | 13. Expected life for specified service, years. | |
| | 14. Material of racks. | |
| | 15. Overall dimensions of rack with the cells in place, cm. | |
| | 16. Weight of rack, Kg. | |
| | 17. Total weight of battery, Kg. | |
| **6.3.11.1.3** | **Battery Chargers:** | |



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| Item | Description | |
|---|---|---|
| | 1. Manufacturer's name and country | |
| | 2. Type designation. | |
| | 3. AC input voltage, V, rms. | |
| | 4. Tolerance for variation in input voltage, +%. | |
| | 5. Rated frequency of input voltage, Hz. | |
| | 6. Tolerance in frequency, %. | |
| | 7. Input current at max. DC output, Amps. rms. | |
| | 8. Output voltage, V, DC. | |
| | 9. Output voltage setting range, volts, DC. | |
| | 10. Variation in output voltage for output current variation from 0 to maximum. | |
| | 11. Rated continuous output current at 50 deg. C., Amps. DC. | |
| | 12. Rated short time current (3 sec.), Amps., DC. | |
| | 13. Time to charge a fully discharged battery, Hr. | |
| | 14. Type of bridge rectifier. | |
| | 15. Circuit breaker for AC input provided (Yes/No). | |
| | 16. Circuit breaker for DC output provided (Yes/No). | |
| | 17. AC voltmeter: | |
| | a) Manufacturer's name and country | |
| | b) Type designation. | |
| | c) Indication range, V, rms. | |
| | 18. AC ammeter: | |
| | a) Manufacturer's name and country | |
| | b) Type designation. | |
| | c) Indication range, Amps., rms. | |
| | 19. DC voltmeter: | |
| | a) Manufacturer's name and country | |
| | b) Type designation. | |
| | c) Indication range, volts. | |
| | 20. DC ammeter: | |
| | a) Manufacturer's name and country | |
| | b) Type designation. | |
| | c) Indication range, Amps. | |



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| Item | Description | |
|---|---|---|
| | 21. Dimensions of chargers (mm x mm x mm). | |
| | 22. Weight, Kg. | |
| **6.3.11.1.4** | **D.C. Distribution Boards:** | |
| | **1. Manufacturer's name and country** | |
| | **2. Type.** | |
| | **3. Applied Standard.** | |
| | **4. Dimensions(maximum).** | |
| | (a) Width, mm. | |
| | (b) Depth, mm. | |
| | (c) Height, mm. | |
| | (d) Weight, Kg. | |
| | **5. Bus Bars:** | |
| | (a) Continuous current rating, Amp. | |
| | (b) Short time (3 sec.) current rating, Amps. | |
| | (c) Material. | |
| | **6. Incoming breakers:** | |
| | (a) Manufacturer's name and country | |
| | (b) Type. | |
| | (c) Rated voltage, V. | |
| | (d) Breaking capacity, kA. | |
| | (e) Continuous rated current, Amps. | |
| | **7. Outgoing breakers:** | |
| | (a) Manufacturer's name and country | |
| | (b) Type. | |
| | (c) Rated voltage, V. | |
| | (d) Breaking capacity, kA. | |
| | (e) Continuous rated current, Amps. | |
| | (f) Thermal release. | |
| | (g) Magnetic release. | |
| | 8. Ground fault detection relay: | |
| | (a) Manufacturer's name and country | |
| | (b) Type designation. | |
| | 9. Relay to indicate battery discharge: | |



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| Item | Description | |
|---|---|---|
| | (a) Manufacturer's name and country | |
| | (b) Type designation. | |
| | 10. Under voltage relay: | |
| | (a) Manufacturer's name and country | |
| | (b) Type designation. | |
| | 11.DC Voltmeter: | |
| | (a) Manufacturer's name and country | |
| | (b) Type designation. | |
| | (c) Indication range, V, DC. | |
| | 12. DC Ammeter: | |
| | (a) Manufacturer's name and country | |
| | (b) Type designation. | |
| | (c) Indication range, Amps, DC. | |
| **6.3.11.2** | **400 Volts A.C. Distribution Boards:** | |
| | **1. Manufacturer's name and country** | |
| | **2. Type/Cat. No.** | |
| | **3. Applied Standards.** | |
| | **4. Dimensions (per switchgear panel).** | |
| | (a) Width, mm. | |
| | (b) Depth, mm. | |
| | (c) Height, mm. | |
| | (d) Weight, Kg. | |
| | **5. Bus Bars** | |
| | (a) Continuous current rating, Amp. | |
| | (b) Short time (3 sec.) current rating, Amps. | |
| | (c) Material. | |
| | **6. Circuit Breaker** | **Outgoing** |
| | (a) Type. | |
| | (b) Manufacturer's name and country | |
| | (c) Continuous rated current, A, rms. | |
| | (d) Voltage rating, kV, rms. | |
| | (e) Frequency, Hz. | |
| | (f) Breaking current. Symmetrical, kA rms. | |



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| Item | Description | |
|---|---|---|
| | (g) Making current, kA, rms. | |
| | (h) Power frequency withstand level, kV, rms. | |
| | (i) Operating duty. | |
| | (j) Closing time, msec. | |
| | (k) Opening time, msec. | |
| | (l) Rated control voltage. | |
| | (m) Method(s) of closing. | |
| | (n) Method(s) of opening. | |
| | (o) Inverse time thermal release(s) | |
| | (p) Time delays magnetic release(s). | |
| | (q) Instantaneous magnetic release(s). | |
| | (r) No volt release(s). | |
| | (s) Type of indications. | |
| | (t) Design test certificate. | |
| | Issuing institute. | |
| | Number and date. | |
| | **7. Current Transformer** | |
| | Manufacturer | |
| | (a) Type. | |
| | (b) Manufacturer's name and country | |
| | (c) Rated voltage, kV. | |
| | (d) Rated nominal current ratios. | |
| | (e) Rated output per phase, VA. | |
| | (f) Accuracy class. | |
| | Protective core. | |
| | Measuring core. | |
| | (g) Accuracy limit factor. | |
| | (h) Short time current rating, kA rms. | |
| | Thermal | |
| | Dynamic. | |
| | (i) Power frequency withstand, voltage, kV, rms. | |
| | (j) Design test certificate. | |
| | Issuing institute. | |



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| Item | Description | |
|---|---|---|
| | Number and date. | |
| | **8. Instruments & Controls** | |
| | (a) Ammeter. | |
| | (b) Voltmeter. | |
| | (c) Watthour meter. | |
| | (d) Synchronoscope. | |
| | (e) Ammeter selector switch. | |
| | (f) Voltmeter selector switch. | |
| | (g) Control switch. | |
| | (h) Indicating lights/alarms. | |
| | (i) Test switches. | |
| | (j) Terminal blocks. | |
| | 9. 600/1000 V Cables. | |
| | (a) Manufacturer's name and country | |
| | (b) Type. | |
| | (c) Reactance at 25 deg.C, mH/km. | |
| | (d) Resistance at 25 deg. C, ohm/km. | |
| | 10. Auxiliary relays. | |
| | (a) Self reset. | |
| | (b) Manual reset. | |
| | (c) Time delay. | |
| | (d) Timing relays. | |
| | (e) Tripping units. | |
| **6.3.11.3** | **A.C. EMERGENCY DIESEL GENERATING SET:** | |
| **6.3.11.3.1** | **Diesel Engine:** | |
| | 1. Manufacturer's name and country | |
| | 2. Model. | |
| | 3. Number of cylinders. | |
| | 4. Bore (mm). | |
| | 5. Stroke (mm) | |
| | 6. Piston Speed | |
| | 7. Compression ratio. | |
| | 8. Horse Power (maximum HP). | |



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| Item | Description | |
|---|---|---|
| | 9. Fuel consumption (100% load) (ltr/hr). | |
| | 10. Fuel consumption (75% load) (ltr/hr). | |
| | 11. Lubrication system nominal oil pressure (kg/cm2) | |
| | 12. Lubrication system minimum oil pressure oil pressure (kg/cm2) | |
| | 13. Lubricating oil Sump capacity (ltr). | |
| | 14. Radiator capacity. | |
| | 15. Combustion air intake at 50 Hz 9 cm3) | |
| | 16. Engine heat radiation (K cal/min.). | |
| | 17. Exhaust gas temperature at manifold, deg. C. | |
| | 18. Exhaust gas rate (ltr/sec.) | |
| | 19. Starting system voltage (v). | |
| **6.3.11.3.2** | **Generator:** | |
| | 1. Manufacturer's name and country | |
| | 2. Type designation | |
| | 3. Generator power output. | |
| | 4. Time delay | |
| | i) Manufacturer's name and country | |
| | ii) Type designation | |
| | 5. Timing. | |
| | i) Manufacturer's name and country | |
| | ii) Type designation | |
| | 6. Tripping | |
| | i) Manufacturer's name and country | |
| | ii) Type designation | |
| | iii) Other miscellaneous relays. (Proposer to provide list) | |



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WATER AND POWER DEVELOPMENT AUTHORITY
PAKISTAN

# ENGINEERING, PROCUREMENT AND CONSTRUCTION (EPC) OF ATTABAD LAKE HYDROPOWER PROJECT (54 MW)
# PACKAGE-III: ELECTRO-MECHANICAL WORKS

## VOLUME-II: EMPLOYER'S REQUIREMENTS

### PART-III: CONCEPTUAL DRAWINGS

AHMC ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

NESPAK · PES · DOLSAR ENGINEERING

MAY 2026

BOOK 4

DOCUMENT NO: BD-ALHPP-03 (V2 CD)

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# CONSTRUCTION OF
# ATTABAD LAKE HYDROPOWER PROJECT (54 MW)
# PACKAGE-III: ELECTRO-MECHANICAL WORKS

## INDEX TO BIDDING DOCUMENTS


VOLUME-I: BIDDING PROCEDURES AND CONDITIONS OF CONTRACT

Part-I: Bidding Procedures

Part-II: Conditions of Contract and Standard Forms

VOLUME-II: EMPLOYER'S REQUIREMENTS

Part-I: Specific Provisions

Part-II: Technical Provisions

Part-III: Conceptual Drawings

VOLUME-III: ADDITIONAL INFORMATION

Part-I: Feasibility Study Report (2021)

Part-II: Feasibility Review Report (2022)

Part-III: Topographic Survey Map Book (2023)

Part-IV: Updated Environmental Impact Assessment (EIA) Report (2023)





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# EPC BIDDING DOCUMENTS OF
# ATTABAD LAKE HYDROPOWER PROJECT (54 MW)
# PACKAGE-III: ELECTRO-MECHANICAL WORKS
# LIST OF DRAWINGS

| Sr.NO. | TITLE OF DRAWINGS | DRAWING NO. |
|---|---|---|
| | A- GENERAL DRAWINGS | |
| 1 | LIST OF DRAWINGS | ALHPP-LD-0000 |
| 2 | PROJECT LOCATION MAP | ALHPP-GN-0101 |
| 3 | PROJECT AREA ACCESSIBILITY MAP | ALHPP-GN-0102 |
| 4 | REGIONAL MAP OF NORTHERN AREA | ALHPP-GN-0103 |
| 5 | CATCHMENT AREA MAP | ALHPP-GN-0104 |
| 6 | PROJECT VICINITY MAP | ALHPP-GN-0105 |
| | B- PROJECT LAYOUT | |
| 7 | PROJECT LAYOUT | ALHPP-LAY-0201 |
| | C- POWER HOUSE | |
| 8 | POWER HOUSE LAYOUT | ALHPP-PH-0301 |
| 9 | POWER HOUSE PLAN AT EL: 2299.25 | ALHPP-PH-0302 |
| 10 | POWER HOUSE PLAN AT EL: 2301.85 | ALHPP-PH-0303 |
| 11 | POWER HOUSE PLAN AT EL: 2308.00 | ALHPP-PH-0304 |
| 12 | POWER HOUSE PLAN AT EL: 2313.30 | ALHPP-PH-0305 |
| 13 | POWER HOUSE SECTION A-A | ALHPP-PH-0306 |
| 14 | POWER HOUSE SECTION B-B | ALHPP-PH-0307 |
| | D- HYDRAULIC STEEL STRUCTURES | |
| 15 | POWER AND FLUSHING INTAKE LAYOUT PLAN AT EL.2425.00 | ALHPP-HSS-0401 |
| 16 | FLUSHING TUNNEL GATE SHAFT ARRANGEMENT | ALHPP-HSS-0402 |
| 17 | FLUSHING TUNNEL SERVICE & GUARD GATE ARRANGEMENT | ALHPP-HSS-0403 |
| 18 | FLUSHING TUNNEL STOPLOG ARRANGEMENT | ALHPP-HSS-0404 |
| 19 | POWER INTAKE EMERGENCY GATE & STOPLOG ARRANGEMENT | ALHPP-HSS-0405 |
| 20 | POWER INTAKE EMERGENCY GATE ARRANGEMENT | ALHPP-HSS-0406 |
| 21 | POWER INTAKE STOPLOG ARRANGEMENT | ALHPP-HSS-0407 |
| 22 | POWER INTAKE TRASHRACK ARRANGEMENT | ALHPP-HSS-0408 |
| 23 | POWERHOUSE DRAFT TUBE GATE ARRANGEMENT | ALHPP-HSS-0409 |
| | E- POWERPLANT ELECTRICAL | |
| 24 | MAIN SINGLE LINE DIAGRAM | ALHPP-PPE-0501 |
| 25 | AC SUPPLY SYSTEM | ALHPP-PPE-0502 |
| 26 | POWER HOUSE AC LV SUPPLY SYSTEM | ALHPP-PPE-0503 |
| 27 | POWER HOUSE DC SUPPLY SYSTEM | ALHPP-PPE-0504 |
| 28 | POWER INTAKE DC SUPPLY SYSTEM | ALHPP-PPE-0505 |
| 29 | PCS CONCEPTUAL LAYOUT | ALHPP-PPE-0506 |
| 30 | PROTECTION SCHEMES | ALHPP-PPE-0507 |
| | F- SWITCHYARD ELECTRICAL | |
| 31 | 132 kV SWITCHYARD SINGLE LINE DIAGRAM | ALHPP-SY-0601 |
| 32 | 132 kV SWITCHYARD EQUIPMENT ARRANGEMENT PLAN | ALHPP-SY-0602 |
| 33 | 132 kV SWITCHYARD AC AUXILIARY SERVICES SYSTEM (TYPICAL) | ALHPP-SY-0603 |
| 34 | 110V DC (FOR 132kV SWITCHYARD) AUXILIARY SERVICES SYSTEM (TYPICAL) | ALHPP-SY-0604 |
| 35 | 132kV SWITCHYARD CONTROL HOUSE BUILDING LAYOUT PLAN | ALHPP-SY-0605 |
| 36 | PROTECTION & METERING SYSTEM 132kV SINGLE LINE DIAGRAM | ALHPP-SY-0606 |
| 37 | PROTECTION & METERING SYSTEM 132kV POWER TRANSFORMER SINGLE LINE DIAGRAM | ALHPP-SY-0607 |
| | G-TELECOM (SCADA) | |
| 38 | 132kV SWITCHYARD 48V DC SYSTEM | ALHPP-TC-0701 |
| 39 | 132kV SWITCHYARD TELECOMMUNICATION NETWORK LAYOUT | ALHPP-TC-0702 |
| 40 | 132kV SWITCHYARD SCADA SYSTEM | ALHPP-TC-0703 |
| 41 | 132kV SWITCHYARD FIBER OPTIC SYSTEM | ALHPP-TC-0704 |

CLIENT:
PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT:
ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT:
AHMC ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS
JOINT VENTURE OF:
NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)
ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD.
PAKISTAN ENGINEERING SERVICES (PVT.) LTD.
BARQAAB CONSULTING SERVICES (PVT.) LTD.
DOLSAR ENGINEERING INC.CO.

| REV. | DATE | DESCRIPTION | APPROVED |
|---|---|---|---|
| 04 | | | |
| 03 | | | |
| 02 | | | |
| 01 | | | |

| | |
|---|---|
| DRAWN | ASIF SAMI |
| RECOMMENDED | - |
| CHD./VER. | - |
| APPROVED | - |

LIST OF DRAWINGS

SCALE: AS SHOWN

DATE : MARCH, 2026

DRAWING No. ALHPP-LD-0000

REV. 0

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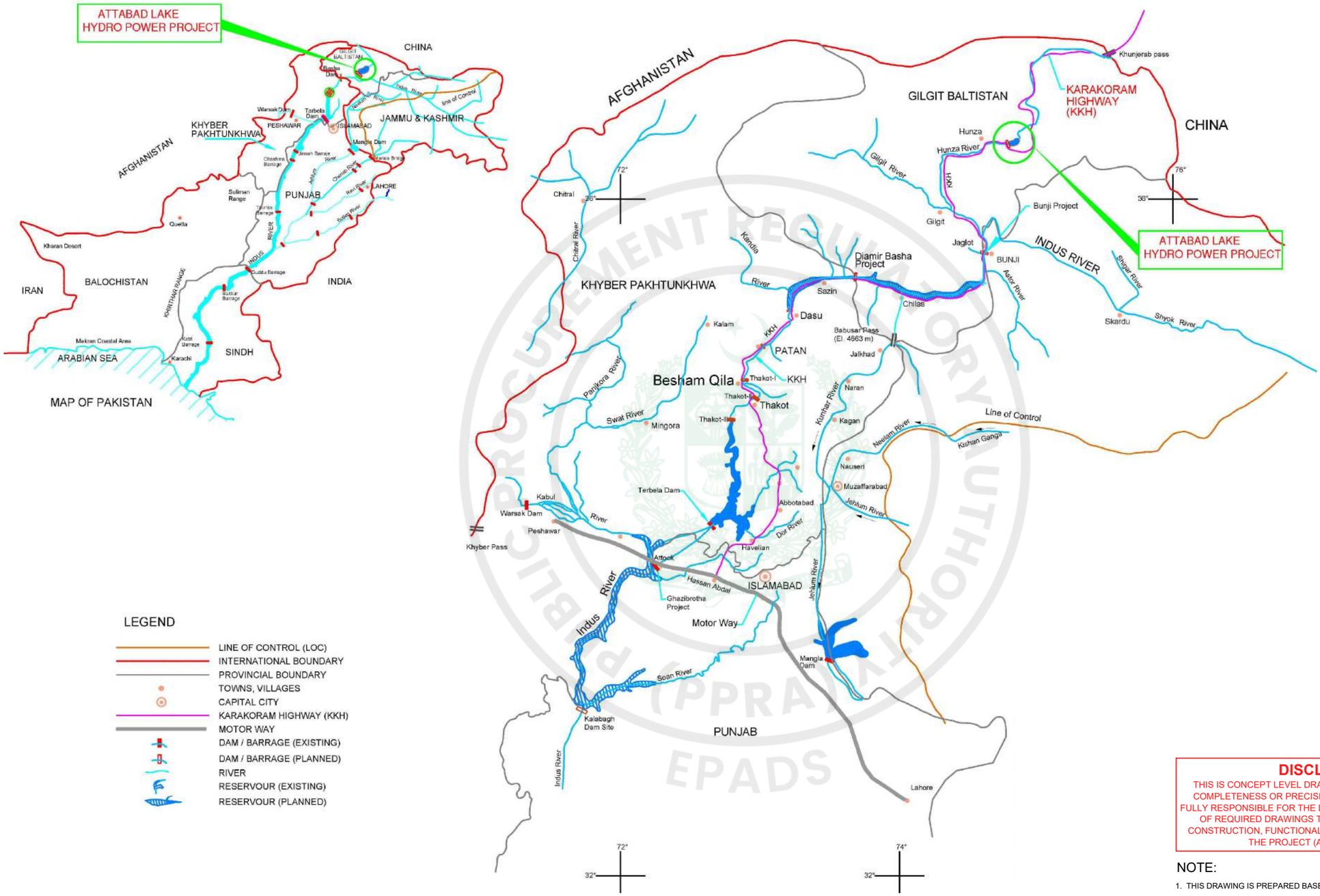
PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

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NOTE:

1. THIS DRAWING IS PREPARED BASED ON FEASIBILITY DRAWING NO. AFS-GN-101.

CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF:
NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)
ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD.
BARQAAB CONSULTING SERVICES (PVT.) LTD.
PAKISTAN ENGINEERING SERVICES (PVT.) LTD.
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| REV. | DATE | DESCRIPTION | APPROVED |
|---|---|---|---|
| 04 | | | |
| 03 | | | |
| 02 | | | |
| 01 | | | |

| | |
|---|---|
| DRAWN | ASIF SAMI |
| RECOMMENDED | - |
| CHD./VER. | - |
| APPROVED | - |

**PROJECT LOCATION MAP**

SCALE: AS SHOWN

DATE : MARCH, 2026

DRAWING No. ALHPP-GN-0101

REV. 0

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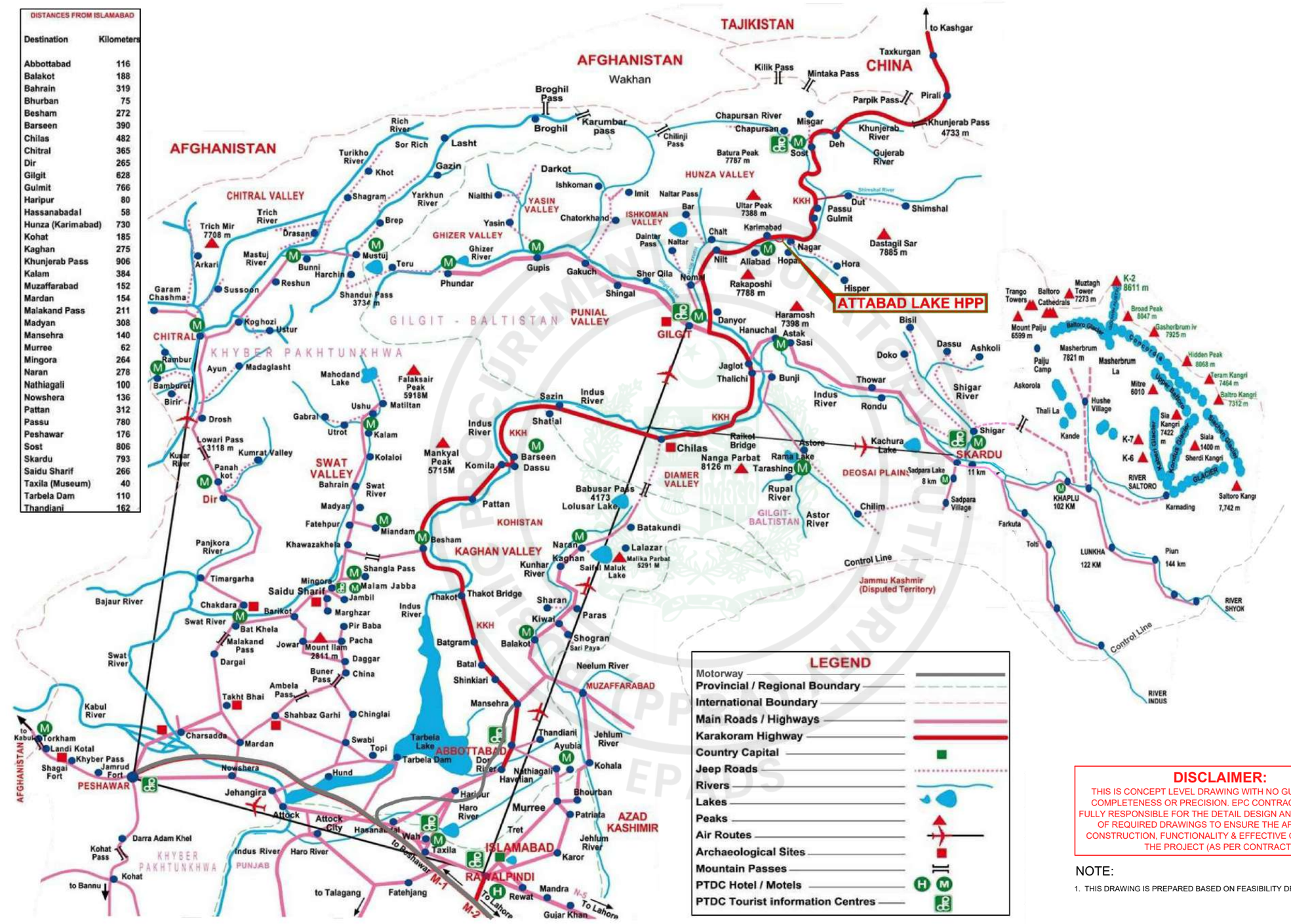
| DISTANCES FROM ISLAMABAD | |
|---|---|
| **Destination** | **Kilometers** |
| Abbottabad | 116 |
| Balakot | 188 |
| Bahrain | 319 |
| Bhurban | 75 |
| Besham | 272 |
| Barseen | 390 |
| Chilas | 482 |
| Chitral | 365 |
| Dir | 265 |
| Gilgit | 628 |
| Gulmit | 766 |
| Haripur | 80 |
| Hassanabadal | 58 |
| Hunza (Karimabad) | 730 |
| Kohat | 185 |
| Kaghan | 275 |
| Khunjerab Pass | 906 |
| Kalam | 384 |
| Muzaffarabad | 152 |
| Mardan | 154 |
| Malakand Pass | 211 |
| Madyan | 308 |
| Mansehra | 140 |
| Murree | 62 |
| Mingora | 264 |
| Naran | 278 |
| Nathiagali | 100 |
| Nowshera | 136 |
| Pattan | 312 |
| Passu | 780 |
| Peshawar | 176 |
| Sost | 806 |
| Skardu | 793 |
| Saidu Sharif | 266 |
| Taxila (Museum) | 40 |
| Tarbela Dam | 110 |
| Thandiani | 162 |

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NOTE:

1. THIS DRAWING IS PREPARED BASED ON FEASIBILITY DRAWING NO. AFS-GN-102.

CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF:
NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)
ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD.
PAKISTAN ENGINEERING SERVICES (PVT.) LTD.
BARQAAB CONSULTING SERVICES (PVT.) LTD.
DOLSAR ENGINEERING INC.CO.

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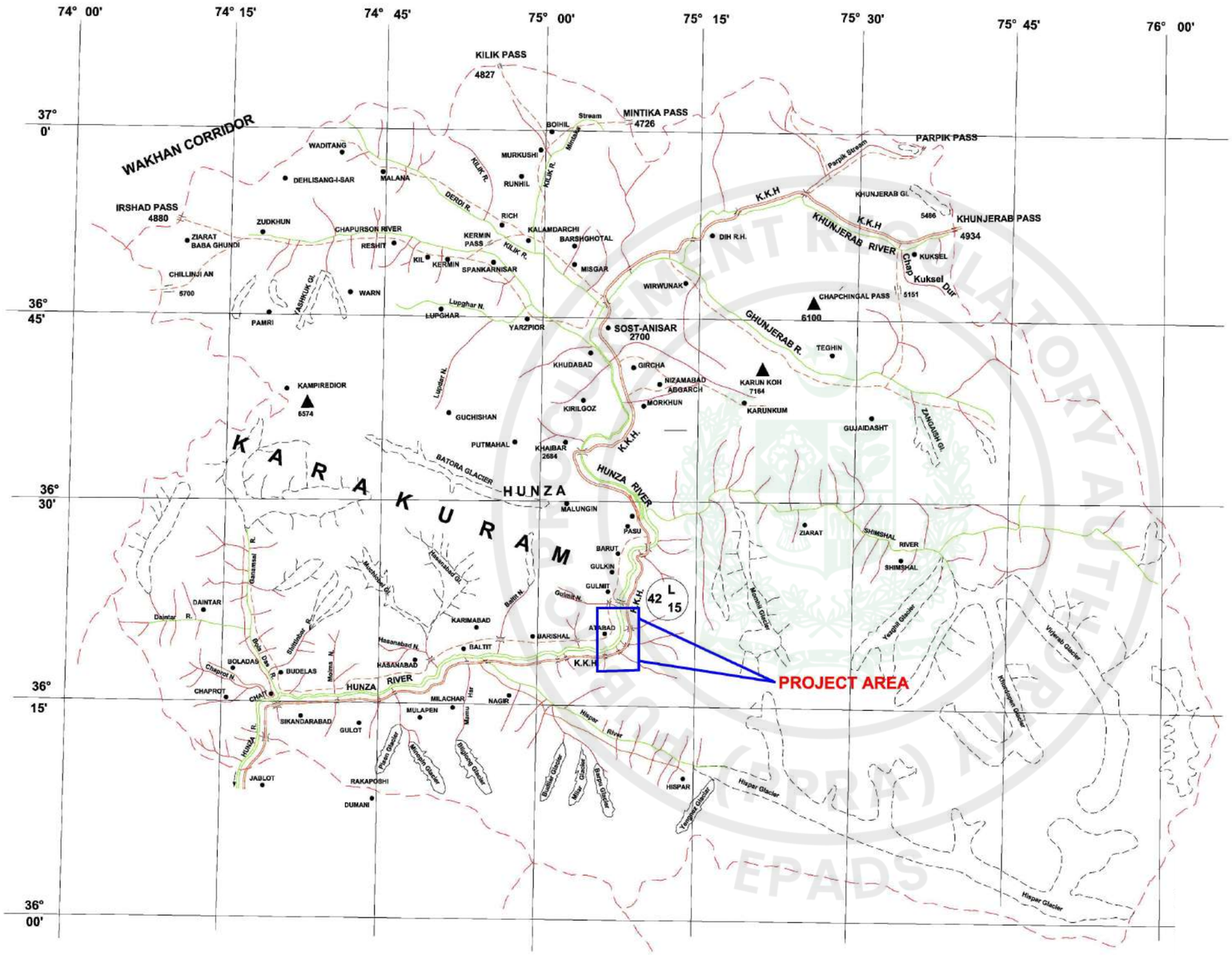
**PROJECT AREA ACCESSIBILITY MAP**

SCALE: AS SHOWN

DATE : MARCH, 2026

DRAWING No. ALHPP-GN-0102

REV. 0




**DISCLAIMER:**

THIS IS CONCEPT LEVEL DRAWING WITH NO GUARANTEE OF COMPLETENESS OR PRECISION. EPC CONTRACTOR WILL BE FULLY RESPONSIBLE FOR THE DETAIL DESIGN AND PREPARATION OF REQUIRED DRAWINGS TO ENSURE THE APPROPRIATE CONSTRUCTION, FUNCTIONALITY & EFFECTIVE OPERATION OF THE PROJECT (AS PER CONTRACT).

NOTE:

1. THIS DRAWING IS PREPARED BASED ON FEASIBILITY DRAWING NO. AFS-GN-101.

CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF:
NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)

ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD.
PAKISTAN ENGINEERING SERVICES (PVT.) LTD.
BARQAAB CONSULTING SERVICES (PVT.) LTD.
DOLSAR ENGINEERING INC.CO.

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**PROJECT VICINITY MAP**

SCALE: AS SHOWN

DATE : MARCH, 2026

DRAWING No. ALHPP-GN-0105

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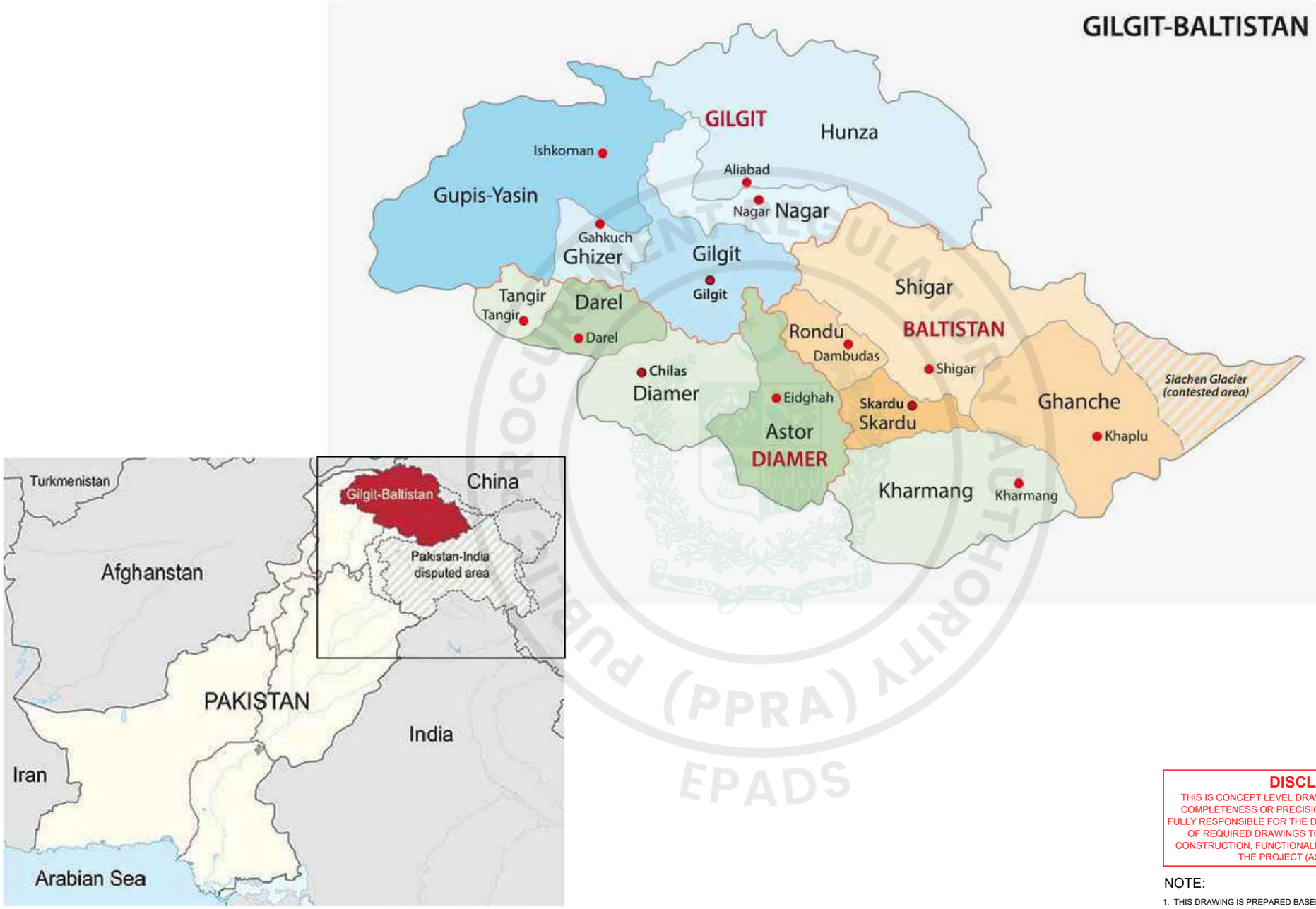


**DISCLAIMER:**

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NOTE:

1. THIS DRAWING IS PREPARED BASED ON FEASIBILITY DRAWING NO. AFS-GN-103.

CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF:
NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)
ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD.
BARQAAB CONSULTING SERVICES (PVT.) LTD.
PAKISTAN ENGINEERING SERVICES (PVT.) LTD.
DOLSAR ENGINEERING INC.CO.

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REGIONAL MAP OF NORTHERN AREA

SCALE: AS SHOWN

DATE : MARCH, 2026

DRAWING No. ALHPP-GN-0103

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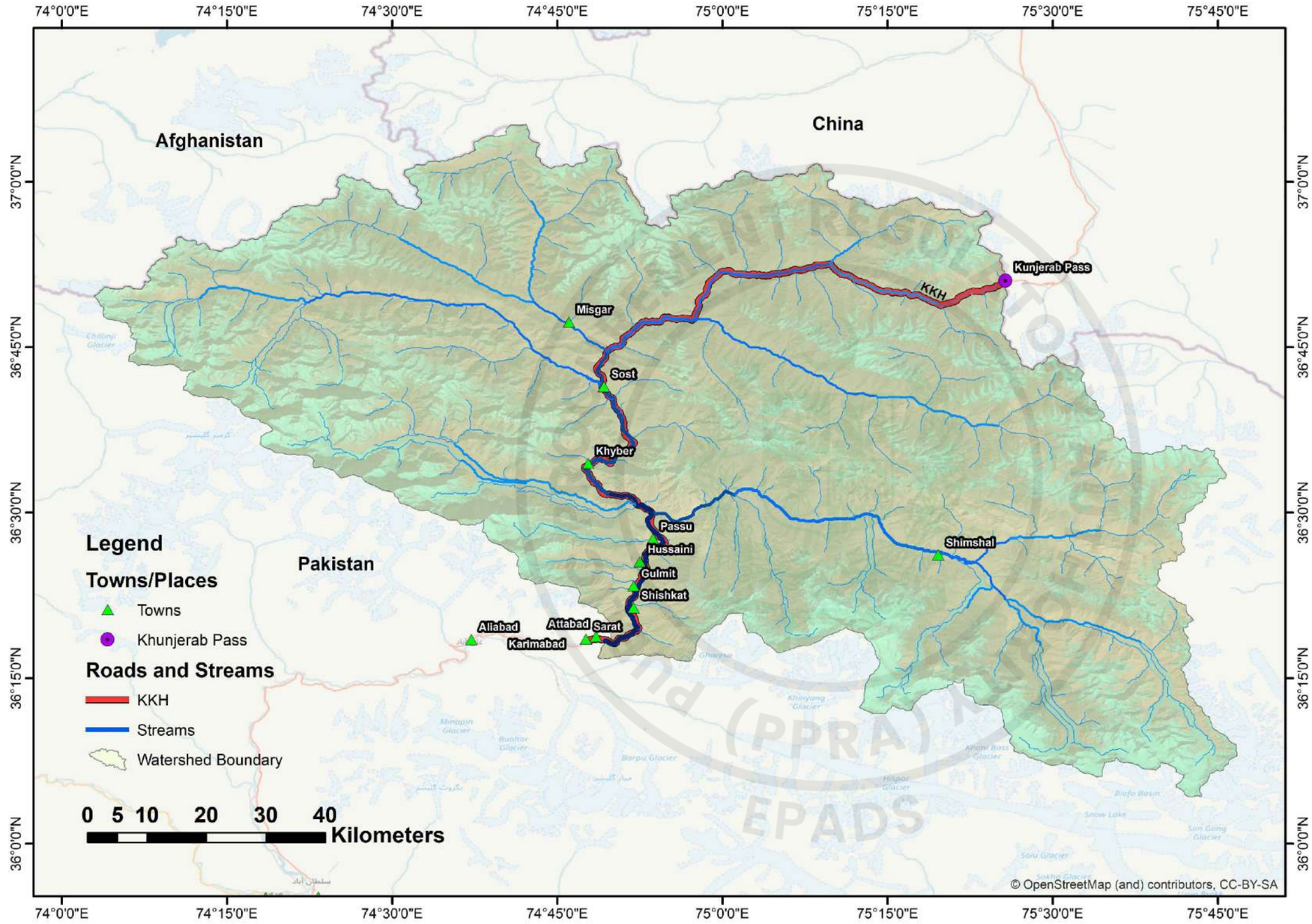


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**DISCLAIMER:**

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NOTE:

1. THIS DRAWING IS PREPARED BASED ON FEASIBILITY DRAWING NO. AFS-GN-104.

CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF:
NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)
ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD.
PAKISTAN ENGINEERING SERVICES (PVT.) LTD.
BARQAAB CONSULTING SERVICES (PVT.) LTD.
DOLSAR ENGINEERING INC.CO.

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**CATCHMENT AREA MAP**

SCALE: AS SHOWN

DATE : MARCH, 2026

DRAWING No. ALHPP-GN-0104

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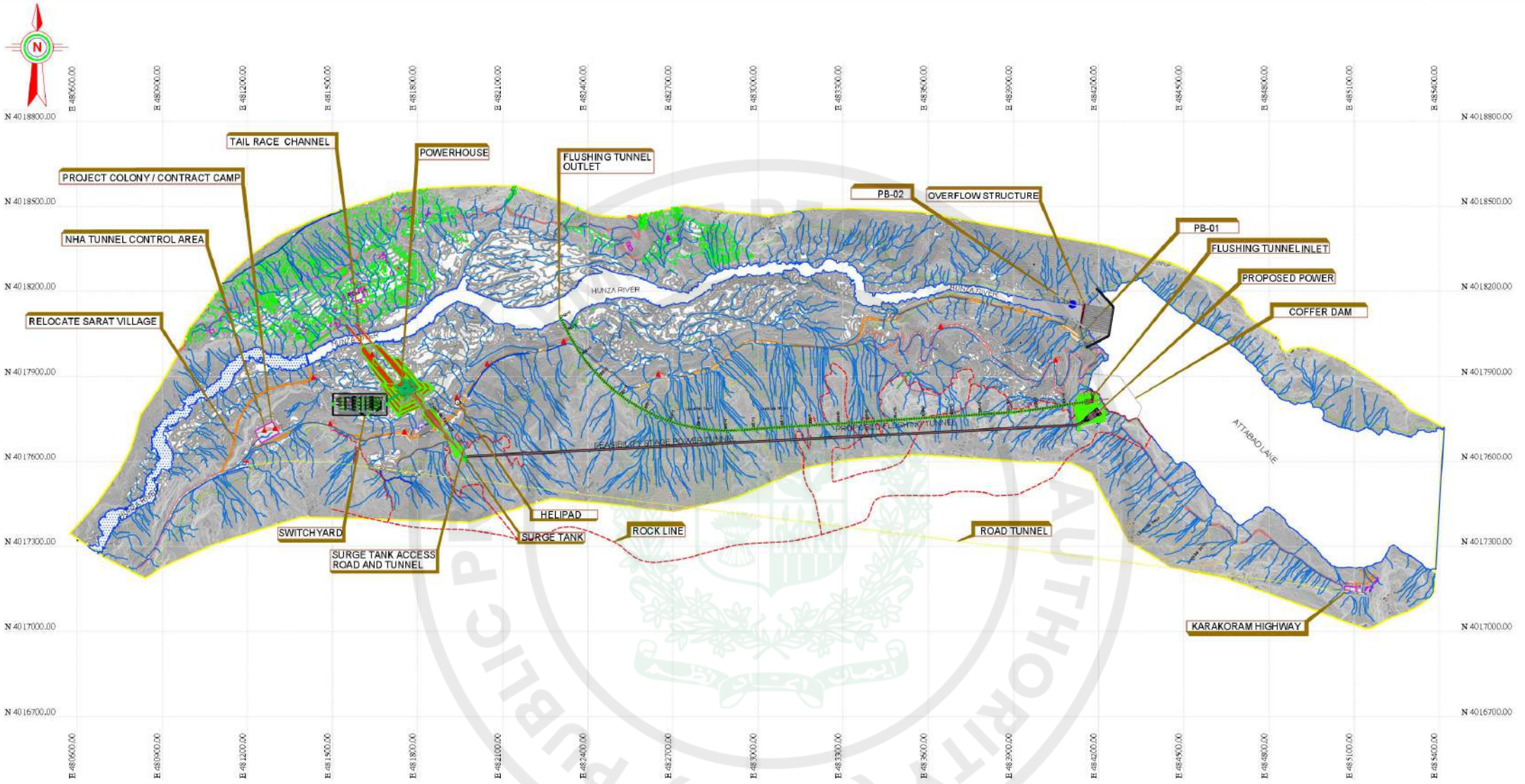
Pakistan Engineering Procurement Authority (PPRA) EPADS

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS




LEGEND:

| | | | |
|---|---|---|---|
| CONTROL POINT | PROJECT BOUNDARY | RIVER | |
| ELECTRIC POLE | AGRICULTURE LAND | SHED | |
| TREES | BUILTUP | STRUCTURE | |
| ROAD | BRIDGE | CONTOUR: | |
| ROAD & TRACK | CULVERT | | |
| ELECTRIC LINE | DRAIN | CONTOUR INDEX | |
| PROPOSED FLUSHING TUNNEL | HELIPAD | | |
| STREAM NETWORK | LAND DEBRI | | |

**DISCLAIMER:**

THIS IS CONCEPT LEVEL DRAWING WITH NO GUARANTEE OF COMPLETENESS OR PRECISION. EPC CONTRACTOR WILL BE FULLY RESPONSIBLE FOR THE ACTUAL DESIGN AND DRAWINGS TO ENSURE THE APPROPRIATE CONSTRUCTION, FUNCTIONALITY & EFFECTIVE OPERATION OF THE PROJECT (AS PER CONTRACT).

NOTE:

1. ALL DIMENSIONS ARE IN METERS

0 140 280 420 560 700 m

SCALE

CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF:
NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)
ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD.
BARGAAB CONSULTING SERVICES (PVT.) LTD.
PAKISTAN ENGINEERING SERVICES (PVT.) LTD.
BOLSAR ENGINEERING INC.CO.

| REV. | DATE | DESCRIPTION | APPROVED |
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DRAWN: ASIF SAMI
RECOMMENDED: -
CHD./VER.: -
APPROVED: -

PROJECT LAYOUT

DATE : MARCH, 2026

DRAWING No: ALHPP-LAY-0201

SCALE: AS SHOWN

REV: 0

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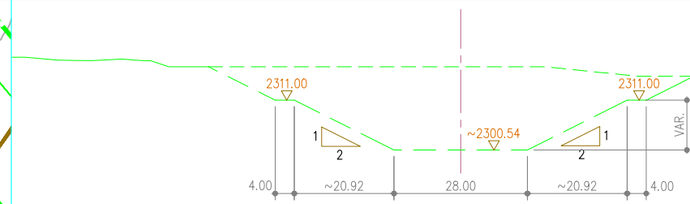
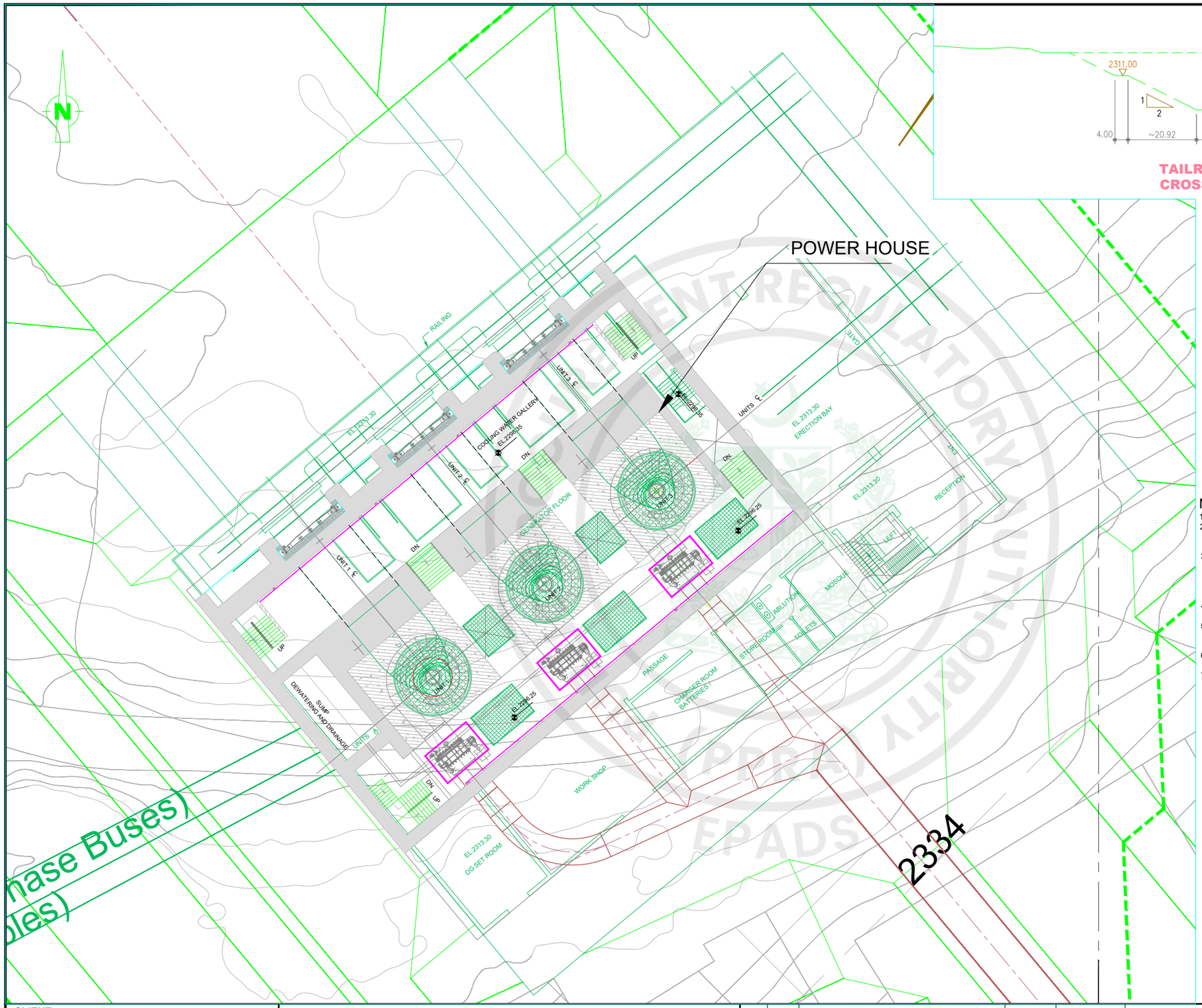
PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS




TAILRACE CHANNEL
CROSS SECTION T-T




**DISCLAIMER:**

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NOTES:

1. ALL DIMENSIONS/ELEVATIONS ARE IN METERS.
2. ELEVATIONS AND LEVELS ARE BASED ON THE TOPOGRAPHIC SURVEY ATTACHED IN PACKAGE III, VOLUME III OF THE BIDDING DOCUMENT. VERIFICATION OF THESE ELEVATIONS IS RESPONSIBILITY OF THE EPC CONTRACTOR.
3. THE EXCAVATION SLOPE/LIMITS ARE TENTATIVE. SURFACE EXCAVATIONS SHOWN ON THIS DRAWING MAY CHANGE DURING DETAILED DESIGN/EXECUTION DESIGN AFTER HAVING MORE INFORMATION ABOUT GEOLOGY AND TOPOGRAPHY OF PROJECT SITE.
4. THE EXCAVATION SLOPES SHOULD BE DEFINED AS A RESULT OF STABILITY ANALYSES.
5. GABION PROTECTION MAY BE APPLIED INSTEAD OF SIDE EXCAVATION. IF THIS IS PREFERRED BY THE CONTRACTOR THE NECESSARY CONTROL FOR THE FREEBOARD SHOULD BE DONE.
6. ACCESS ROADS ARE NOT SHOWN. THE CONTRACTOR WILL DESIGN THE ROADS ACCORDING TO HIS OWN REQUIREMENT.
7. THE CONTRACTOR WILL BE ABLE TO MAKE NECESSARY CHANGES IN THE DIMENSIONS OF THE STRUCTURES, DIVERSION AND DEWATERING SYSTEM, EXCAVATION AND THE CONSTRUCTION METHODOLOGY IN ACCORDANCE WITH THE PROPOSED SCHEME.

0 3 6 9 12 15 m
SCALE

CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF:
NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)
ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD.
BARQAAB CONSULTING SERVICES (PVT.) LTD.
PAKISTAN ENGINEERING SERVICES (PVT.) LTD.
DOLSAR ENGINEERING INC.CO.

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POWER HOUSE LAYOUT

SCALE: AS SHOWN

DATE : MARCH, 2026

DRAWING No. ALHPP-PH-0301

REV. 0

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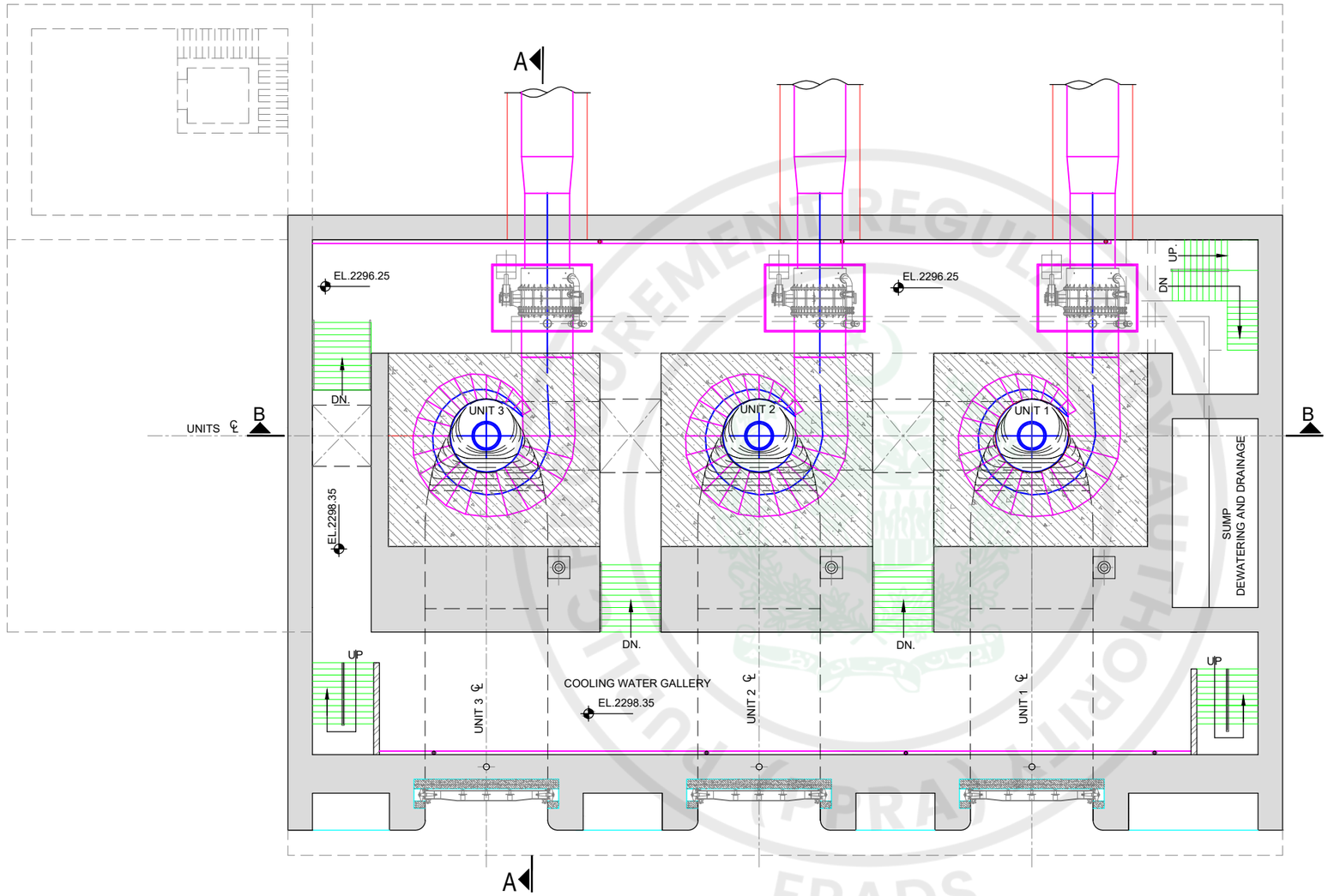


PLAN AT EL. 2299.25

**DISCLAIMER:**

THIS IS CONCEPT LEVEL DRAWING WITH NO GUARANTEE OF COMPLETENESS OR PRECISION. EPC CONTRACTOR WILL BE FULLY RESPONSIBLE FOR THE ACTUAL DESIGN AND DRAWINGS TO ENSURE THE APPROPRIATE CONSTRUCTION, FUNCTIONALITY & EFFECTIVE OPERATION OF THE PROJECT (AS PER CONTRACT).

NOTES:

1. ALL DIMENSIONS ARE IN METERS.
2. ELEVATIONS AND LEVELS ARE BASED ON THE TOPOGRAPHIC SURVEY ATTACHED IN PACKAGE III, VOLUME IIIOF THE BIDDING DOCUMENT. VERIFICATION OF THESE ELEVATIONS IS RESPONSIBILITY OF THE EPC CONTRACTOR.

0 2.0 4.0 6.0 8.0 10 m

SCALE

CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF:
NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)

ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD.
PAKISTAN ENGINEERING SERVICES (PVT.) LTD.
BARQAAB CONSULTING SERVICES (PVT.) LTD.
DOLSAR ENGINEERING INC.CO.

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| APPROVED | - |

**POWER HOUSE PLAN AT EL. 2299.25**

SCALE: AS SHOWN

DATE : MARCH, 2026

DRAWING No. ALHPP-PH-0302

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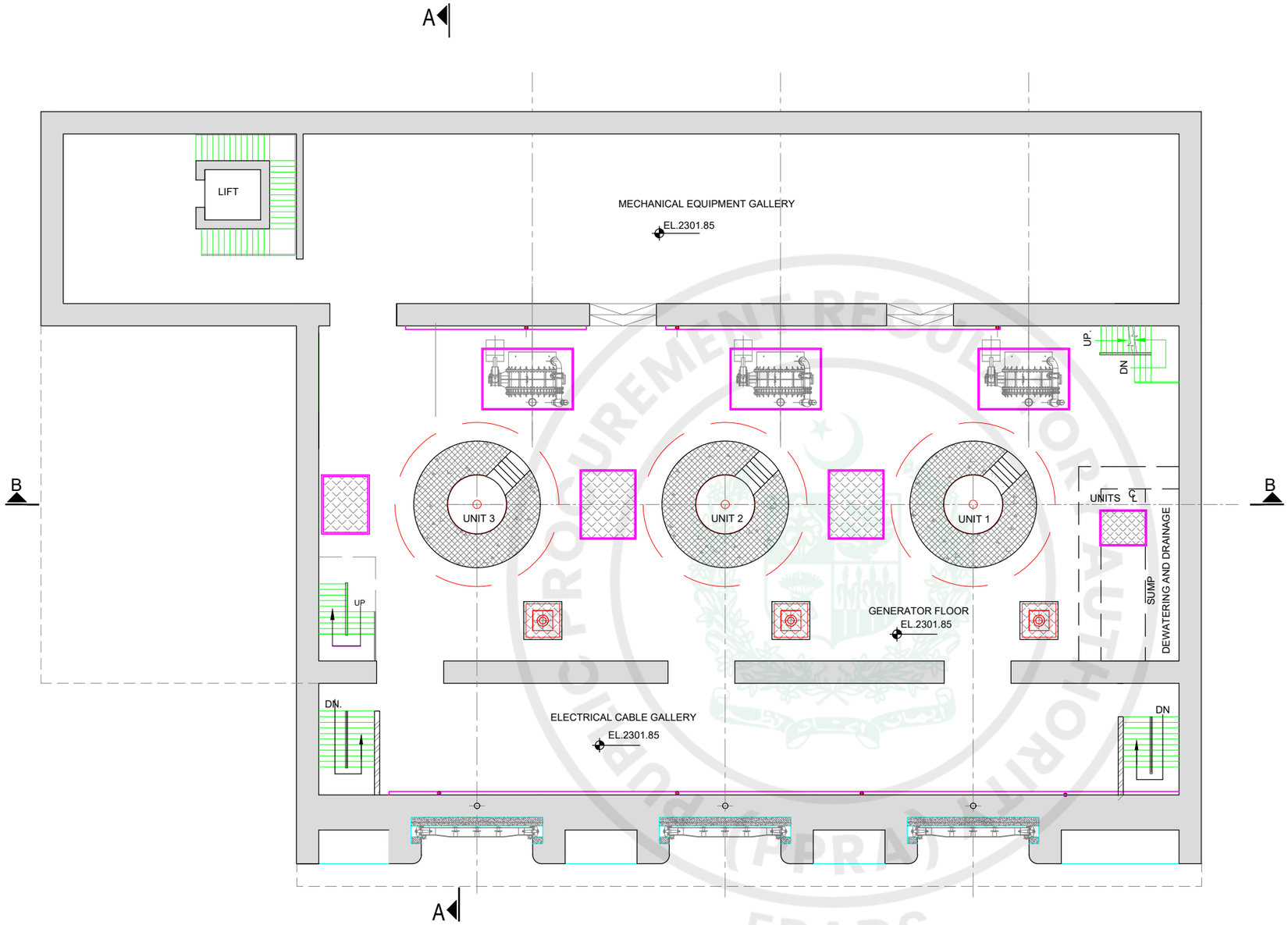


PLAN AT EL. 2301.85

**DISCLAIMER:**

THIS IS CONCEPT LEVEL DRAWING WITH NO GUARANTEE OF COMPLETENESS OR PRECISION. EPC CONTRACTOR WILL BE FULLY RESPONSIBLE FOR THE ACTUAL DESIGN AND DRAWINGS TO ENSURE THE APPROPRIATE CONSTRUCTION, FUNCTIONALITY & EFFECTIVE OPERATION OF THE PROJECT (AS PER CONTRACT).

NOTES:

1. ALL DIMENSIONS ARE IN METERS.
2. ELEVATIONS AND LEVELS ARE BASED ON THE TOPOGRAPHIC SURVEY ATTACHED IN PACKAGE III, VOLUME IIIOF THE BIDDING DOCUMENT. VERIFICATION OF THESE ELEVATIONS IS RESPONSIBILITY OF THE EPC CONTRACTOR.

0 2.0 4.0 6.0 8.0 10 m
SCALE

CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF:
NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)
ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD.
BARQAAB CONSULTING SERVICES (PVT.) LTD.
PAKISTAN ENGINEERING SERVICES (PVT.) LTD.
DOLSAR ENGINEERING INC.CO.

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**POWER HOUSE PLAN AT EL. 2301.85**

SCALE: AS SHOWN

DATE : MARCH, 2026

DRAWING No. ALHPP-PH-0303

REV. 0

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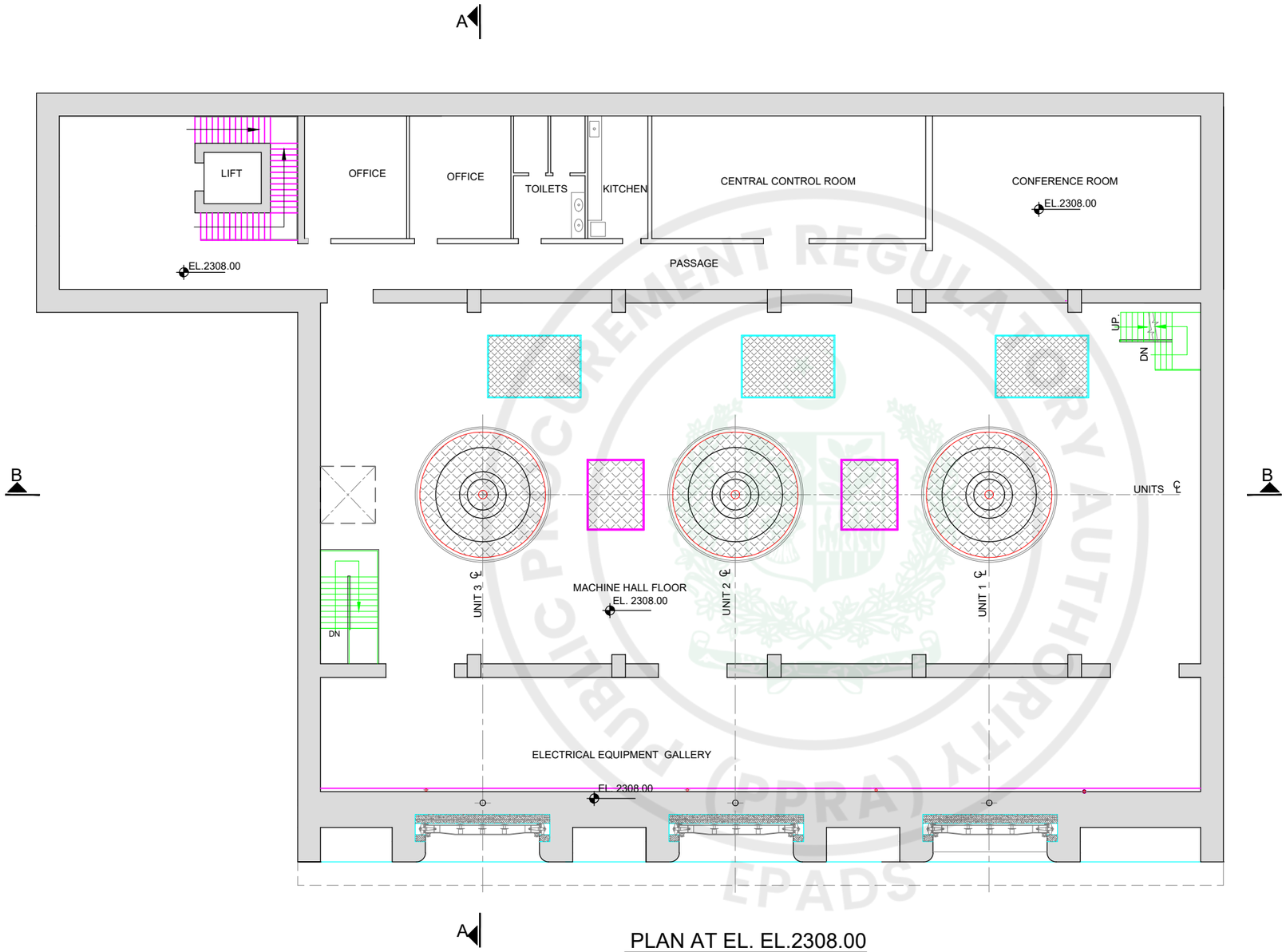


PLAN AT EL. EL.2308.00

**DISCLAIMER:**

THIS IS CONCEPT LEVEL DRAWING WITH NO GUARANTEE OF COMPLETENESS OR PRECISION. EPC CONTRACTOR WILL BE FULLY RESPONSIBLE FOR THE ACTUAL DESIGN AND DRAWINGS TO ENSURE THE APPROPRIATE CONSTRUCTION, FUNCTIONALITY & EFFECTIVE OPERATION OF THE PROJECT (AS PER CONTRACT).

NOTES:

1. ALL DIMENSIONS ARE IN METERS.
2. ELEVATIONS AND LEVELS ARE BASED ON THE TOPOGRAPHIC SURVEY ATTACHED IN PACKAGE III, VOLUME IIIOF THE BIDDING DOCUMENT. VERIFICATION OF THESE ELEVATIONS IS RESPONSIBILITY OF THE EPC CONTRACTOR.

0 2.0 4.0 6.0 8.0 10 m

SCALE: A

CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF:
NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)
ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD.
PAKISTAN ENGINEERING SERVICES (PVT.) LTD.
BARQAAB CONSULTING SERVICES (PVT.) LTD.
DOLSAR ENGINEERING INC.CO.

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POWER HOUSE
PLAN AT EL. 2308.00

SCALE: AS SHOWN

DATE : MARCH, 2026

DRAWING No. ALHPP-PH-0304

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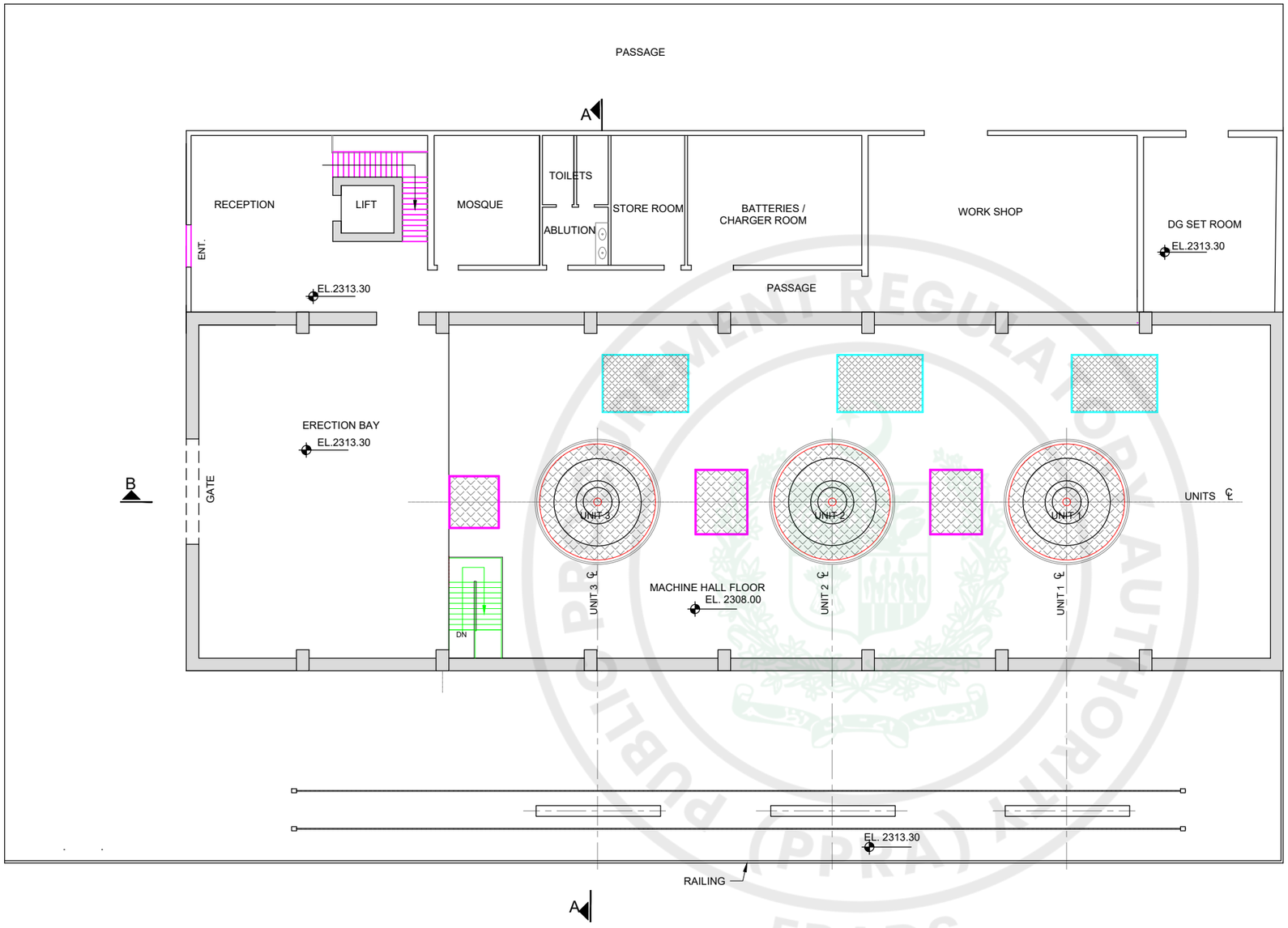


PLAN AT EL. EL.2313.30

**DISCLAIMER:**

THIS IS CONCEPT LEVEL DRAWING WITH NO GUARANTEE OF COMPLETENESS OR PRECISION. EPC CONTRACTOR WILL BE FULLY RESPONSIBLE FOR THE ACTUAL DESIGN AND DRAWINGS TO ENSURE THE APPROPRIATE CONSTRUCTION, FUNCTIONALITY & EFFECTIVE OPERATION OF THE PROJECT (AS PER CONTRACT).

NOTES:

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2. ELEVATIONS AND LEVELS ARE BASED ON THE TOPOGRAPHIC SURVEY ATTACHED IN PACKAGE III, VOLUME IIIOF THE BIDDING DOCUMENT. VERIFICATION OF THESE ELEVATIONS IS RESPONSIBILITY OF THE EPC CONTRACTOR.

0 2.0 4.0 6.0 8.0 10 m

SCALE: A

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|---|---|---|
| CLIENT: | PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY | |
| PROJECT: | ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | |
| CONSULTANT: | ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>JOINT VENTURE OF:<br>NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)<br>ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD.<br>BARQAAB CONSULTING SERVICES (PVT.) LTD.<br>PAKISTAN ENGINEERING SERVICES (PVT.) LTD.<br>DOLSAR ENGINEERING INC.CO. | |

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**POWER HOUSE PLAN AT EL.2313.30**

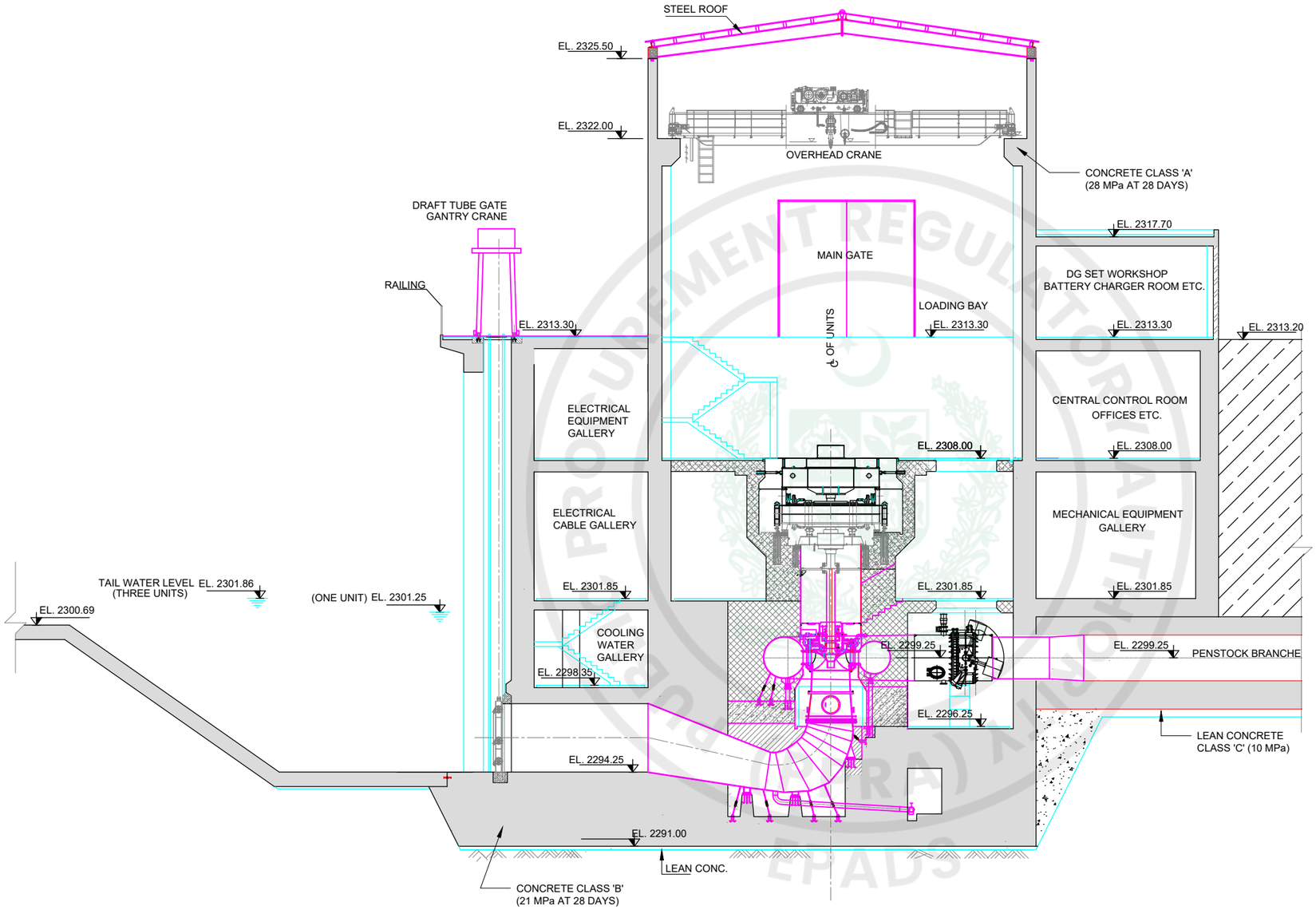
SCALE: AS SHOWN

DATE : MARCH, 2026

DRAWING No. ALHPP-PH-0305

REV. 0

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS




SECTION-A-A

**DISCLAIMER:**

THIS IS CONCEPT LEVEL DRAWING WITH NO GUARANTEE OF COMPLETENESS OR PRECISION. EPC CONTRACTOR WILL BE FULLY RESPONSIBLE FOR THE ACTUAL DESIGN AND DRAWINGS TO ENSURE THE APPROPRIATE CONSTRUCTION, FUNCTIONALITY & EFFECTIVE OPERATION OF THE PROJECT (AS PER CONTRACT).

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0 2.0 4.0 6.0 8.0 10 m

SCALE: A

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|---|---|
| CLIENT: | PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY |
| PROJECT: | ATTABAD LAKE HYDROPOWER PROJECT (54 MW) |
| CONSULTANT: | ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>JOINT VENTURE OF:<br>NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)<br>ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD.<br>BARQAAB CONSULTING SERVICES (PVT.) LTD.<br>PAKISTAN ENGINEERING SERVICES (PVT.) LTD.<br>DOLSAR ENGINEERING INC.CO. |

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**POWER HOUSE SECTION A-A**

SCALE: AS SHOWN

DATE : MARCH, 2026

DRAWING No. ALHPP-PH-0306

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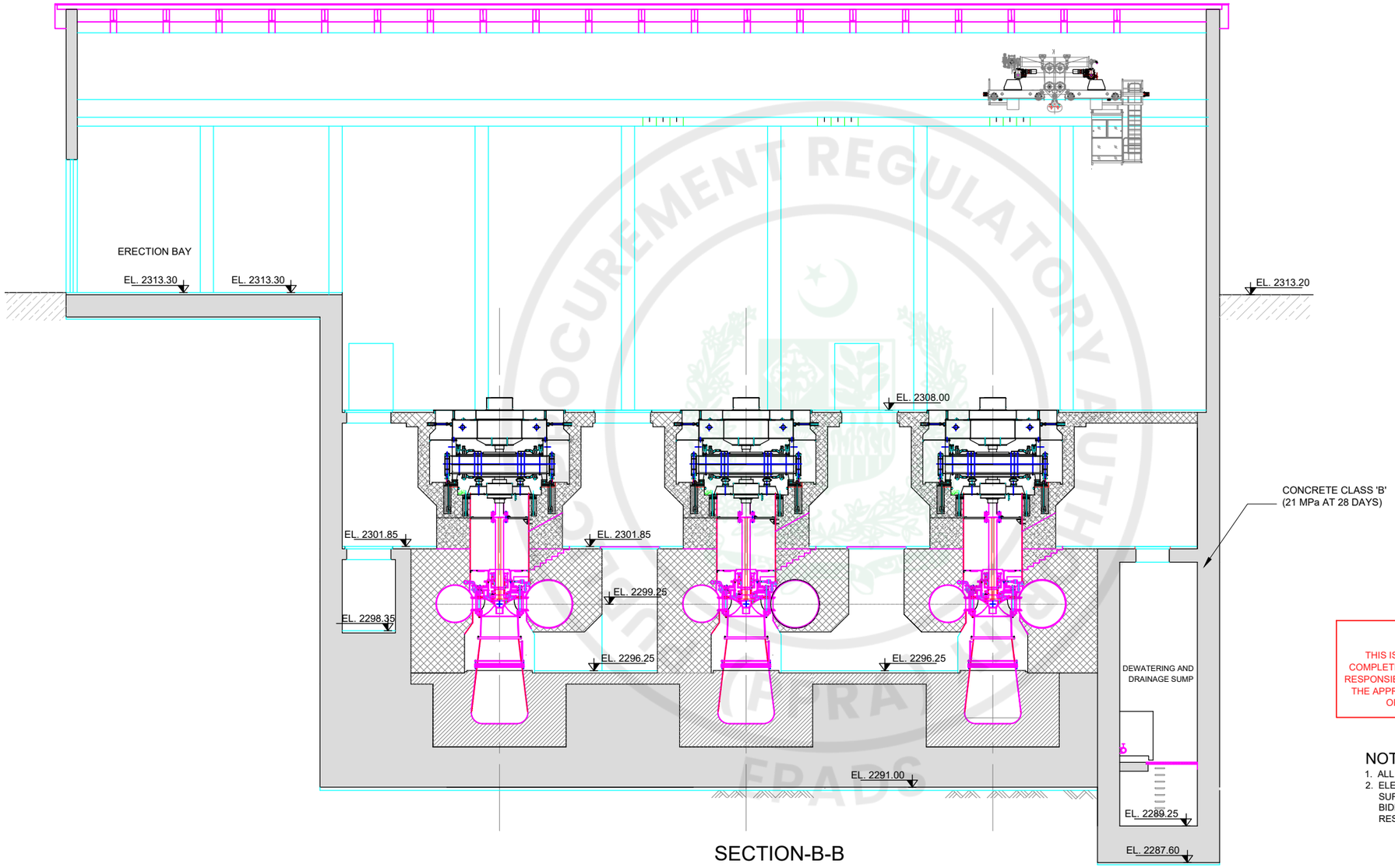


SECTION-B-B

**DISCLAIMER:**

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0 2.0 4.0 6.0 8.0 10 m
SCALE: A

CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF:
NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)
ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD.
PAKISTAN ENGINEERING SERVICES (PVT.) LTD.
BARQAAB CONSULTING SERVICES (PVT.) LTD.
DOLSAR ENGINEERING INC.CO.

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POWER HOUSE
SECTION B-B

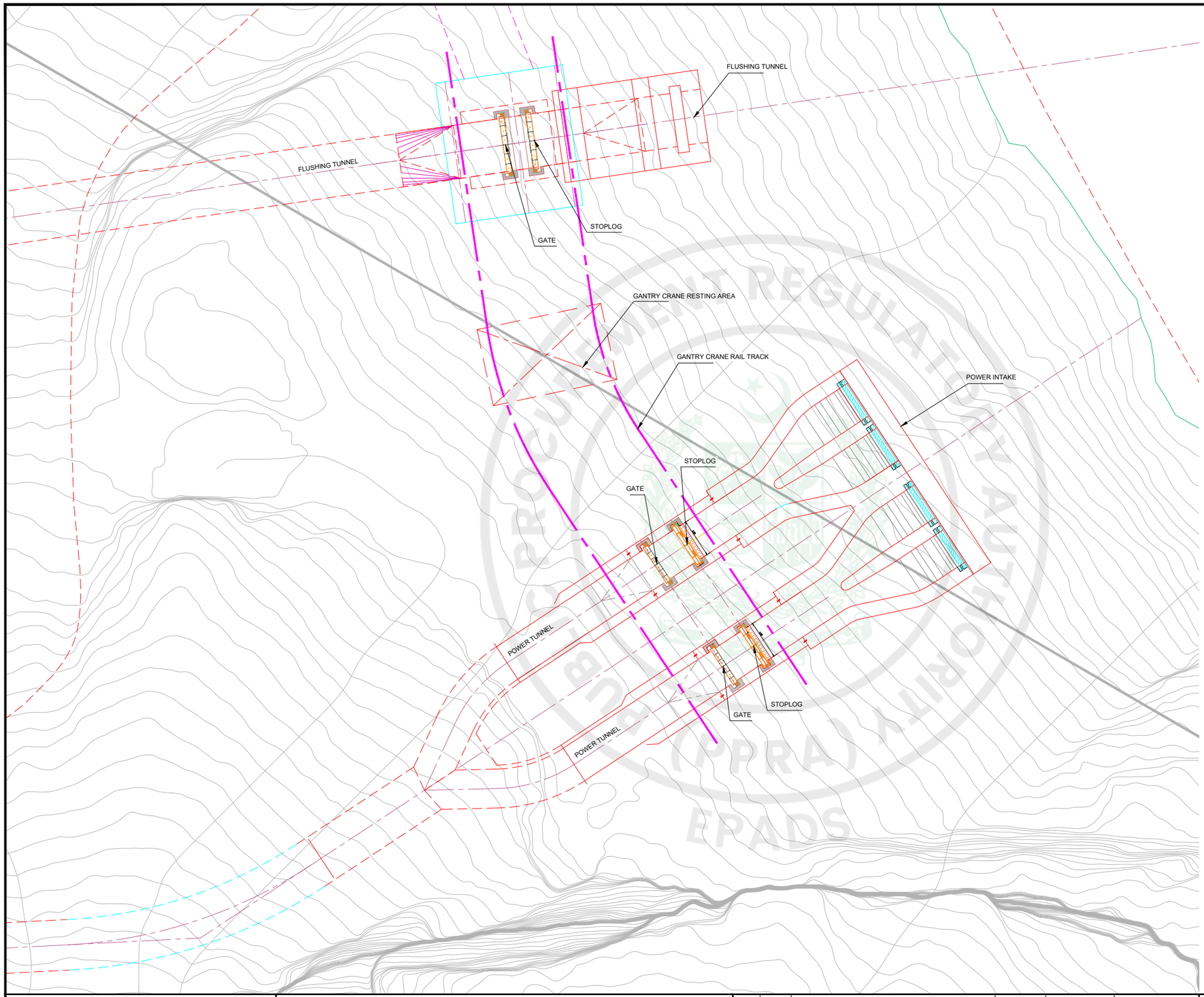
SCALE: AS SHOWN

DATE : MARCH, 2026

DRAWING No. ALHPP-PH-0307

REV. 0

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS




## DISCLAIMER:

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## NOTES:

1. ALL DIMENSIONS ARE IN METERS.
2. ELEVATIONS AND LEVELS ARE BASED ON THE TOPOGRAPHIC SURVEY ATTACHED IN PACKAGE III, VOLUME III OF THE BIDDING DOCUMENT. VERIFICATION OF THESE ELEVATIONS IS RESPONSIBILITY OF THE EPC CONTRACTOR.

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SCALE

**CLIENT:**
\images.jpg
**PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY**

**PROJECT:**
**ATTABAD LAKE HYDROPOWER PROJECT (54 MW)**

**CONSULTANT:**
AHMC ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS
JOINT VENTURE OF:
NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)
ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD.
BARQAAB CONSULTING SERVICES (PVT.) LTD.
PAKISTAN ENGINEERING SERVICES (PVT.) LTD.
DOLSAR ENGINEERING INC.CO.

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**POWER AND FLUSHING INTAKE LAYOUT PLAN AT EL.2425.00**

SCALE: AS SHOWN
DATE : MARCH, 2026
DRAWING No. ALHPP-HSS-0401
REV. 0

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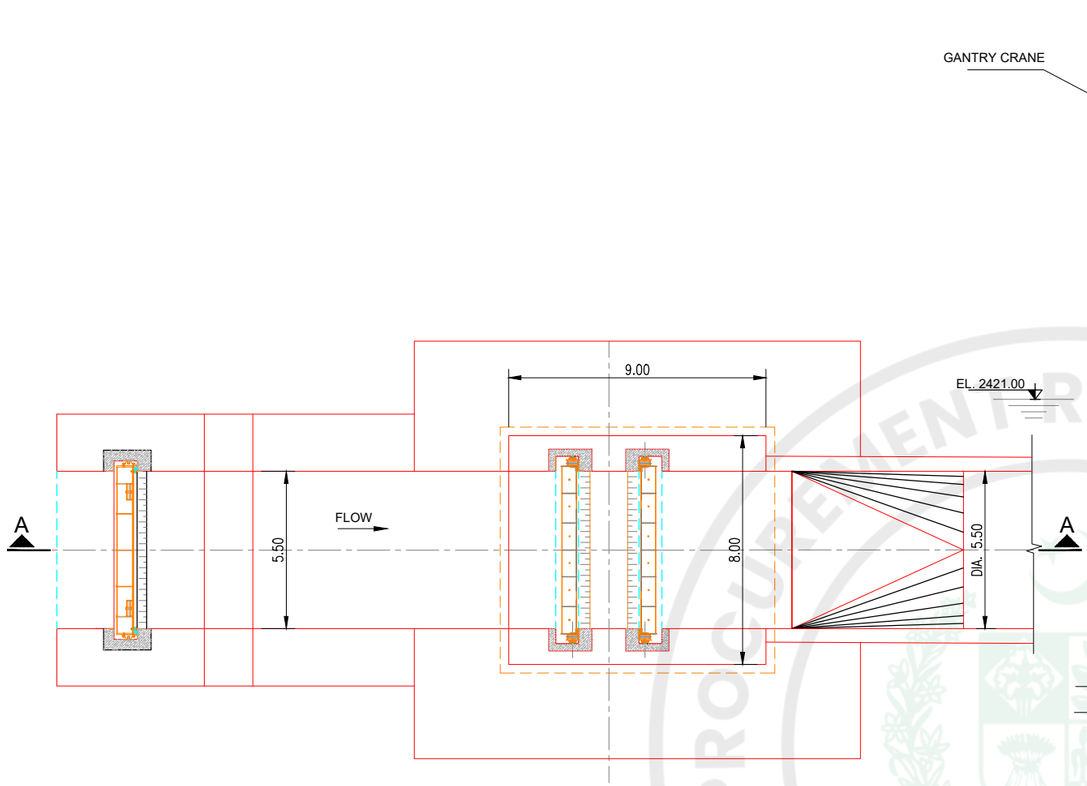
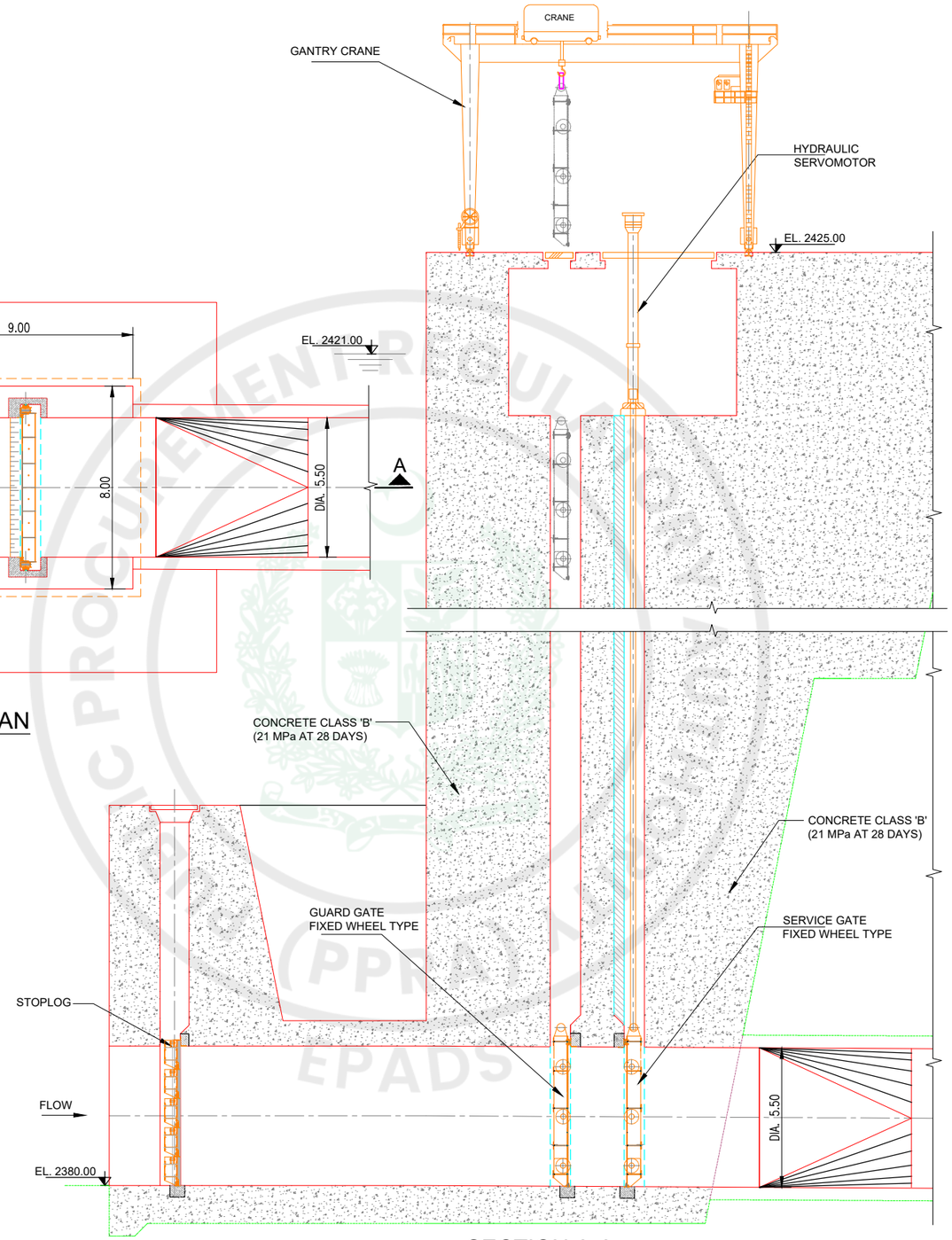



PLAN




SECTION A-A

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0 1.0 2.0 3.0 4.0 5.0 m
SCALE

CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: AHMC ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF:
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BARQAAB CONSULTING SERVICES (PVT.) LTD.
PAKISTAN ENGINEERING SERVICES (PVT.) LTD.
DOLSAR ENGINEERING INC.CO.

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**FLUSHING TUNNEL GATE SHAFT ARRANGEMENT**

SCALE: AS SHOWN

DATE : MARCH, 2026

DRAWING No. ALHPP-HSS-0402

REV.

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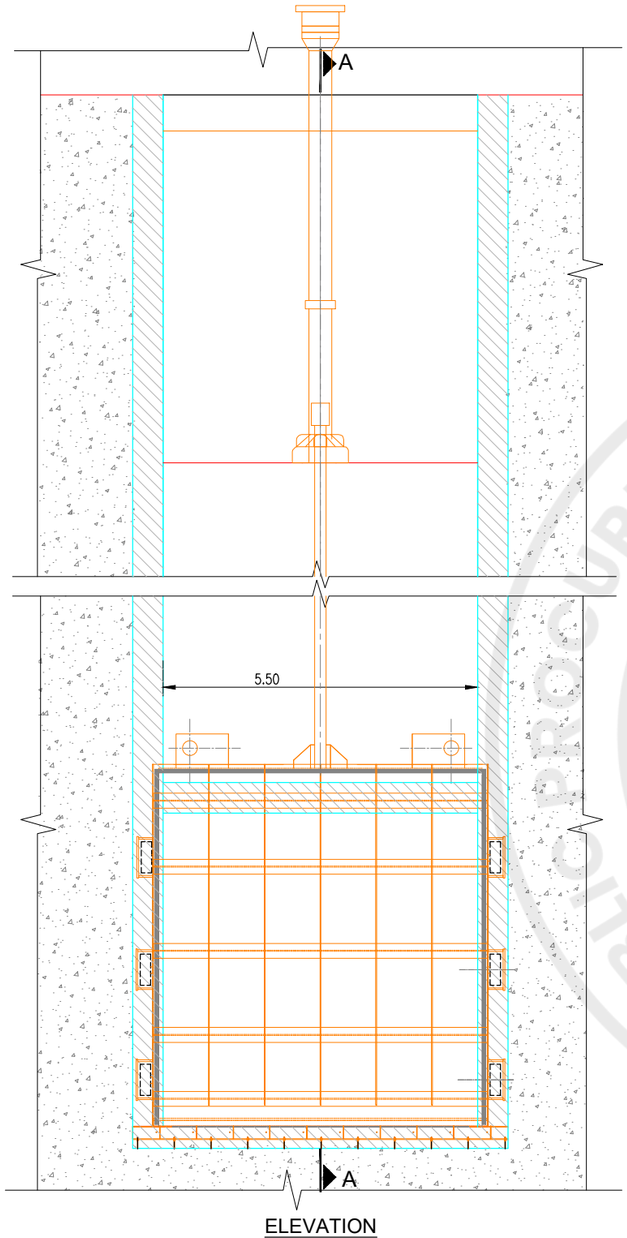
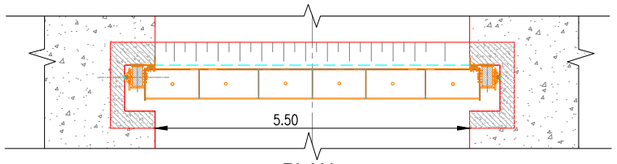
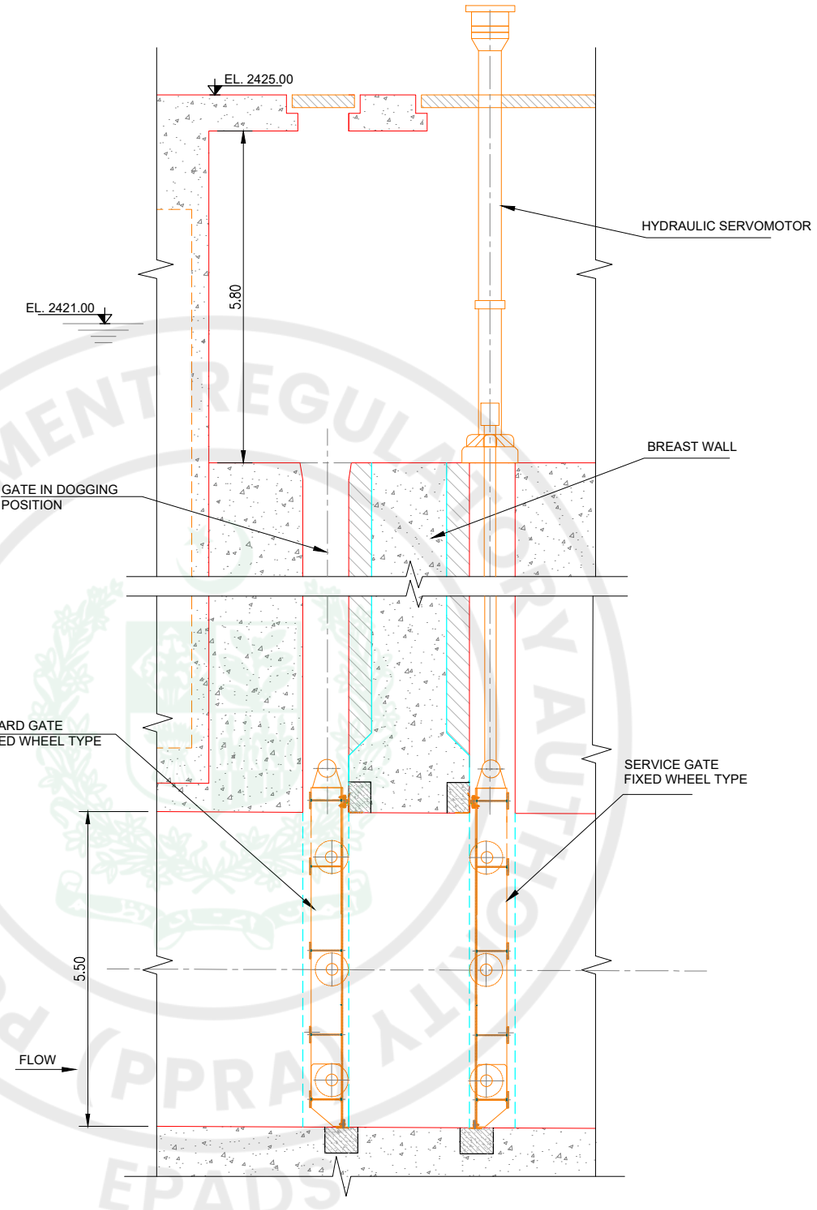



ELEVATION




PLAN




SECTION A-A

**DISCLAIMER:**

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NOTE:

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0 1.0 2.0 3.0 4.0 5.0 m

SCALE

CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF:
NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)
ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD.
BARQAAB CONSULTING SERVICES (PVT.) LTD.
PAKISTAN ENGINEERING SERVICES (PVT.) LTD.
DOLSAR ENGINEERING INC.CO.

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FLUSHING TUNNEL
SERVICE & GUARD GATE ARRANGEMENT

SCALE: AS SHOWN

DATE : MARCH, 2026

DRAWING No. ALHPP-HSS-0403

REV. 0

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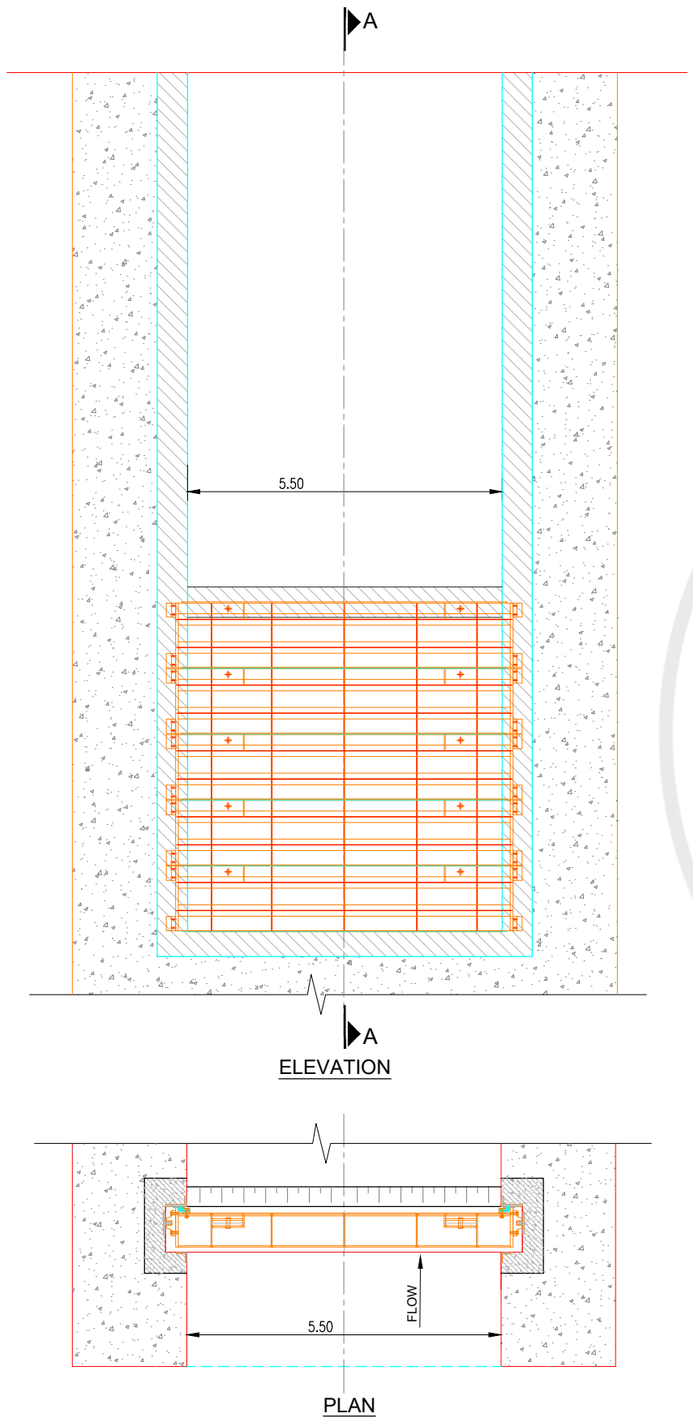
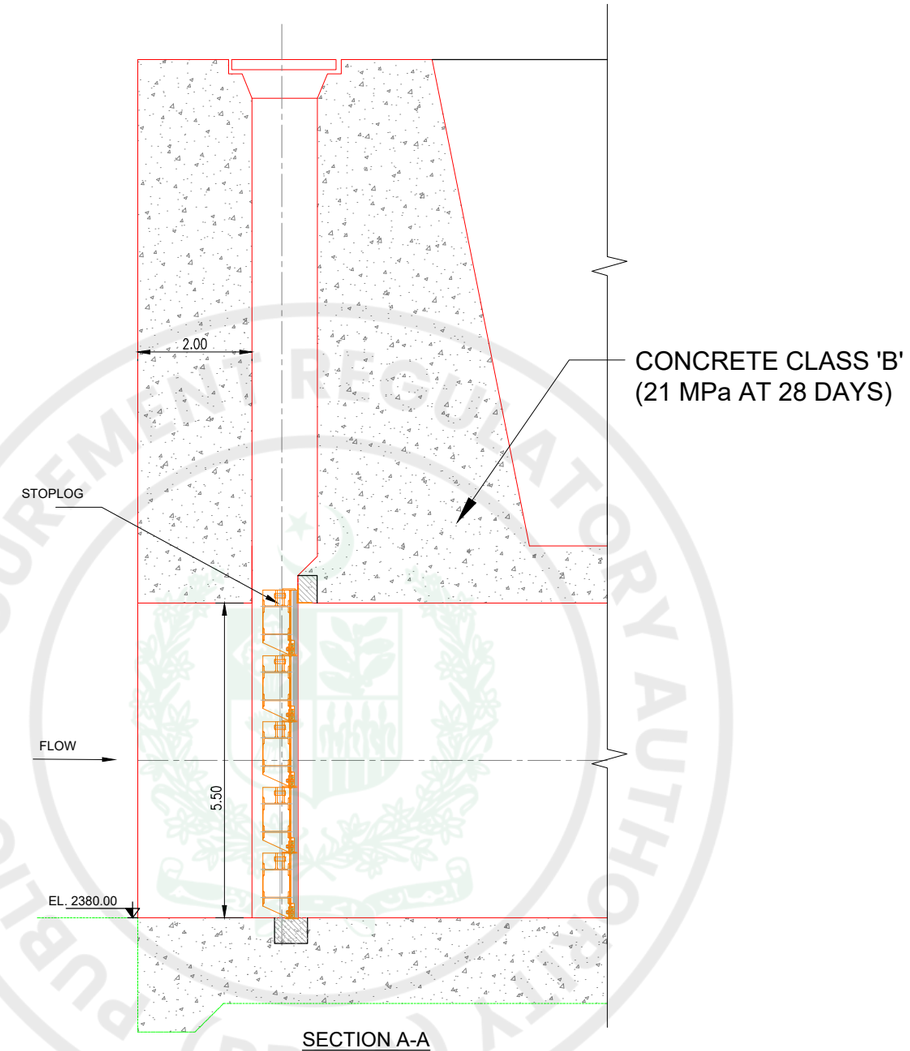



ELEVATION




PLAN




SECTION A-A

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0 1.0 2.0 3.0 4.0 5.0 m
SCALE

CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF:
NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)
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BARQAAB CONSULTING SERVICES (PVT.) LTD.
PAKISTAN ENGINEERING SERVICES (PVT.) LTD.
DOLSAR ENGINEERING INC.CO.

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FLUSHING TUNNEL
STOPLOG ARRANGEMENT

SCALE: AS SHOWN

DATE : MARCH, 2026

DRAWING No. ALHPP-HSS-0404

REV. 0

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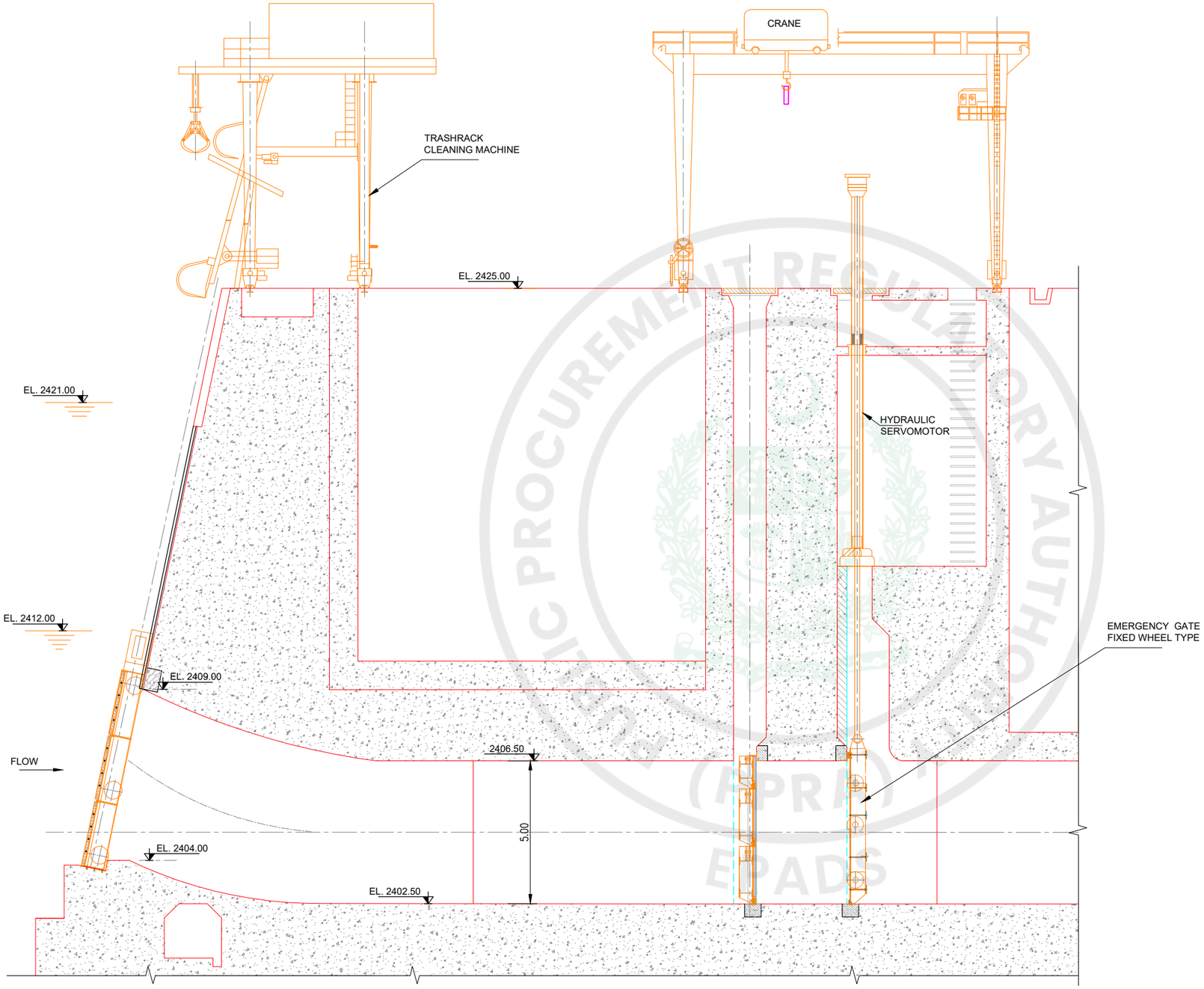


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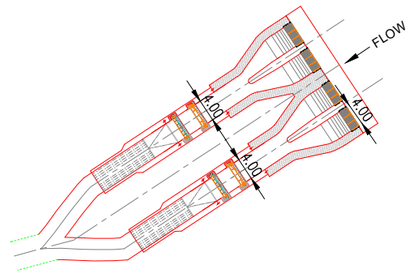


KEY PLAN

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0 1.5 3.0 4.5 6.0 7.5 m
SCALE

CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF:
NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)
ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD.
BARQAAB CONSULTING SERVICES (PVT.) LTD.
PAKISTAN ENGINEERING SERVICES (PVT.) LTD.
DOLSAR ENGINEERING INC.CO.

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POWER INTAKE
EMERGENCY GATE & STOPLOG ARRANGEMENT

SCALE: AS SHOWN

DATE : MARCH, 2026

DRAWING No. ALHPP-HSS-0405

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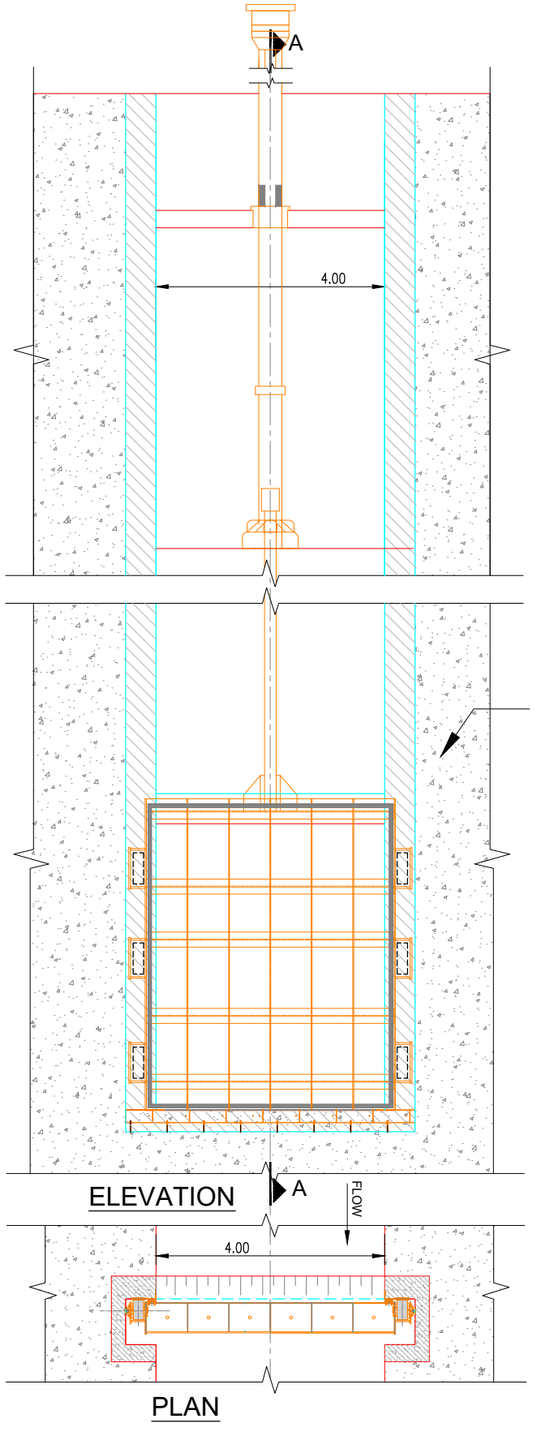
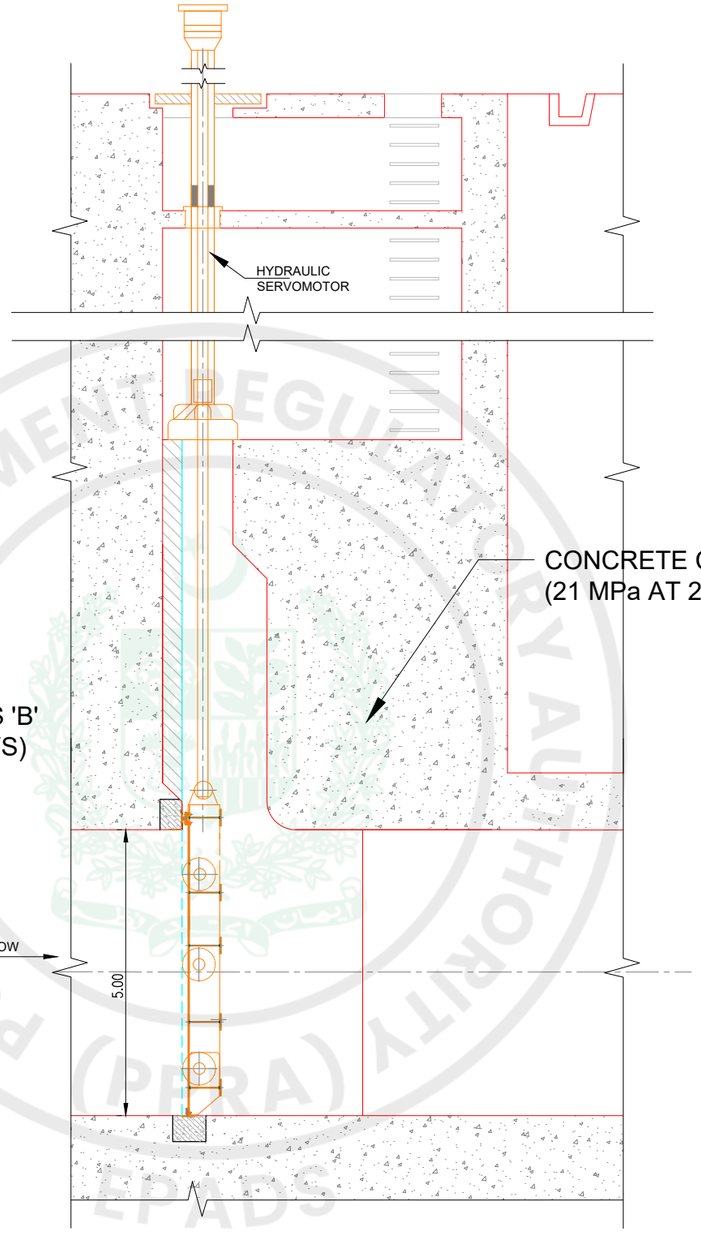
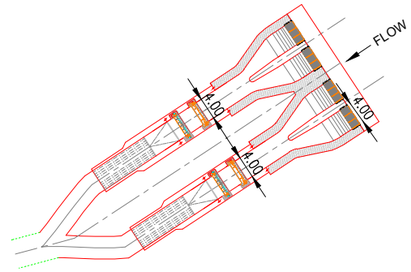



SECTION A-A




KEY PLAN

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0 1.0 2.0 3.0 4.0 5.0 m
SCALE

CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF:
NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)
ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD.
BARQAAB CONSULTING SERVICES (PVT.) LTD.
PAKISTAN ENGINEERING SERVICES (PVT.) LTD.
DOLSAR ENGINEERING INC.CO.

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POWER INTAKE
EMERGENCY GATE ARRANGEMENT

SCALE: AS SHOWN

DATE : MARCH, 2026

DRAWING No. ALHPP-HSS-0406

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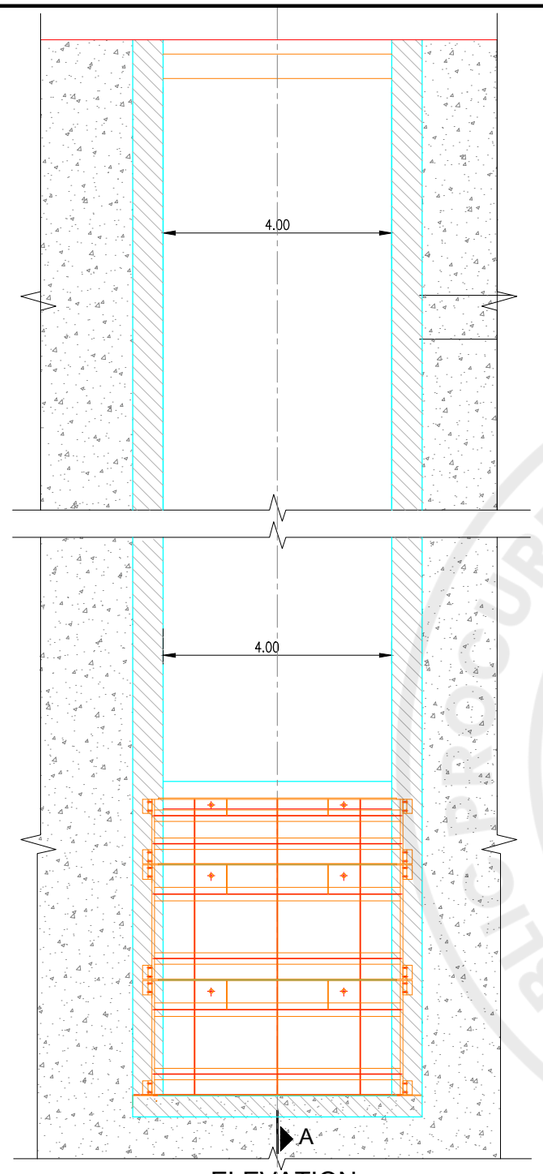
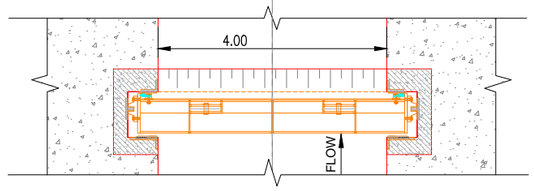



ELEVATION

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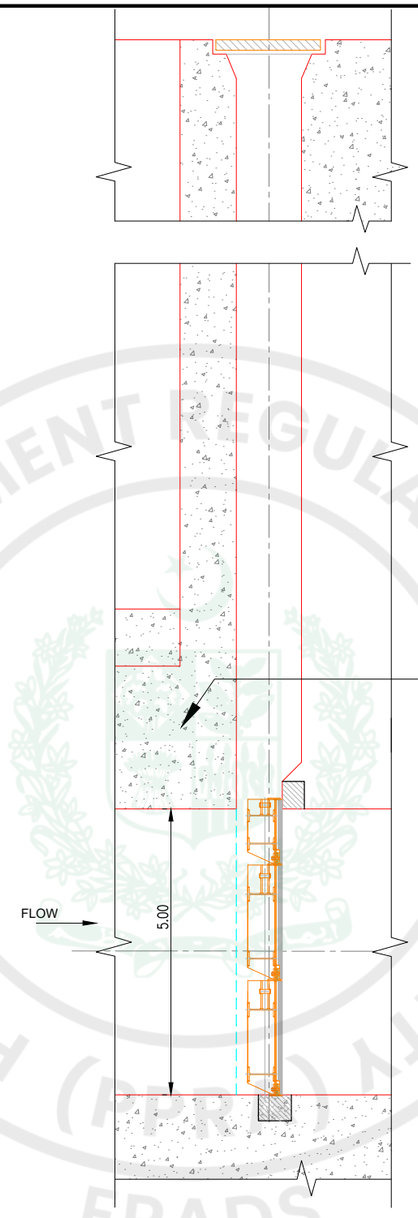
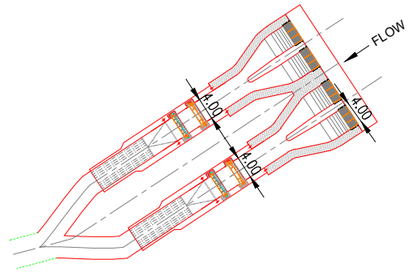



SECTION A-A




KEY PLAN

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0 1.0 2.0 3.0 4.0 5.0 m

SCALE

CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF:
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PAKISTAN ENGINEERING SERVICES (PVT.) LTD.
DOLSAR ENGINEERING INC.CO.

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POWER INTAKE STOPLOG ARRANGEMENT

SCALE: AS SHOWN

DATE : MARCH, 2026

DRAWING No. ALHPP-HSS-0407

REV.

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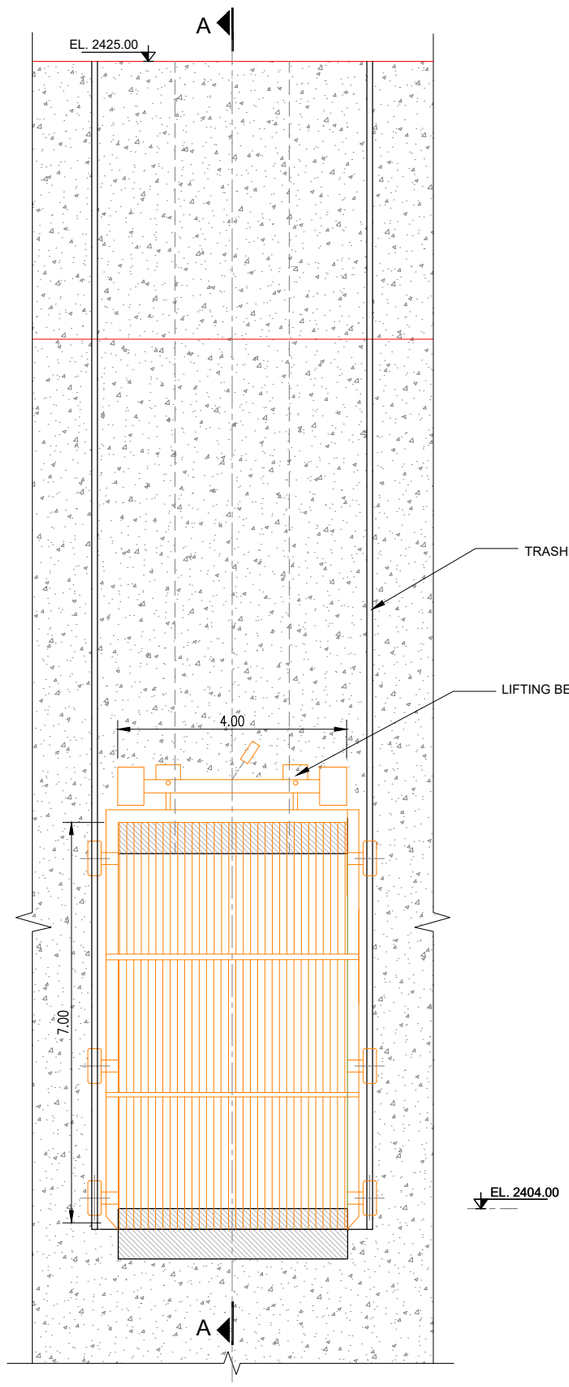
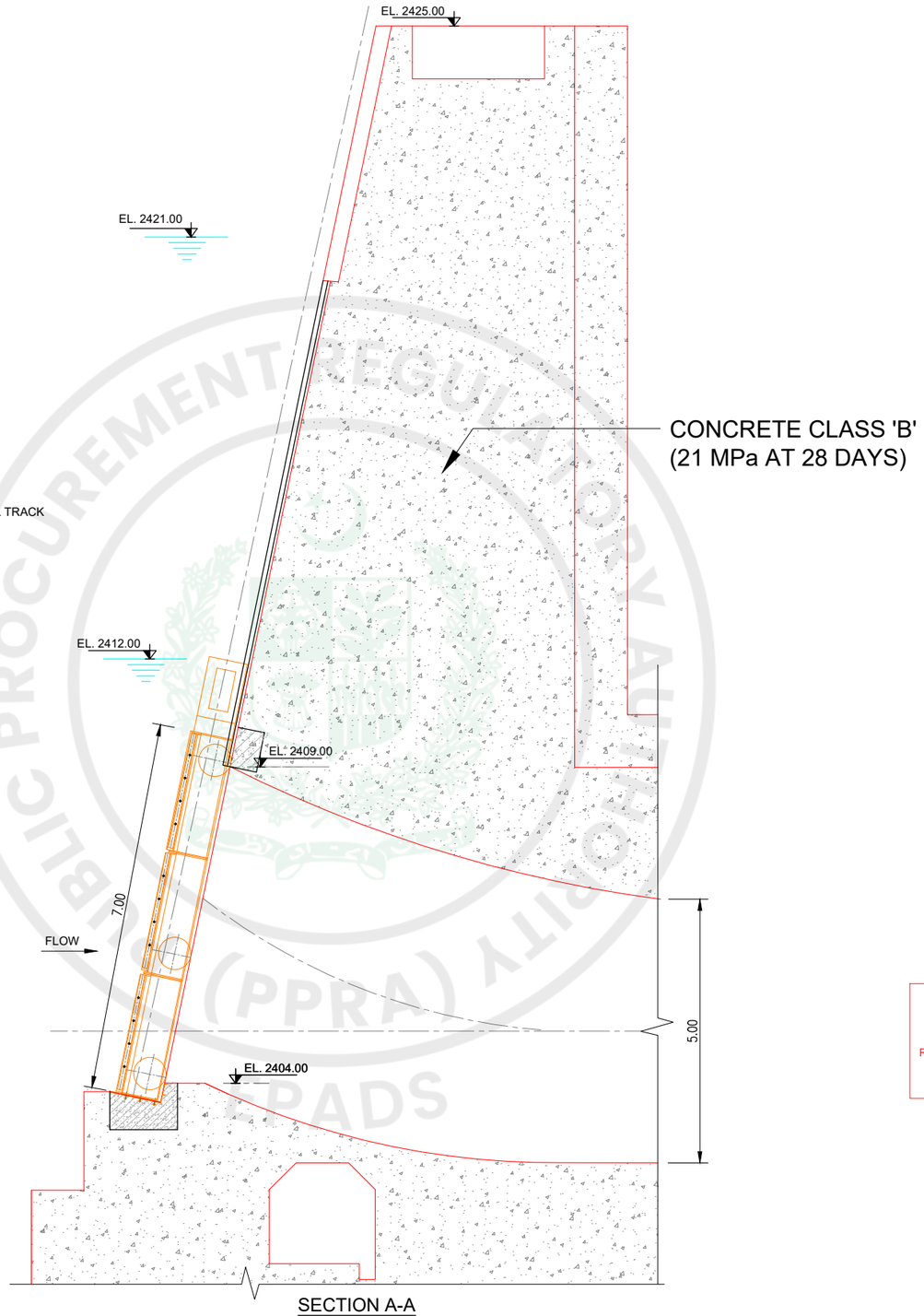
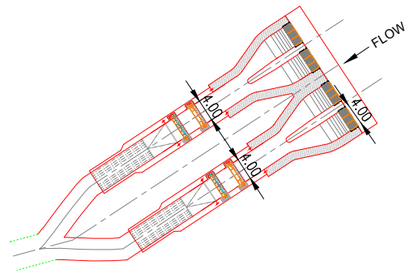



ELEVATION




SECTION A-A




KEY PLAN

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0 1.0 2.0 3.0 4.0 5.0 m
SCALE

CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF:
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DOLSAR ENGINEERING INC.CO.

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POWER INTAKE
TRASHRACK ARRANGEMENT

SCALE: AS SHOWN

DATE : MARCH, 2026

DRAWING No. ALHPP-HSS-0408

REV. 0

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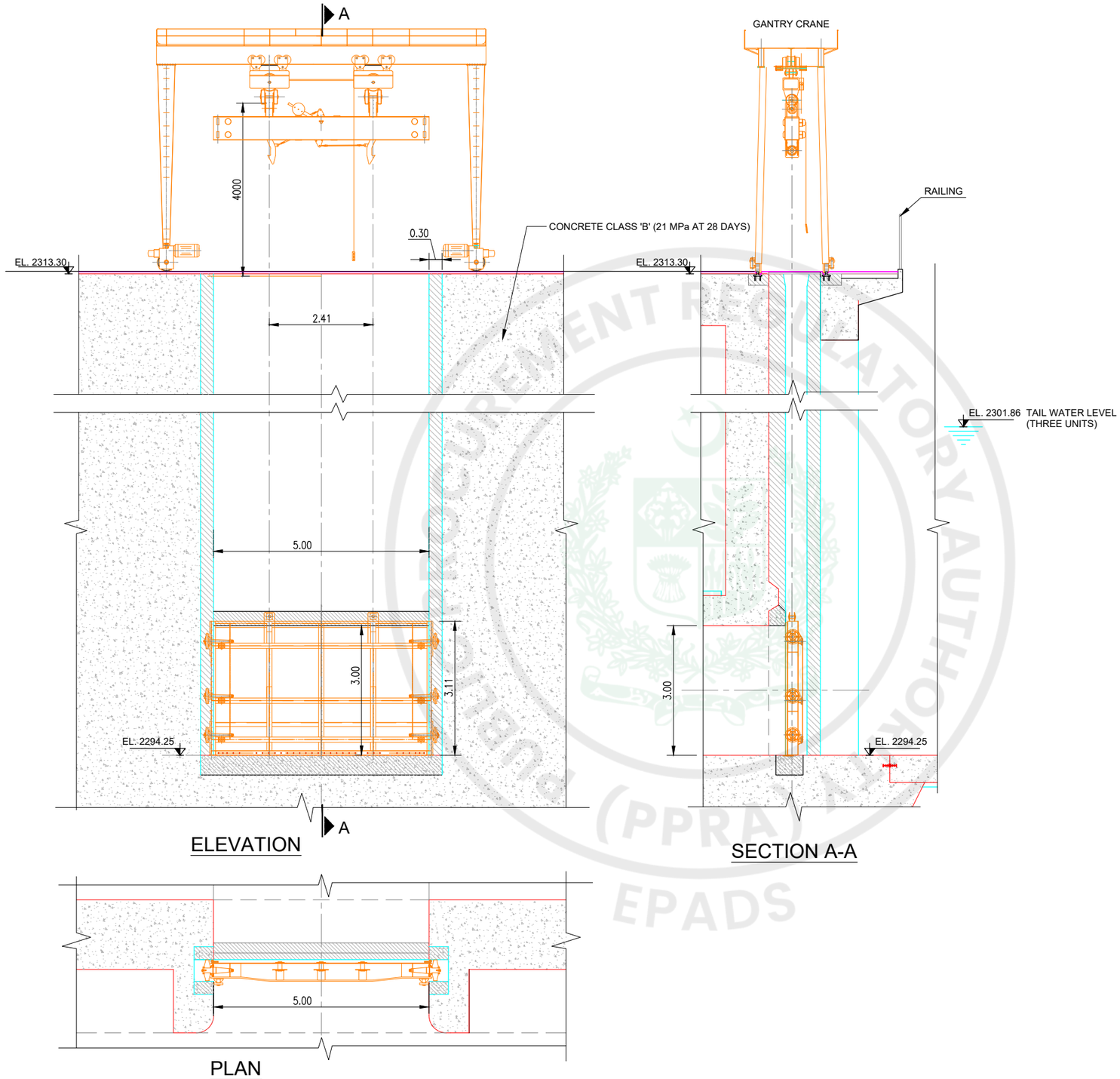


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SCALE

CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

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CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

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| APPROVED | - |

**POWERHOUSE**
**DRAFT TUBE GATE ARRANGEMENT**

SCALE: AS SHOWN

DATE : MARCH, 2026

DRAWING No. ALHPP-HSS-0409

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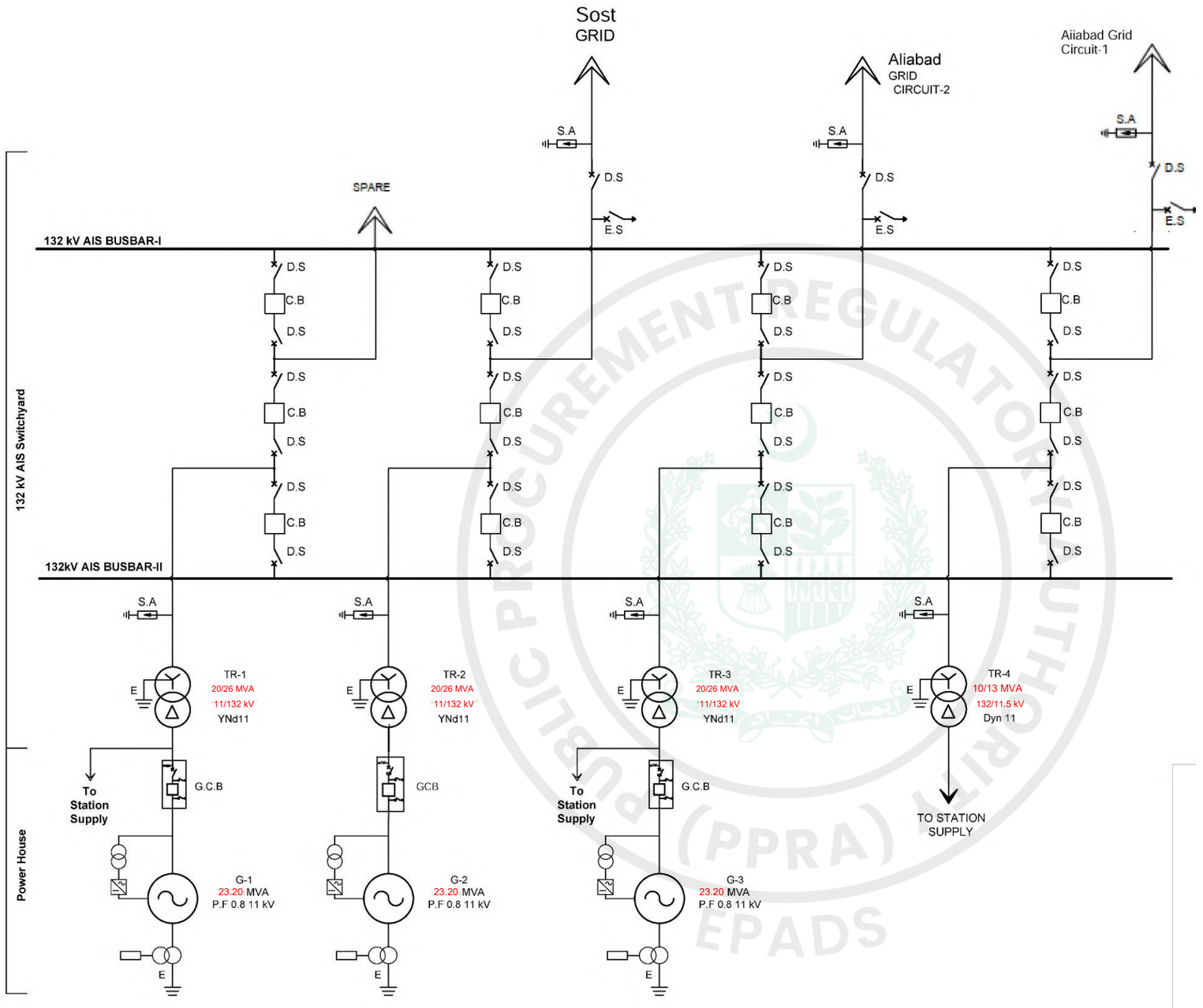


| LEGEND: | |
|---|---|
| SYMBOL | DESCRIPTION |
| | 3~ GENERATOR |
| | 132 kV CIRCUIT BREAKER |
| | TRANSFORMER |
| | TRANSMISSION LINE |
| | SURGE ARRESTER |
| | EARTH/GROUND |
| | NEUTRAL GROUND RESISTOR |
| | EARTHING SWITCH |
| | DISCONNECTOR SWITCH |
| | 11 kV GENERATOR C.B |

## DISCLAIMER:

THIS IS CONCEPT LEVEL DRAWING WITH NO GUARANTEE OF COMPLETENESS OR PRECISION. EPC CONTRACTOR WILL BE FULLY RESPONSIBLE FOR THE DETAIL DESIGN AND PREPARATION OF REQUIRED DRAWINGS TO ENSURE THE APPROPRIATE CONSTRUCTION, FUNCTIONALITY & EFFECTIVE OPERATION OF THE PROJECT (AS PER CONTRACT).

## NOTES:

1. DRAWING SHOWS THE BASIC CONCEPT OF ELECTRICAL SYSTEM. FINAL DESIGN SHALL BE DEVELOPED BY CONTRACTOR DURING DETAIL DESIGN STAGE.
2. FINAL RATINGS OF VARIOUS EQUIPMENT SHALL BE DETERMINED ON DETAILED DESIGN STAGE.
3. THIS DRAWING IS PREPARED BASED ON FEASIBILITY DRAWING NO. AFS-EM-451.

CLIENT:
PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT:
ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT:
AHMC ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF:
NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)
ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD.
BARQAAB CONSULTING SERVICES (PVT.) LTD.
PAKISTAN ENGINEERING SERVICES (PVT.) LTD.
DOLSAR ENGINEERING INC.CO.

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| DRAWN | ASIF SAMI |
| RECOMMENDED | - |
| CHD./VER. | - |
| APPROVED | - |

MAIN SINGLE LINE DIAGRAM

SCALE: AS SHOWN

DATE : MARCH, 2026

DRAWING No. ALHPP-PPE-0501

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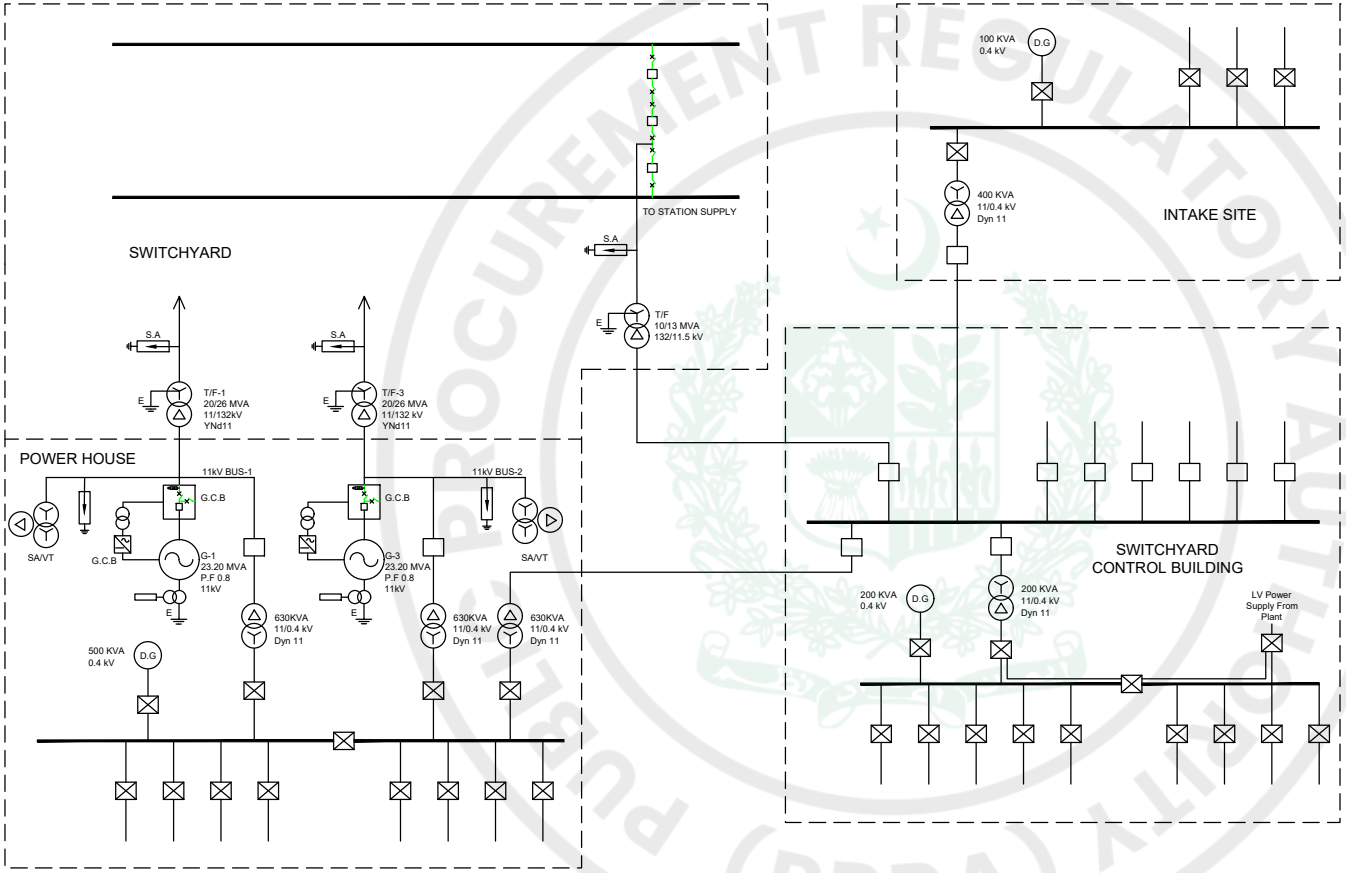


| LEGEND: | |
|---|---|
| SYMBOL | DESCRIPTION |
| | MV CIRCUIT BREAKER |
| | LV CIRCUIT BREAKER |
| | TRANSFORMER |
| | DIESEL GENERATOR |
| N.C | NORMALLY CLOSE |
| N.O | NORMALLY OPEN |

**DISCLAIMER:**

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NOTES:

1. DRAWING SHOWS THE BASIC CONCEPT OF ELECTRICAL SYSTEM. FINAL DESIGN SHALL BE DEVELOPED BY CONTRACTOR DURING DETAIL DESIGN STAGE.
2. FINAL RATINGS OF VARIOUS EQUIPMENT SHALL BE DETERMINED ON DETAILED DESIGN STAGE.
3. THE NUMBER OF CIRCUITS FOR 11kV & 400V SUPPLY SHALL BE DETERMINED BY THE ENGINEER/CONTRACTOR BASED ON THE AUXILIARY LOAD OF THE PLANT.
4. THIS DRAWING IS PREPARED BASED ON FEASIBILITY DRAWING NO. AFS-EM-452.

CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: AHMC ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF: NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)

ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD. | BARQAAB CONSULTING SERVICES (PVT.) LTD. | PAKISTAN ENGINEERING SERVICES (PVT.) LTD. | DOLSAR ENGINEERING INC.CO.

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| DRAWN | ASIF SAMI |
| RECOMMENDED | - |
| CHD./VER. | - |
| APPROVED | - |

**AC SUPPLY SYSTEM ( OVERALL SCHEME )**

SCALE: AS SHOWN

DATE : MARCH, 2026

DRAWING No. ALHPP-PPE-0502

REV. 0

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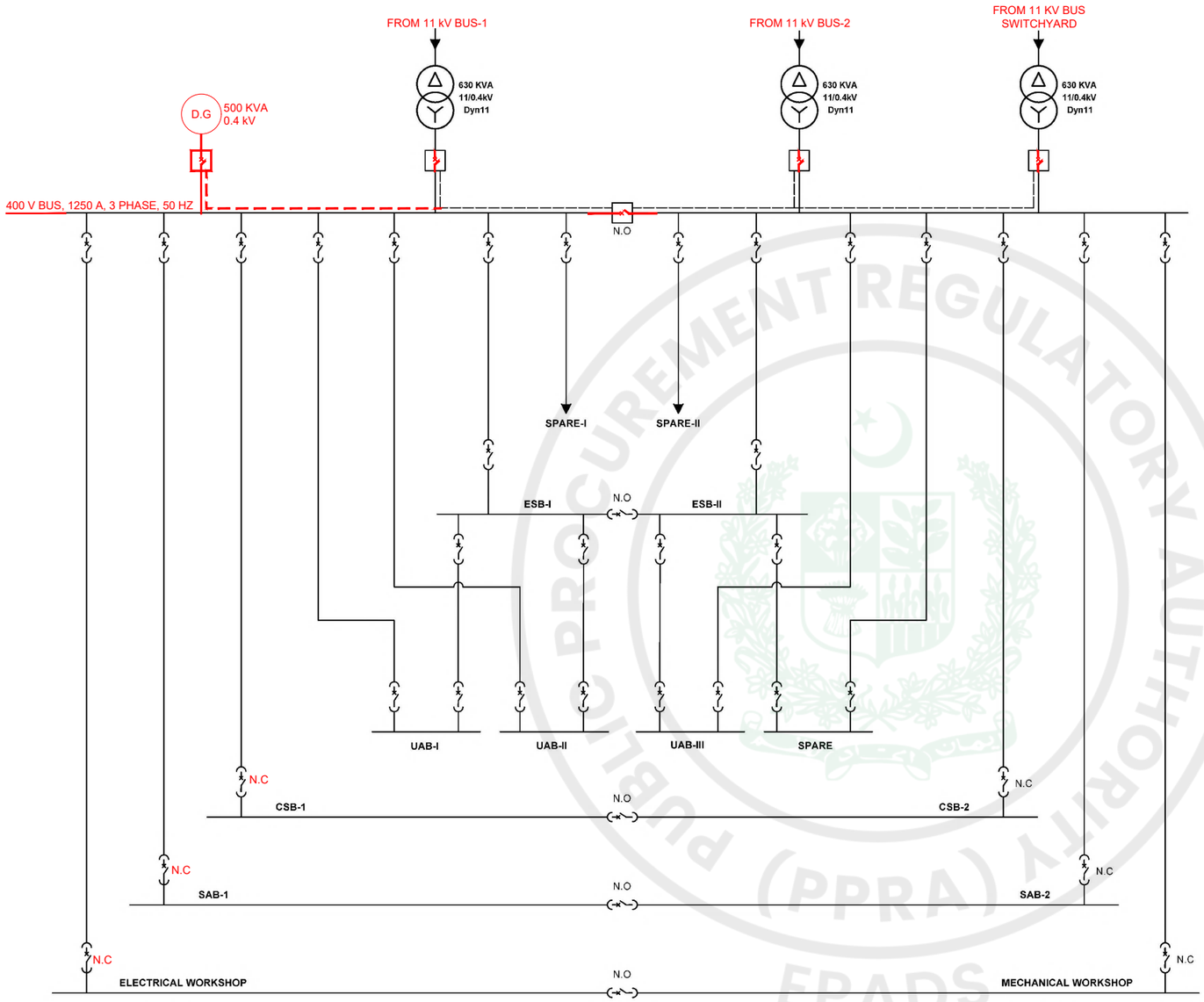


| LEGEND: | |
|---|---|
| SYMBOL | DESCRIPTION |
| | LV CIRCUIT BREAKER |
| | TRANSFORMER |
| D.G | DIESEL GENERATOR |
| N.C | NORMALLY CLOSE |
| N.O | NORMALLY OPEN |

**DISCLAIMER:**

THIS IS CONCEPT LEVEL DRAWING WITH NO GUARANTEE OF COMPLETENESS OR PRECISION. EPC CONTRACTOR WILL BE FULLY RESPONSIBLE FOR THE DETAIL DESIGN AND PREPARATION OF REQUIRED DRAWINGS TO ENSURE THE APPROPRIATE CONSTRUCTION, FUNCTIONALITY & EFFECTIVE OPERATION OF THE PROJECT (AS PER CONTRACT).

NOTES:

1. DRAWING SHOWS THE BASIC CONCEPT OF ELECTRICAL SYSTEM. FINAL DESIGN SHALL BE DEVELOPED BY CONTRACTOR DURING DETAIL DESIGN STAGE.
2. FINAL RATINGS OF VARIOUS EQUIPMENT SHALL BE DETERMINED ON DETAILED DESIGN STAGE.
3. THE NUMBER OF CIRCUITS FOR 400V SUPPLY SHALL BE DETERMINED BY THE ENGINEER/CONTRACTOR BASED ON THE AUXILIARY LOAD OF THE PLANT.
4. THIS DRAWING IS PREPARED BASED ON FEASIBILITY DRAWING NO. AFS-EM-453.

CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF:
NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)
ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD.
BARQAAB CONSULTING SERVICES (PVT.) LTD.
PAKISTAN ENGINEERING SERVICES (PVT.) LTD.
DOLSAR ENGINEERING INC.CO.

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| DRAWN | ASIF SAMI |
| RECOMMENDED | - |
| CHD./VER. | - |
| APPROVED | - |

**POWER HOUSE AC LV SUPPLY SYSTEM**

SCALE: AS SHOWN

DATE : MARCH, 2026

DRAWING No. ALHPP-PPE-0503

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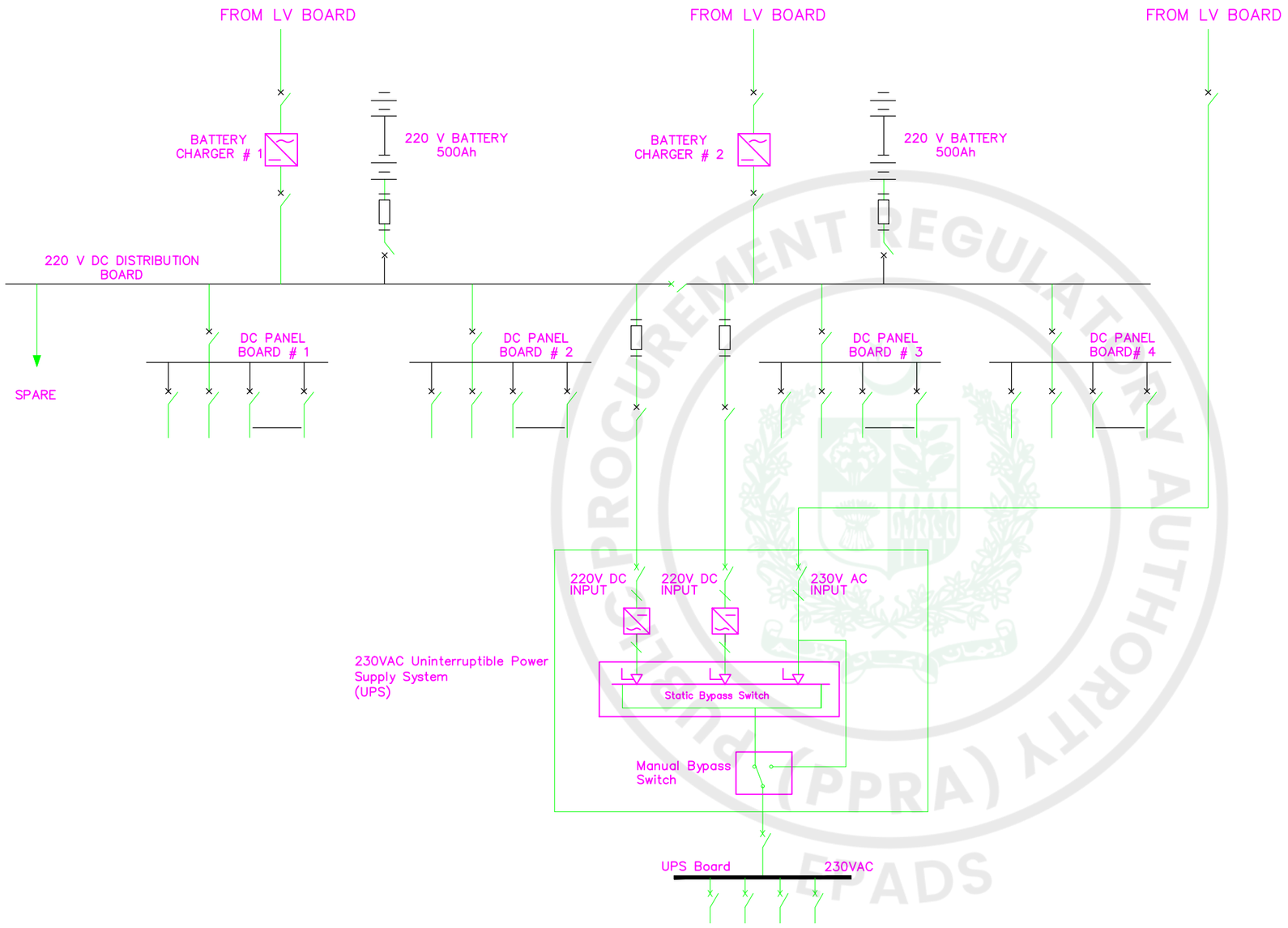


| LEGEND | |
|---|---|
| | LV CIRCUIT BREAKER |
| | FUSE |

**DISCLAIMER:**

THIS IS CONCEPT LEVEL DRAWING WITH NO GUARANTEE OF COMPLETENESS OR PRECISION. EPC CONTRACTOR WILL BE FULLY RESPONSIBLE FOR THE DETAIL DESIGN AND PREPARATION OF REQUIRED DRAWINGS TO ENSURE THE APPROPRIATE CONSTRUCTION, FUNCTIONALITY & EFFECTIVE OPERATION OF THE PROJECT (AS PER CONTRACT).

NOTES:

1. THE DRAWING DETAILS THE BASIC CONCEPT OF THE DC & AC ESSENTIAL SYSTEM. FINAL DETAILS SHALL BE DEVELOPED BY THE EPC CONTRACTOR DURING DETAILED DESIGN STAGE.
2. DETAILS, RATINGS AND LOAD PROFILES OF THE FOLLOWING EQUIPMENT SHALL BE DEFINED BY THE EPC CONTRACTOR:
   - BATTERY CHARGERS
   - BATTERY
   - INVERTER SYSTEM
   - DC SWITCHGEAR & PANEL BOARDS
3. THE NUMBER OF FEEDERS OF DC & AC PANEL BOARDS ARE FOR INDICATIVE PURPOSE ONLY, THE EXACT NUMBER OF FEEDERS REQUIRED SHALL BE DEFINED BY THE EPC CONTRACTOR.

CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF:
NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)
ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD.
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PAKISTAN ENGINEERING SERVICES (PVT.) LTD.
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| DRAWN | ASIF SAMI |
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| CHD./VER. | - |
| APPROVED | - |

**POWER HOUSE DC SUPPLY SYSTEM**

SCALE: AS SHOWN

DATE : MARCH, 2026

DRAWING No. ALHPP-PPE-0504

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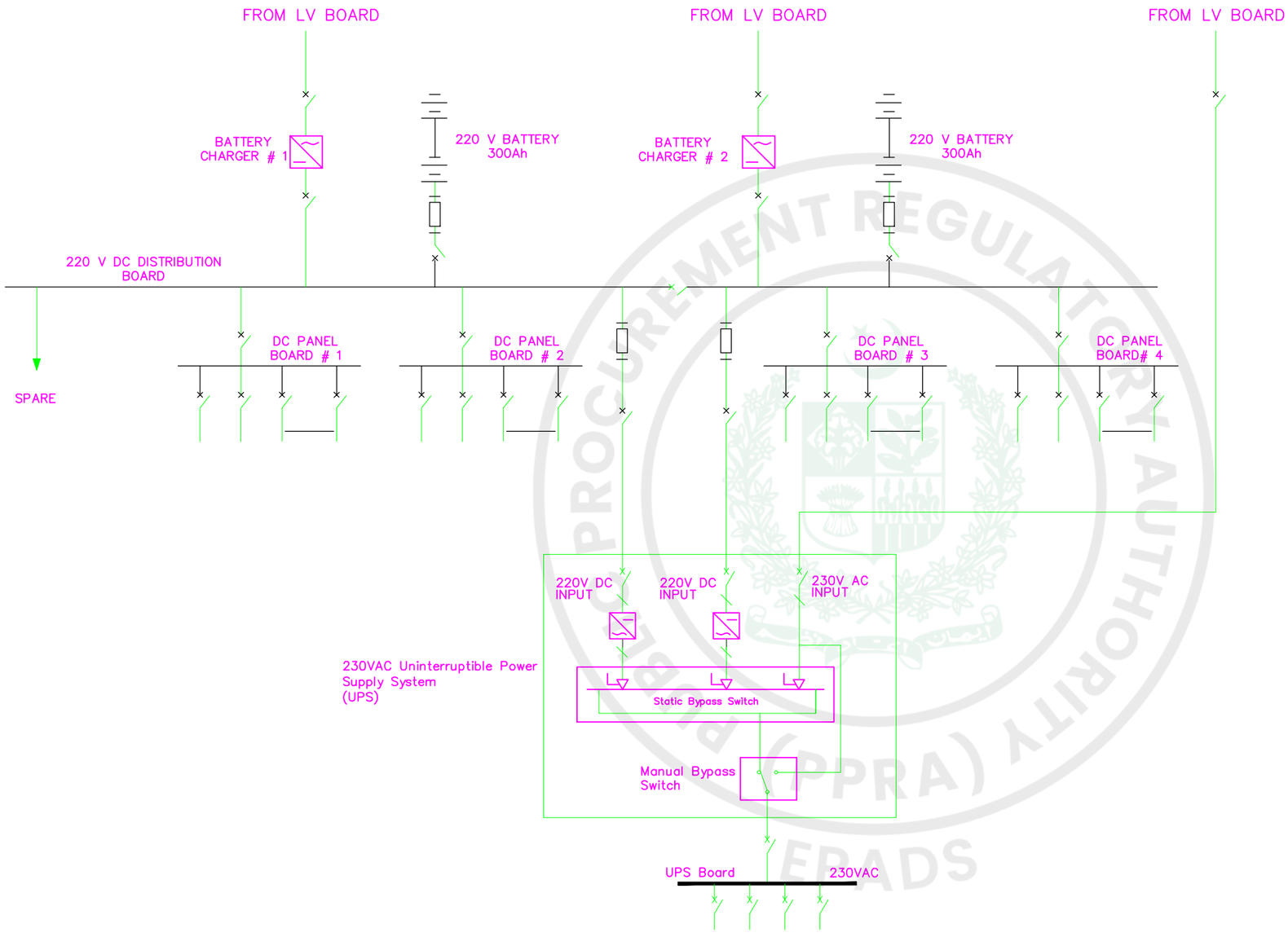


| LEGEND | |
|---|---|
| | LV CIRCUIT BREAKER |
| | FUSE |

**DISCLAIMER:**

THIS IS CONCEPT LEVEL DRAWING WITH NO GUARANTEE OF COMPLETENESS OR PRECISION. EPC CONTRACTOR WILL BE FULLY RESPONSIBLE FOR THE DETAIL DESIGN AND PREPARATION OF REQUIRED DRAWINGS TO ENSURE THE APPROPRIATE CONSTRUCTION, FUNCTIONALITY & EFFECTIVE OPERATION OF THE PROJECT (AS PER CONTRACT).

NOTES:

1. THE DRAWING DETAILS THE BASIC CONCEPT OF THE DC & AC ESSENTIAL SYSTEM. FINAL DETAILS SHALL BE DEVELOPED BY THE EPC CONTRACTOR DURING DETAILED DESIGN STAGE.
2. DETAILS, RATINGS AND LOAD PROFILES OF THE FOLLOWING EQUIPMENT SHALL BE DEFINED BY THE EPC CONTRACTOR:
   - BATTERY CHARGERS
   - BATTERY
   - INVERTER SYSTEM
   - DC SWITCHGEAR & PANEL BOARDS
3. THE NUMBER OF FEEDERS OF DC & AC PANEL BOARDS ARE FOR INDICATIVE PURPOSE ONLY, THE EXACT NUMBER OF FEEDERS REQUIRED SHALL BE DEFINED BY THE EPC CONTRACTOR.

CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF:
NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)
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| DRAWN | ASIF SAMI |
| RECOMMENDED | - |
| CHD./VER. | - |
| APPROVED | - |

**POWER INTAKE DC SUPPLY SYSTEM**

SCALE: AS SHOWN

DATE : MARCH, 2026

DRAWING No. ALHPP-PPE-0505

REV. 0

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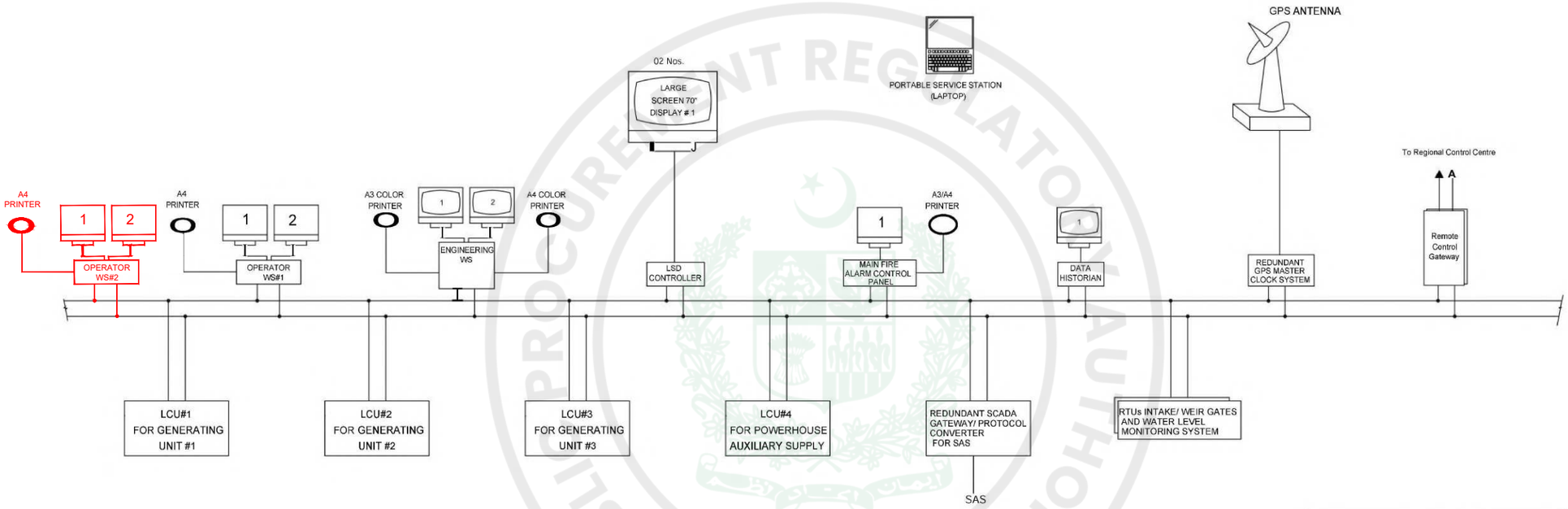


| LEGEND | |
|---|---|
| LCU | LOCAL CONTROL UNIT |
| LSD | LARGE SCREEN DISPLAY |
| GPS | GLOBAL POSITIONING SYSTEM |
| WS | WORKSTATION |

**DISCLAIMER:**

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NOTES:

1. THE DRAWING SHOWS THE BASIC CONCEPT OF PCS CONFIGURATION, FINAL DETAIL SHALL BE DEVELOPED BY THE EPC CONTRACTOR DURING DESIGN STAGE.

CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF:
NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)
ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD.
BARQAAB CONSULTING SERVICES (PVT.) LTD.
PAKISTAN ENGINEERING SERVICES (PVT.) LTD.
DOLSAR ENGINEERING INC.CO.

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**PCS CONCEPTUAL LAYOUT**

SCALE: AS SHOWN

DATE : MARCH, 2026

DRAWING No. ALHPP-PPE-0506

REV. 0

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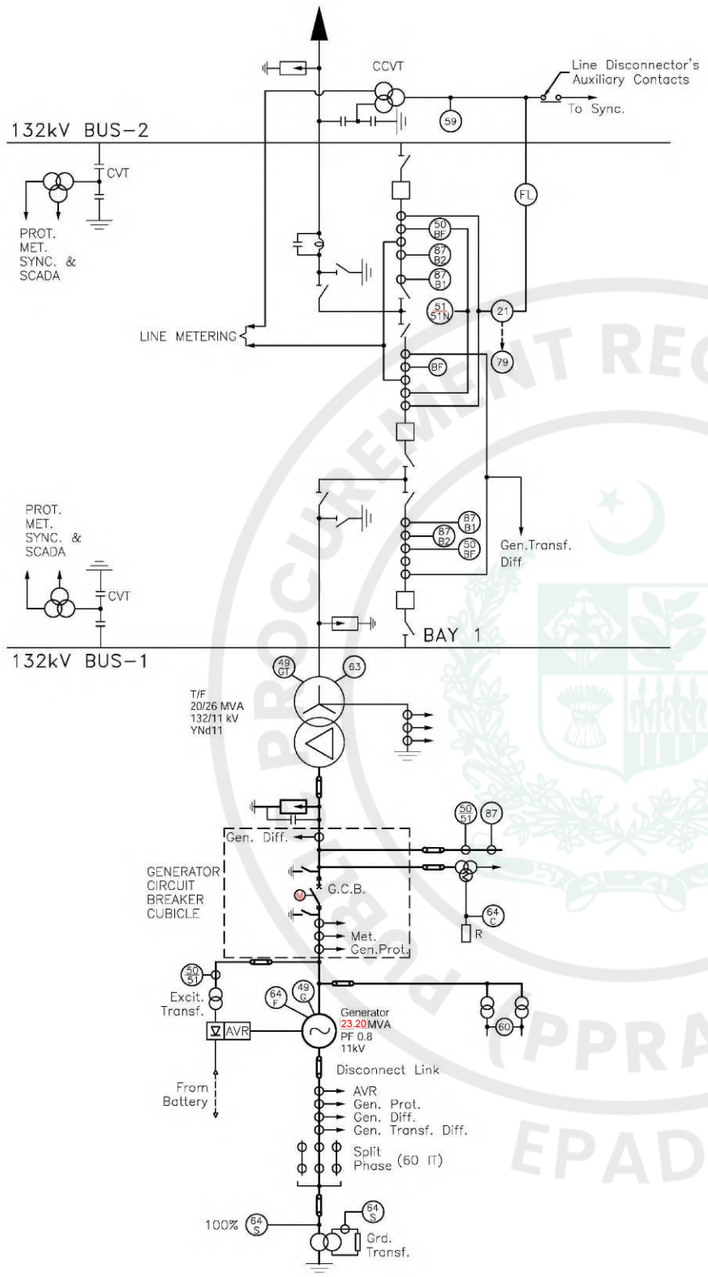


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NOTE:

1. DRAWING SHOWS THE BASIC CONCEPT OF ELECTRICAL PROTECTION SYSTEM. FINAL PROTECTION DESIGN EQUIPMENT RATINGS SHALL BE DETERMINED BY ENGINEER/CONTRACTOR DURING DETAIL DESIGN STAGE.
2. THIS DRAWING IS PREPARED BASED ON FEASIBILITY DRAWING NO. AFS-EM-457.

CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF:
NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)
ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD.
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PAKISTAN ENGINEERING SERVICES (PVT.) LTD.
DOLSAR ENGINEERING INC.CO.

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| DRAWN | ASIF SAMI |
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| APPROVED | - |

**PROTECTION SCHEMES**

SCALE: AS SHOWN

DATE : MARCH, 2026

DRAWING No. ALHPP-PPE-0507

REV. 0

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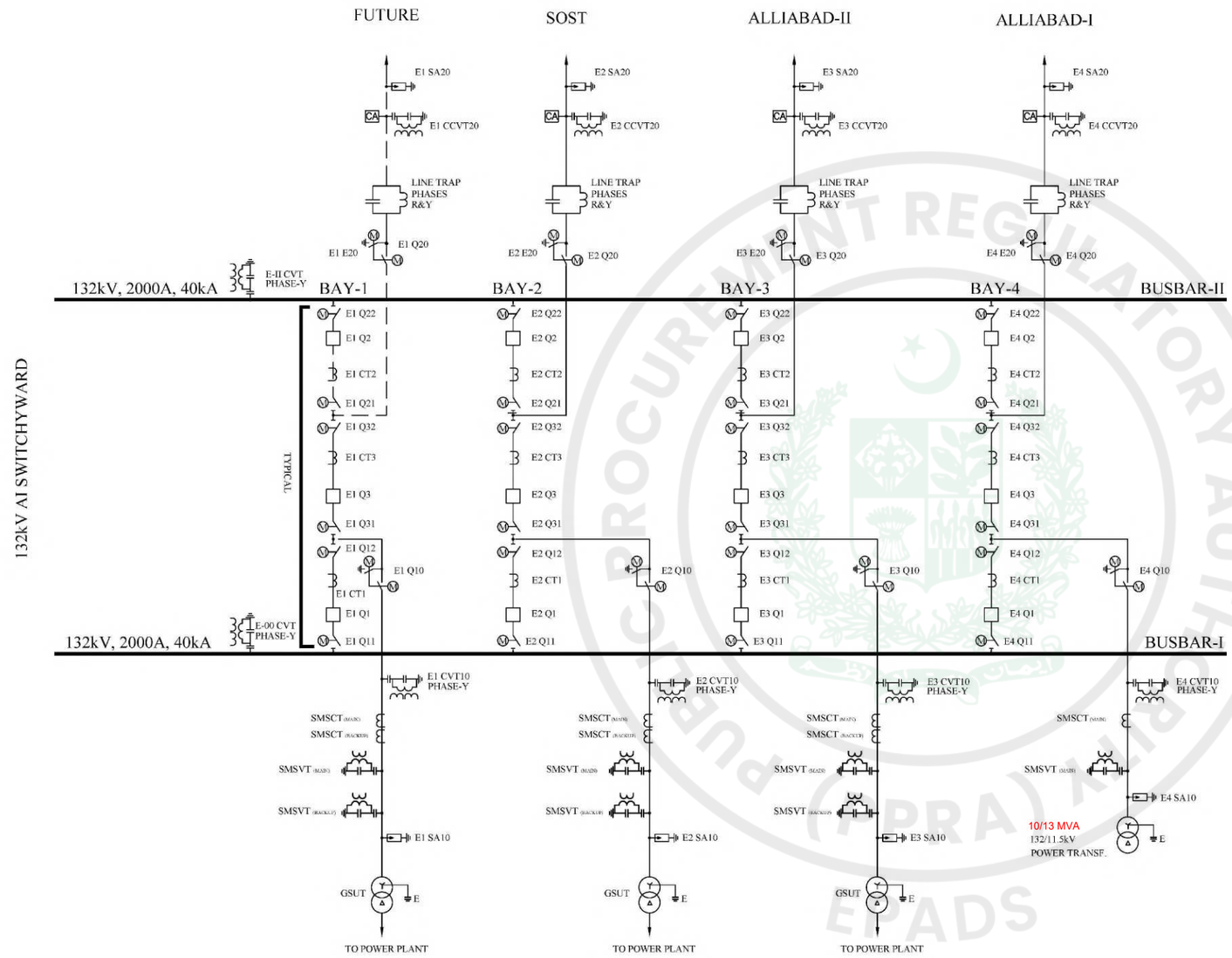


**LEGEND:-**

| SYMEOLS | DESCRIPTION | 132kV |
|---|---|---|
| | POWER TRANSFORMER (PTR), STATION AUXILIRAY TRANSFORMER (PMT) | 10/13 MVA |
| | CIRCUIT BREAKER | 2000A, 40kA |
| | MOTOR OPERATED DISCONNECTOR | 2000A, 40kA |
| | DISCONNECTOR WITH EARTHING SWITCH (MOTOR OPERATED) | 2000A, 40kA |
| | CURRENT TRANSFORMER | FOR CB SIDE CT 1600/800/400/150/1A<br>FOR PTR SIDE CT 1600/800/400/150/1A<br>SMS CT 1600/400/150/1A |
| | CAPACITOR VOLTAGE TRANSFORMER (CVT) SMS | 132kV/$\sqrt{3}$/ 110/$\sqrt{3}$ V,/110V 0.2 + 3P, 3P |
| | CURRENT TRANSFORMER (CT) SMS | |
| | SURGE ARRESTER | 120kV, 98kV |
| | LINE TRAP | - |
| | SECURE METERING SYSTEM VOLTAGE TRANSFORMER (SMSVT) | 132kV/$\sqrt{3}$/ 110/$\sqrt{3}$ V,/110V 0.2 |
| CA | COUPLING CAPACITOR VOLTAGE TRANSFORMER (CCVT) WITH CARRIER FREQUANCY FACILITY | 132kV/$\sqrt{3}$/ 110/$\sqrt{3}$ V,/110V 0.2 + 3P, 3P |

**LEGEND:-**

SCOPE OF WORK

FOR FUTURE

**NOTES:**

1. **ALL 5P20 CLASS CTs SHALL EE AS PER IEC 61869-2.**
2. **132kV BAY EQUIPMENT ARE RATED 2000A, 40kA.**

**DISCLAIMER:**

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CLIENT: **PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY**

PROJECT: **ATTABAD LAKE HYDROPOWER PROJECT (54 MW)**

**CONSULTANT:** ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF:
NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)
ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD.
BARQAAB CONSULTING SERVICES (PVT.) LTD.
PAKISTAN ENGINEERING SERVICES (PVT.) LTD.
DOLSAR ENGINEERING INC.CO.

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| DRAWN | ASIF SAMI |
| RECOMMENDED | - |
| CHD./VER. | - |
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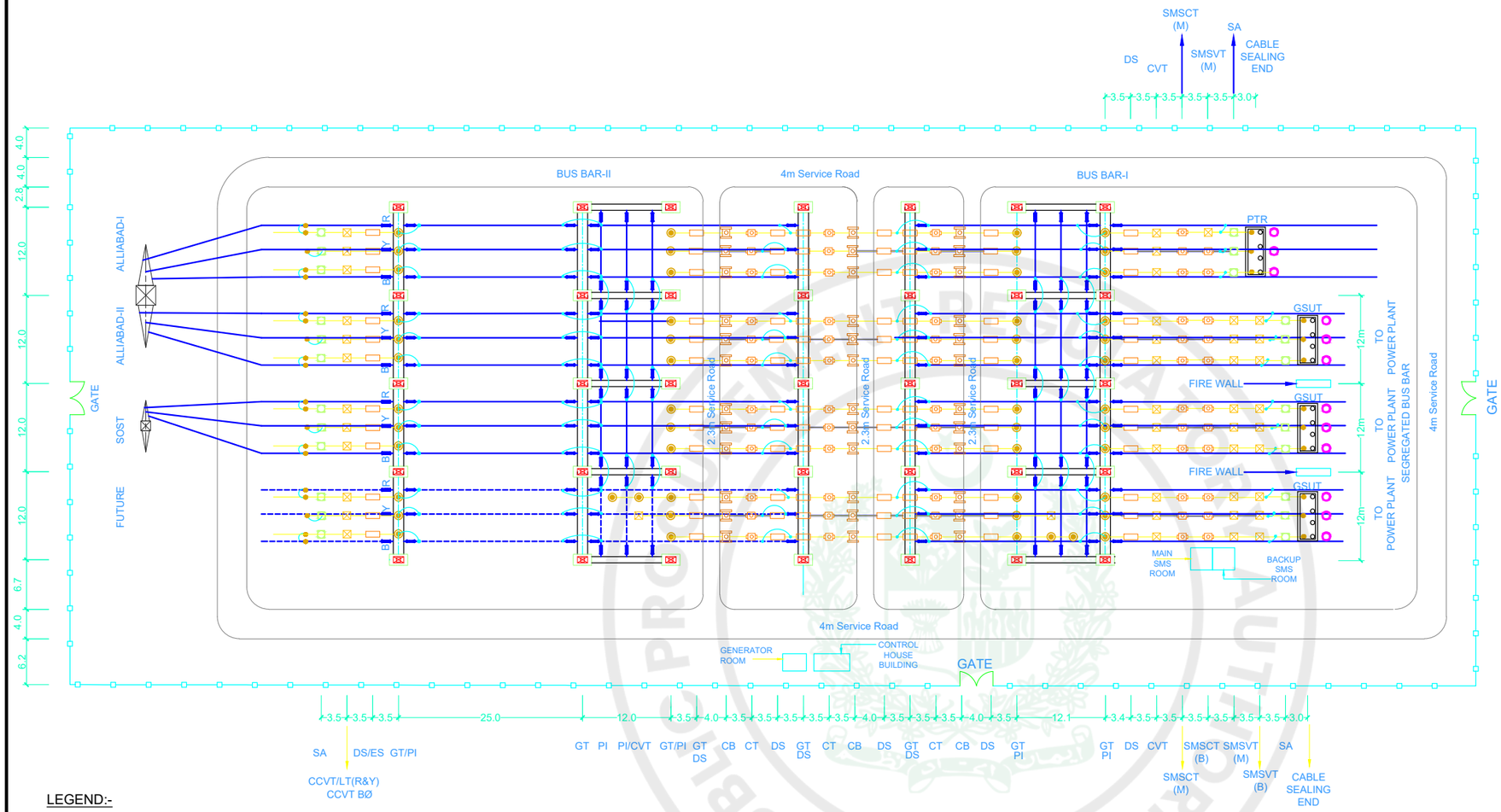
**132 kV SWITCHYARD SINGLE LINE DIAGRAM**

SCALE: AS SHOWN

DATE : MARCH, 2023

DRAWING No. ALHPP-SY-0601

REV. 0




LEGEND:-

| SYMBOLS | DESCRIPTION |
|---|---|
| | SURGE ARRESTER (SA) |
| | CAPACITOR VOLTAGE TRANSFORMER (CVT) |
| | LINE TRAP (LT) |
| | GANTRY TOWER (GT) |
| | SHIELD WIRE |
| | CREOPISES/TUBULOR CONDUCTOR |
| | POST INSULATOR (PI) |
| | INSULATOR STRING (TENSION) |
| | MARSHALLING KIOSK (M.K) |
| | DISCONNECTOR SWITCH (DS) |
| | CIRCUIT BREAKER (CB) |
| | CURRENT TRANSFORMER (CT) |

## NOTES:

1. SPANS BETWEEN SUBSTATION GANTRIES AND THE RELEVANT TRANSMISSION LINE TOWERS SHALL BE FURNISHED BY OTHERS. HOWEVER, THE CONTRACTOR SHALL SUPPLY AND INSTALL ALL NECESSARY JUMPERS/DROPPERS AND HARDWARE FOR CONNECTIONS BETWEEN TRANSMISSION LINES AND THE SUBSTATION EQUIPMENT.
2. INSTALL ALUMINIUM ALLOY CONDUCTOR INSIDE THE ALLUMINIUM TUBULAR CONDUCTOR TO PREVENT VIBRATION AND TACK-WELDING TO PREVENT ARCING OF THIS PARALLEL CONDUCTOR AT THE ENDS.
3. CORROSION INHIBITING COMPOUNDS SHALL BE USED FOR ALL ELECTRICAL CONNECTIONS AND SHALL BE APPLIED TO CONTACT GROOVES AND ON CONDUCTORS PRIOR TO ASSEMBLY.
4. BUS SUPPORT CLAMPS SHALL BE DESIGNED TO ALLOW FOR THERMAL EXPANSION.
5. SPECIAL CARE SHALL BE EXERCISED IN HANDLING ALL TUBING, CABLE AND FITTINGS TO PREVENT SCRATCHES ON THEIR SURFACES. TO PREVENT CORONA, ALL WELDS MADE ON CONDUCTORS OR FITTINGS SHALL BE MADE WITH A SMOOTH BEAD WHICH SHALL BE FILED AND SANDED.
6. LAYOUT SHALL BE ADJUSTED DURING DETAIL DESIGN STAGE
7. ALL DIMENSIONS SHALL BE MEASURED FROM TOP OF FOUNDATIONS.
8. INTERCONNECTION BETWEEN POWER HOUSE AND 132kV SWITCHYARD WILL BE THROUGH SEGREGATED BUS BAR AS SPECIFIED IN POWER PLANT SPECIFICATION.

**DISCLAIMER:**

THIS IS CONCEPT LEVEL DRAWING WITH NO GUARANTEE OF COMPLETENESS OR PRECISION. EPC CONTRACTOR WILL BE FULLY RESPONSIBLE FOR THE DETAIL DESIGN AND PREPARATION OF REQUIRED DRAWINGS TO ENSURE THE APPROPRIATE CONSTRUCTION, FUNCTIONALITY & EFFECTIVE OPERATION OF THE PROJECT (AS PER CONTRACT).

CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF: NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)

ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD. | BARQAAB CONSULTING SERVICES (PVT.) LTD.

PAKISTAN ENGINEERING SERVICES (PVT.) LTD. | DOLSAR ENGINEERING INC.CO.

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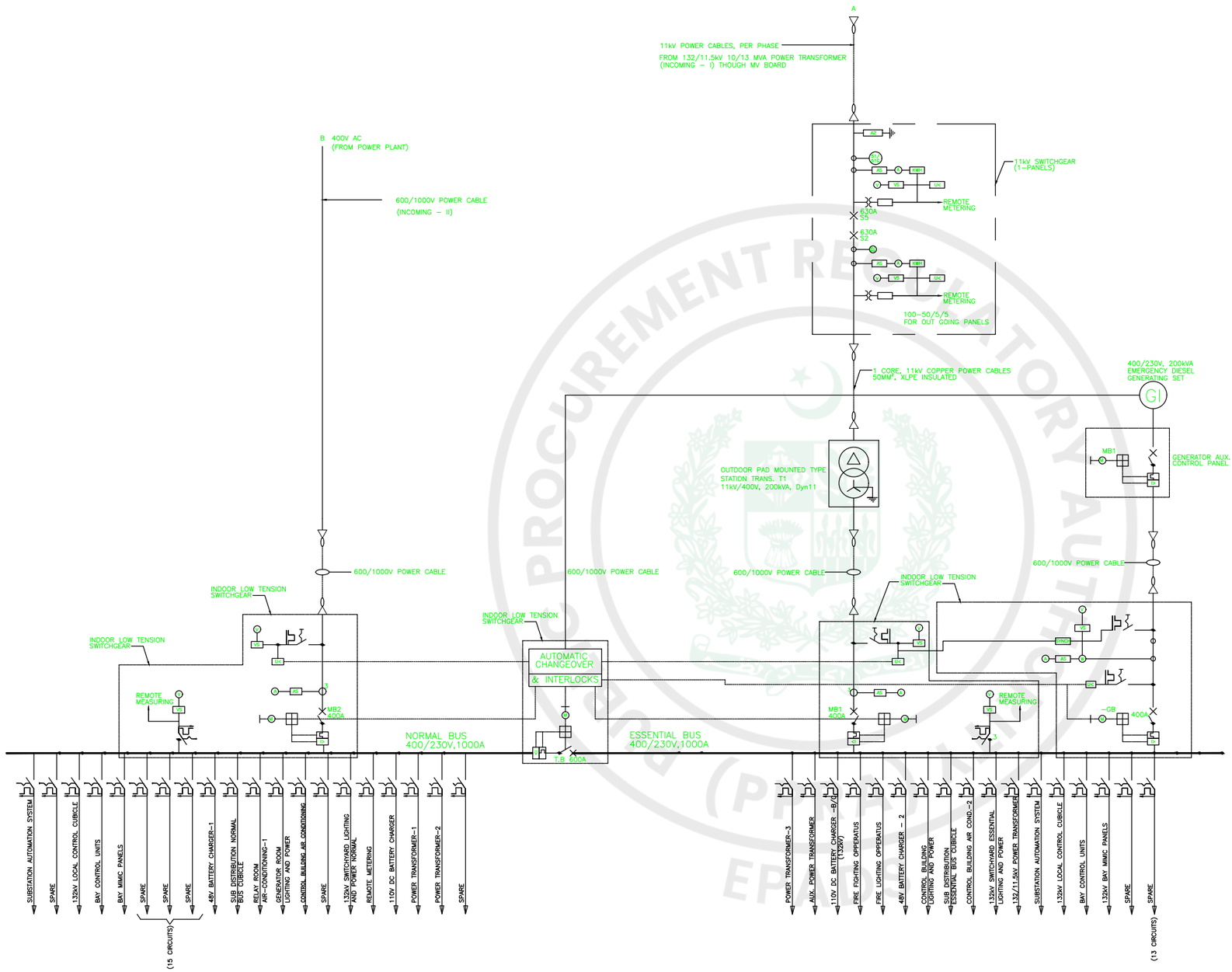
**132 kV SWITCHYARD EQUIPMENT ARRANGEMENT PLAN**

SCALE: AS SHOWN

DATE : MARCH, 2023

DRAWING No. ALHPP-SY-0602

REV. 0




LEGEND:-

| SYMBOL | DESCRIPTION |
|---|---|
| M | MOTOR OPERATED CONTROL |
| | MOLDED CASE CIRCUIT BREAKER |
| G1 | DIESEL GENERATING SET |
| 50 | DEFINITE TIME OVER CURRENT RELAY |
| 50/G | GROUND FAULT RELAY |
| 87 | POWER TRANSFORMER DIFFERENTIAL CURRENT PROTECTION |
| | STATION AUXILIARY TRANSFORMER |
| SYNH | SYNCHROSCOPE |
| W | WATT - METER |
| VS | VOLT METER SELECTOR SWITCH |
| AS | AMMETER SELECTOR SWITCH |
| KWH | KILOWATT - HOUR METER |
| VH | VAR - HOUR METER |
| U< | UNDER VOLTAGE RELAY |
| | RESISTOR |
| SA | SURGE ARRESTOR |
| | AIR CIRCUIT BREAKER (MOTOR OPERATED) |
| | CURRENT TRANSFORMER |
| A | AMMETER |
| V | VOLTMETER |
| | VACUUM CIRCUIT BREAKER (11kV) |
| | POTENTIAL TRANSFORMER |
| G.B | GENERATOR BREAKER |
| M.B | MAIN BREAKER |
| T.B | TIE BREAKER |

NOTES:

1. THIS DRAWING SHOWS ONLY TYPICAL AC OUTGOING CIRCUITS.
2. EMERGENCY DIESEL GENERATING SET SHALL BE SUPPLIED COMPLETE WITH CONTROL, PROTECTION, METERING, INDICATION AND ANNUNCIATION SYSTEMS AS SPECIFIED.
3. FOLLOWING REMOTE CONTROLS OF THE DIESEL GENERATOR/DIESEL ENGINE SHALL BE PROVIDED ON THE DIESEL GENERATOR PANEL IN CONTROL ROOM:
   A) DIESEL GENERATOR START.
   B) GENERATOR STOP.
   C) VOLTAGE AND CURRENT INDICATION.
   D) FREQUENCY INDICATION.
4. DETAILS FOR CONTROL, METERING, INDICATIONS AND OTHER INSTRUMENTS RELEVANT TO AC SYSTEM SHALL BE FINALIZED AT THE DETAIL DESIGN STAGE.
5. THE SIZES OF THE CABLES ON THIS DRAWING ARE APPROXIMATE SIZES. THE CONTRACTOR SHALL SUBMIT CALCULATIONS FOR APPROVAL OF THE EMPLOYER'S REPRSENTATIVE FOR THE SELECTION OF CABLES STAGE.
6. THE CONTRACTOR SHALL PROVIDE SUB-DISTRIBUTION BOARDS AS SPECIFIED / REQUIRED BY THE EMPLOYER'S REPRESENTATIVE.
7. THE SIZE OF BUSBAR AND MCBs SHALL BE DETERMINED BY THE CONTRACTOR AND SHALL BE SUBJECT TO APPROVAL BY THE EMPLOYER'S REPRESENTATIVE. FRAME SIZES OF MCBs SHALL BE 250A MINIMUM.
8. BCU SHALL BE PROVIDED TO COVER ALL 11kV SWGR SIGNALS TO SAS.
9. ENERGY METERS FOR 400V SHALL BE HOUSED IN EACH PAD MOUNTED TRANSFORMER.

**DISCLAIMER:**

THIS IS CONCEPT LEVEL DRAWING WITH NO GUARANTEE OF COMPLETENESS OR PRECISION. EPC CONTRACTOR WILL BE FULLY RESPONSIBLE FOR THE DETAIL DESIGN AND PREPARATION OF REQUIRED DRAWINGS TO ENSURE THE APPROPRIATE CONSTRUCTION, FUNCTIONALITY & EFFECTIVE OPERATION OF THE PROJECT (AS PER CONTRACT).

CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF:
NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)
ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD.
PAKISTAN ENGINEERING SERVICES (PVT.) LTD.
BARQAAB CONSULTING SERVICES (PVT.) LTD.
DOLSAR ENGINEERING INC.CO.

| REV. | DATE | DESCRIPTION | APPROVED |
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| DRAWN | ASIF SAMI |
| RECOMMENDED | - |
| CHD./VER. | - |
| APPROVED | - |

**132 kV SWITCHYARD AC AUXILIARY SERVICES SYSTEM (TYPICAL)**

SCALE: AS SHOWN

DATE : MARCH, 2023

DRAWING No. ALHPP-SY-0603

REV. 0

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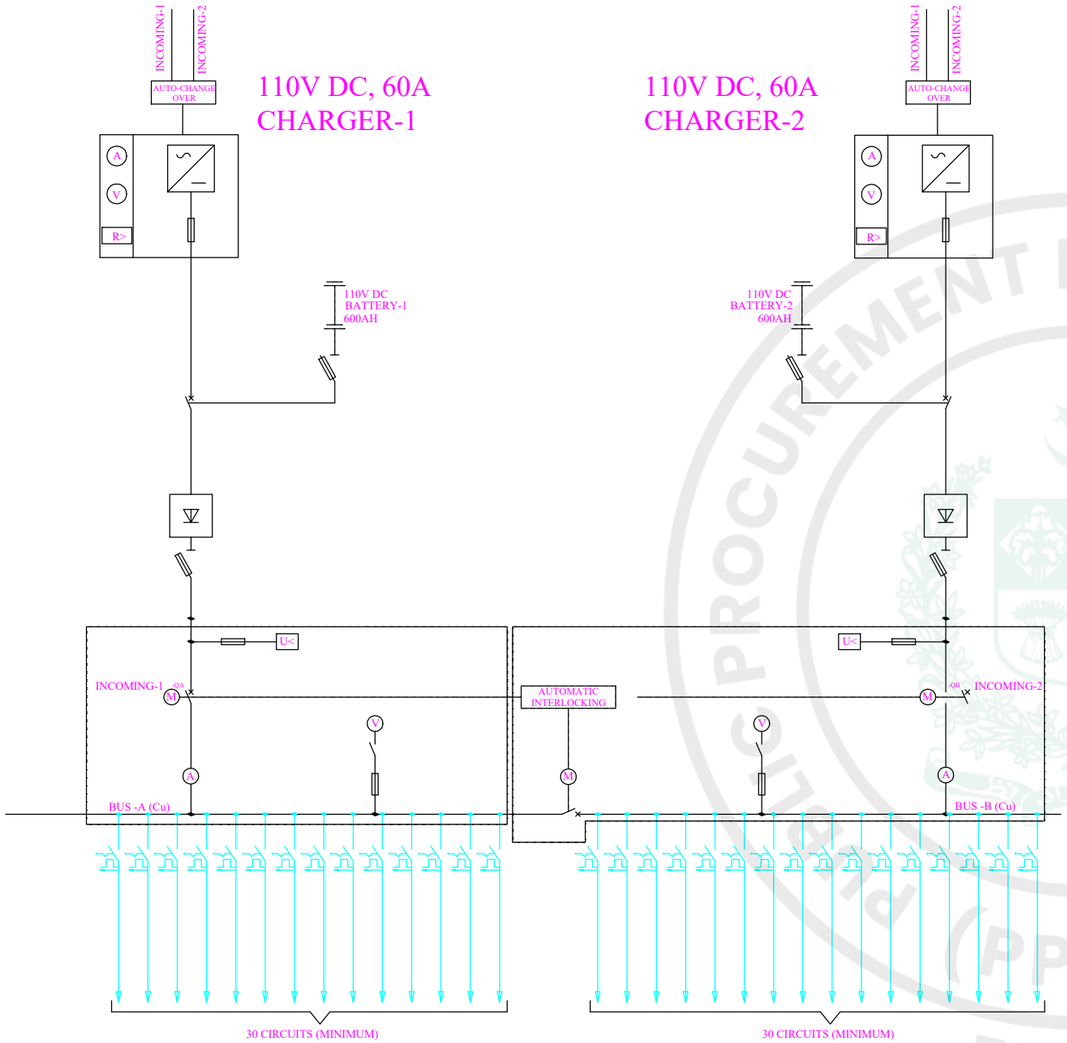


LEGEND:-

| SYMBOL | DESCRIPTION |
|---|---|
| | MOTOR OPERATED CIRCUIT BREAKER |
| | MINIATURE CIRCUIT BREAKER |
| | FUSE |
| | FUSED ISOLATOR |
| A | AMMETER |
| V | VOLTMETER |
| U< | UNDER VOLTAGE RELAY |
| R> | EARTH LEAKAGE RELAY |
| | VOLTAGE DROPPING DIODES |
| | CHANGE-OVER SWITCH |
| | HIGH FREQUENCY BATTERY CHARGER |

## NOTES:

1. ALL THE INDICATED INSTRUMENTS ARE TENTATIVE TO DESCRIBE GENERAL DESIGN PARAMETERS & METHODOLOGY AND DO NOT RELIEVE THE CONTRACTOR FROM ANY OF HIS OBLIGATIONS IN COMPLETION OF ENTIRE SCOPE OF WORK UNDER THIS CONTRACT.
2. THIS DRAWING SHOWS THE SCHEMATIC ARRANGEMENT OF 110V DC STATION SERVICES AUXILIARY SUPPLY.
3. THE ALLOCATION / ARRANGEMENT OF OUTGOING CIRCUITS SHALL BE AS PER SPECIFICATIONS.
4. THE SIZES OF 110V DC DISTRIBUTION PANEL CIRCUIT BREAKERS SHALL BE DETERMINED BY THE CONTRACTOR AS PER THE LOAD REQUIREMENT AND SHALL BE SUBJECT TO APPROVAL AT DETAIL DESIGN STAGE.
5. AUDIBLE AND VISUAL ALARMS SHALL BE PROVIDED ON SAS/ 132KV CONTROL PANEL (BUS PANEL) AND RESPECTIVE DISTRIBUTION PANEL TO INDICATE TRIPPING OF ANY OF THE 110V DC CIRCUIT BREAKER.
6. 110V DC BUS VOLTAGE SHALL ALSO BE INDICATED ON THE SAS/132KV COMMON CONTROL BOARD (COMMON ALARMS).
7. FOLLOWING SHALL BE FINALIZED AT DETAIL DESIGN STAGE SUBJECT TO APPROVAL OF ENGINEER.
   (A) NO. OF CIRCUIT TO VARIOUS LOADS.
   (B) SIZE OF BUSBAR, MCB'S AND SPAREMCB'S BREAKERS.
   (C) RATING OF ALL INCOMING & OUT CIRCUIT BREAKERS.
8. HIGH FREQUENCY BATTERY CHARGER AS WELL AS SCR BASED CHARGER CAN BE OFFERED WITH FOLLOWING ARRANGEMENT.
   (A) (N+2) MODULE BATTERY CHARGER AGAINST HIGH FREQUENCY ARRANGEMENT.
   (B) 03 NOS. BATTERY CHARGER AGAINST SCR BASED ARRANGEMENT WITH 01 NO. STANDBY BATTERY CHARGER ALONG WITH AUTO TRANSFER SWITCH IN CASE OF FAILLURE OF ANY BATTERY CHARGER.

**DISCLAIMER:**

THIS IS CONCEPT LEVEL DRAWING WITH NO GUARANTEE OF COMPLETENESS OR PRECISION. EPC CONTRACTOR WILL BE FULLY RESPONSIBLE FOR THE DETAIL DESIGN AND PREPARATION OF REQUIRED DRAWINGS TO ENSURE THE APPROPRIATE CONSTRUCTION, FUNCTIONALITY & EFFECTIVE OPERATION OF THE PROJECT (AS PER CONTRACT).

CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS
JOINT VENTURE OF:
NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD(LEAD FIRM)
ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD.
BARQAAB CONSULTING SERVICES (PVT.) LTD.
PAKISTAN ENGINEERING SERVICES (PVT.) LTD.
DOLSAR ENGINEERING INC.CO.

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| DRAWN | ASIF SAMI |
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110V DC (FOR 132kV SWITCHYARD) AUXILIARY SERVICES SYSTEM (TYPICAL)

SCALE: AS SHOWN

DATE : MARCH, 2026

DRAWING No. ALHPP-SY-0604

REV.

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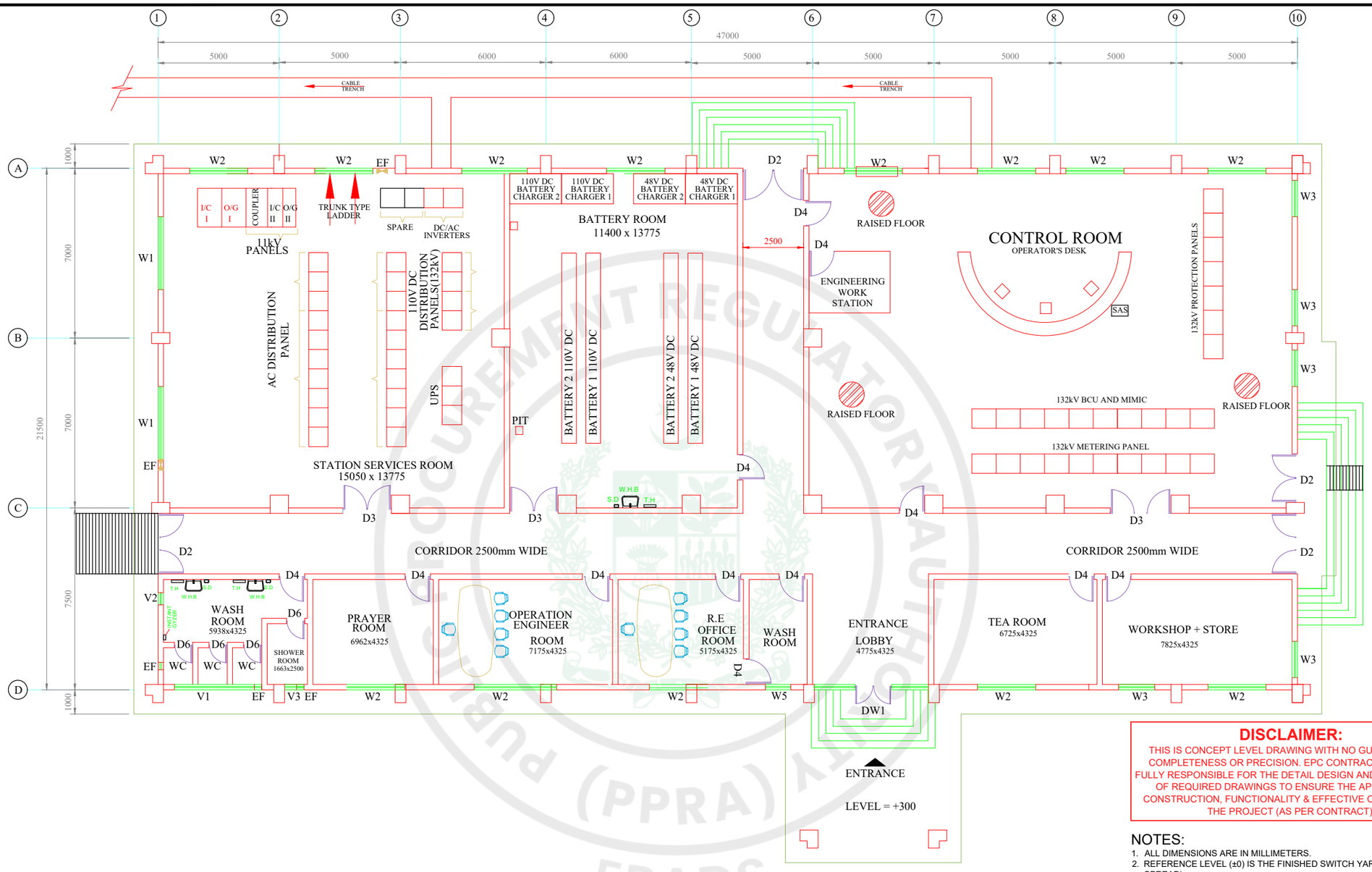


**DISCLAIMER:**

THIS IS CONCEPT LEVEL DRAWING WITH NO GUARANTEE OF COMPLETENESS OR PRECISION. EPC CONTRACTOR WILL BE FULLY RESPONSIBLE FOR THE DETAIL DESIGN AND PREPARATION OF REQUIRED DRAWINGS TO ENSURE THE APPROPRIATE CONSTRUCTION, FUNCTIONALITY & EFFECTIVE OPERATION OF THE PROJECT (AS PER CONTRACT).

## NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. REFERENCE LEVEL (±0) IS THE FINISHED SWITCH YARD LEVEL (TOP OF GRAVEL SPREAD).
3. PVC (EMBEDDED) PIPES OF APPROPRIATE SIZES CONSIDERING FUTURE REQUIREMENTS, SHALL BE PROVIDED FOR CABLES BETWEEN BATTERY BANK, BATTERY CHARGERS AND AC/DC PANELS WHERE EVER NEEDED.
4. LAYOUT PLAN FOR THE BATTERY BANKS IN THE BATTERY ROOM SHALL BE FINALIZED AT THE DETAIL DESIGN STAGE.
5. THE SPACE OF CABLE TRENCH OR OPENING IN THE CONTROL HOUSE BUILDING ,NOT USED FOR PANELS, SHALL BE PROVIDED WITH STEEL CHECKERED PLATE COVERS WITH PROPER STIFFENERS AND LIFTING ARRANGEMENT.
6. AT THE POINT OF ENTRY OF CABLE TRENCHES IN CONTROL HOUSE BUILDING, PROPER BLOCKING OF RAIN WATER AND RATS ETC. SHALL BE PROVIDED. BOTTOM ENTRY PLATES OF PANELS SHALL BE PROVIDED WITH PROPER CABLE GLANDS & SPARE HOLES BE TEMPORARILY BLOCK FOR FUTURE USE.
7. ADEQUATE NUMBER OF R.C.C. PIPES SHALL BE PROVIDED AT 11kV CABLE ENTRY INTO STATION SERVICES ROOM. TRENCH AND SPARE PIPES SHALL BE TEMPORARILY BLOCKED FOR FUTURE USE.
8. FALSE CIELING SHALL BE PROVIDED IN COMPLETE C.H.B.

| | | | |
|---|---|---|---|
| CLIENT: | PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY | CONSULTANT: | ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>JOINT VENTURE OF:<br>NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD(LEAD FIRM)<br>ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD.<br>BARQAAR CONSULTING SERVICES (PVT.) LTD.<br>PAKISTAN ENGINEERING SERVICES (PVT.) LTD.<br>DOLSAR ENGINEERING INC.CO. |
| PROJECT: | ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | | |

| REV. | DATE | DESCRIPTION | APPROVED |
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| DRAWN | ASIF SAMI |
| RECOMMENDED | - |
| CHD./VER. | - |
| APPROVED | - |

**132 kV SWITCHYARD CONTROL HOUSE BUILDING LAYOUT PLAN**

SCALE: AS SHOWN

DATE : MARCH, 2023

DRAWING No. ALHPP-SY-0605

REV. 0

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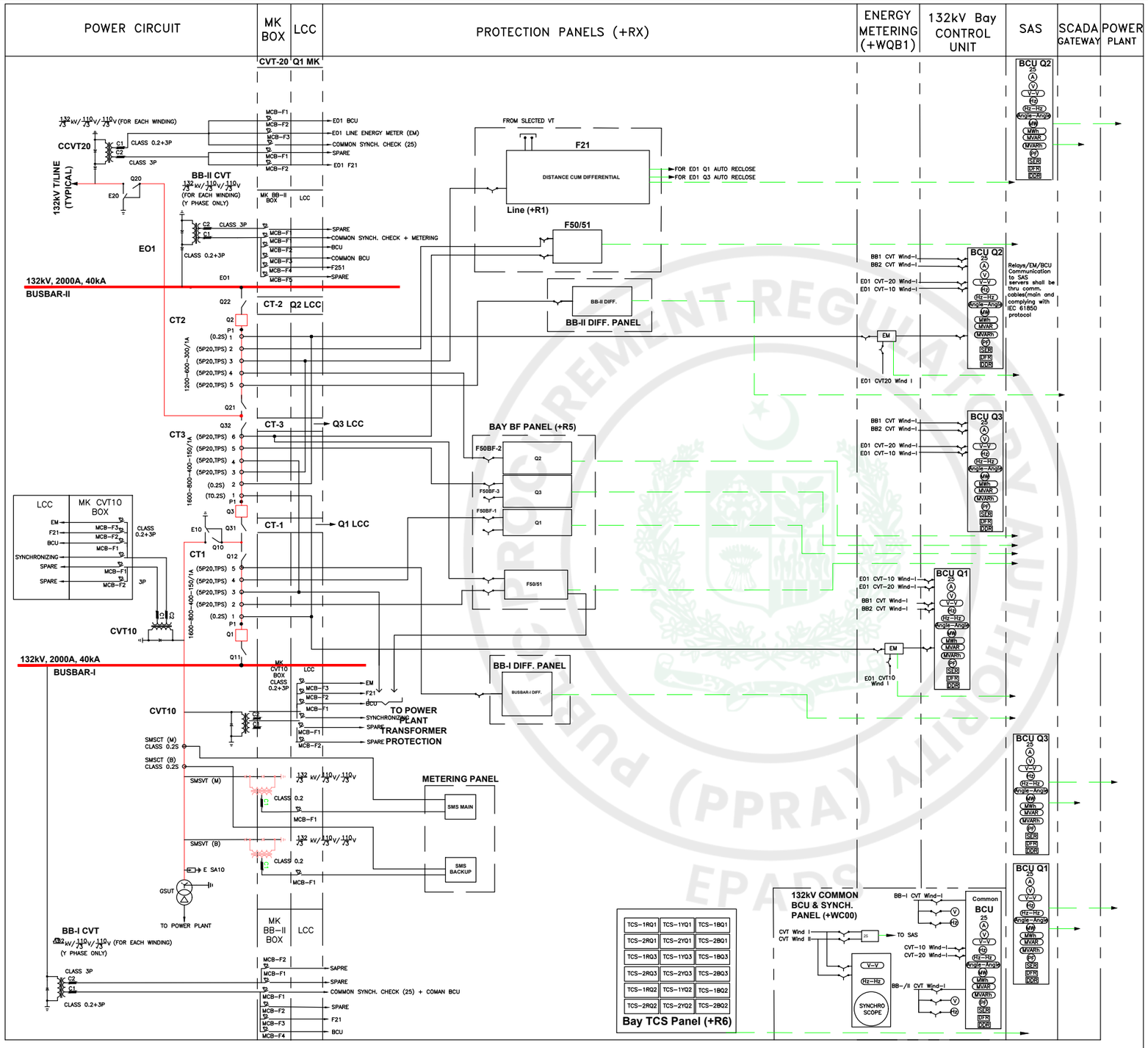


## LEGEND :-

| ITEM | DESCRIPTION | ITEM | DESCRIPTION |
|---|---|---|---|
| 21 | Distance cum differential relay | 95 | CT Supervision Relay |
| 24 | Volts per hertz/Over excitation | Angle | Phase Angle Meter/Angle measurement |
| 25 | Synchronism-check device | A | Ammeter/Ampere Measurement |
| 50 | Instantaneous Overcurrent Relay | Hz | Frequency Meter/Frequency measurement |
| 50N | Neutral Instantaneous Overcurrent | Hz-Hz | Double Frequency Meter/Double Frequency measurement |
| 50BF | Breaker Failure Relay | MW | Megawatt Meter/MW Power measurement |
| 50EF | End Fault Protection | MWh | Megawatthour Meter/MWh Energy Measurement |
| 51 | AC Time Overcurrent Relay | MVAR | Megavar Meter/MVAR Power measurement |
| 51N | Neutral Time Overcurrent | MVARh | Megawatthour Meter/MVARh Energy measurement |
| 67 | AC Directional Overcurrent | PF | Power Factor Meter/PF Measurement |
| 67N | Neutral Directional Overcurrent | V | Voltmeter/Voltage Measurement |
| 68 | Power Swing Blocking | V-V | Double Voltmeter |
| 74 | Alarm Relay | BCU | Bay Controller Unit |
| 79 | Auto Reclose | DDR | Dynamic Disturbance Recorder |
| 81 | Frequency | DFR | Digital Fault Recorder |
| 86 | Lock-out Relay | EM | Energy Meter |
| 87B | Busbar Differential Relay | FL | Distance Fault Locator |
| 94 | Self Reset/Tripping Relay | PQM | Power Quality Monitor |
| FR | Fault Recorder | SER | Sequence of Events Recorder |
| -.-.- | Panel | SOTF | Switch On To Fault |
| ..... | Status/Control/Metering To SAS/SCADA | TCS | Trip Circuit Supervision Relay |
| | Test Switch | VTFF | VT Fuse Fail |

## DISCLAIMER:

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## NOTES.

1. POSITION SCHEMES ARE BASED ON MULTIFUNCTION RELAYS. HOWEVER IF SOME FUNCTIONS ARE NOT POSSIBLE TO ACCOMODATE WITHIN RELAY SEPARATE RELAY SHALL BE PROVIDED.
2. ALL FOUR CVTs SHALL BE PROVIDED TO BCU FOR SYNCHROCHECK AND FOR SPECIFIC BREAKER VT SELECTION SHALL BE WITHIN BCU.
3. CVT MCB SHALL BE PROVIDED BEFORE BCU, RELAY & ENERGY METER.
4. BCU SHALL BE PROVIDED PER CIRCUIT BREAKER.
5. E01, E02 & E03 ARE TYPICAL.

SHEET NO. 1 OF 2

CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF: NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)

ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD.

PAKISTAN ENGINEERING SERVICES (PVT.) LTD.

BARQAAB CONSULTING SERVICES (PVT.) LTD.

DOLSAR ENGINEERING INC.CO.

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| CHD./VER. | - |
| APPROVED | - |

PROTECTION & METERING SYSTEM
132kV SINGLE LINE DIAGRAM

SCALE: AS SHOWN

DATE : MARCH, 2023

DRAWING No. ALHPP-SY-0606

REV. 0

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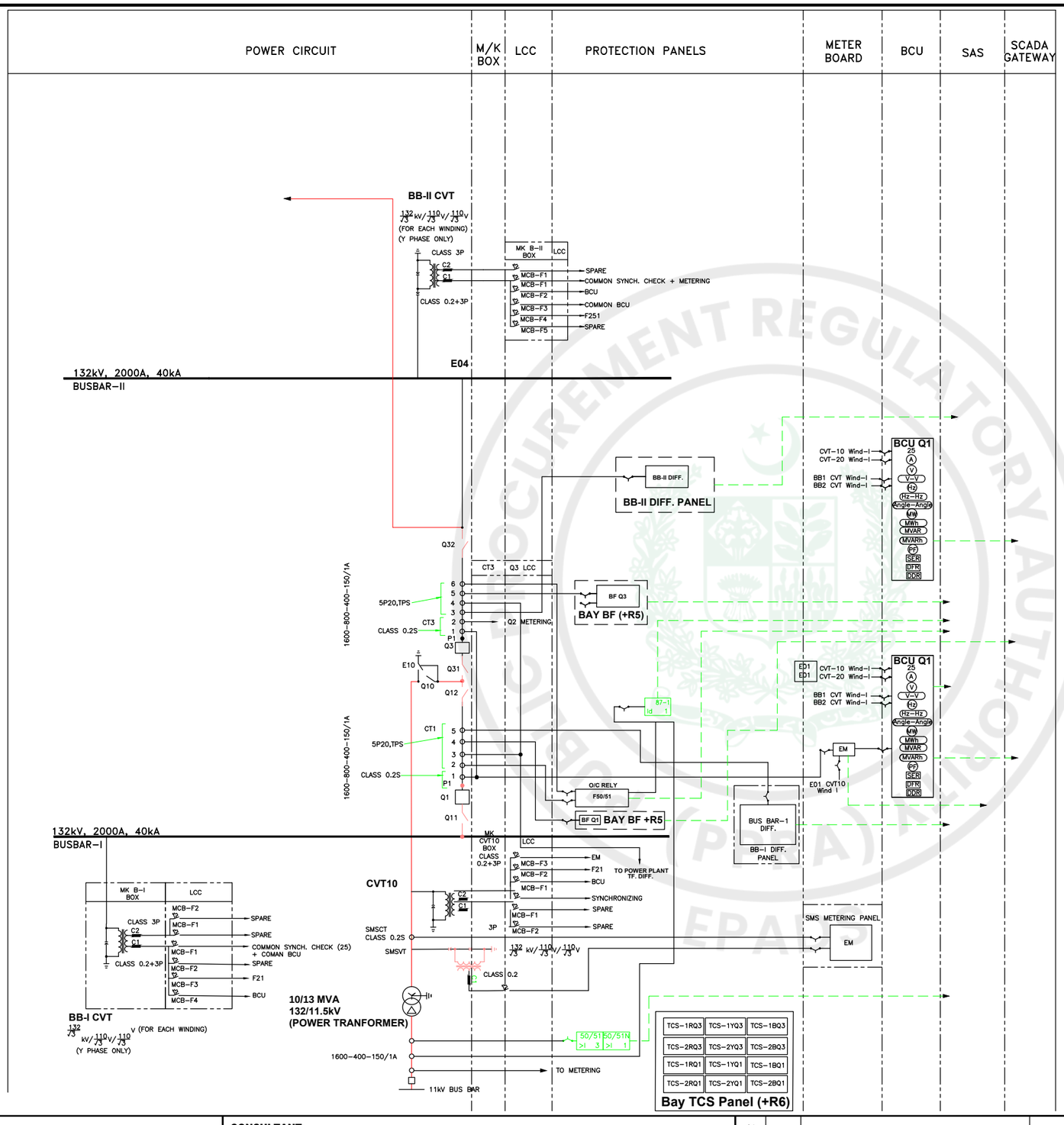


LEGEND :-

| ITEM | DESCRIPTION |
|---|---|
| 21 | Distance cum differential relay |
| 24 | Volts per hertz/Over excitation |
| 25 | Synchronism-check device |
| 50 | Instantaneous Overcurrent Relay |
| 50N | Neutral Instantaneous Overcurrent |
| 50BF | Breaker Failure Relay |
| 50EF | End Fault Protection |
| 51 | AC Time Overcurrent Relay |
| 51N | Neutral Time Overcurrent |
| 67 | AC Directional Overcurrent |
| 67N | Neutral Directional Overcurrent |
| 68 | Power Swing Blocking |
| 74 | Alarm Relay |
| 79 | Auto Reclose |
| 81 | Frequency |
| 86 | Lock-out Relay |
| 87B | Busbar Differential Relay |
| 94 | Self Reset/Tripping Relay |
| FR | Fault Recorder |
| -.-.- | Panel |
| ..... | Status/Control/Metering To SAS/SCADA |
| | Test Switch |

LEGEND :-

| ITEM | DESCRIPTION |
|---|---|
| 95 | CT Supervision Relay |
| Angle | Phase Angle Meter/Angle measurement |
| A | Ammeter/Ampere Measurement |
| Hz | Frequency Meter/Frequency measurement |
| Hz-Hz | Double Frequency Meter/Double Frequency measurement |
| MW | Megawatt Meter/MW Power measurement |
| MWh | Megawatthour Meter/MWh Energy Measurement |
| MVAR | Megavar Meter/MVAR Power measurement |
| MVARh | Megawatthour Meter/MVARh Energy measurement |
| PF | Power Factor Meter/PF Measurement |
| V | Voltmeter/Voltage Measurement |
| V-V | Double Voltmeter |
| BCU | Bay Controller Unit |
| DDR | Dynamic Disturbance Recorder |
| DFR | Digital Fault Recorder |
| EM | Energy Meter |
| FL | Distance Fault Locator |
| PQM | Power Quality Monitor |
| SER | Sequence of Events Recorder |
| SOTF | Switch On To Fault |
| TCS | Trip Circuit Supervision Relay |
| VTFF | VT Fuse Fail |

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NOTES :-

1. POSITION SCHEMES ARE BASED ON MULTIFUNCTION RELAYS. HOWEVER IF SOME FUNCTIONS ARE NOT POSSIBLE TO ACCOMODATE WITHIN RELAY SEPARATE RELAY SHALL BE PROVIDED.
2. ALL CVTs SHALL BE PROVIDED TO BCU FOR SYNCHROCHECK AND FOR SPECIFIC BREAKER VT SELECTION SHALL BE WITHIN BCU.
3. CVT MCB SHALL BE PROVIDED BEFORE BCU, RELAY & ENERGY METER.
4. BCU SHALL BE PROVIDED PER CIRCUIT BREAKER.

SHEET NO. 2 OF 2

CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF: NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)

ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD. | BARQAAB CONSULTING SERVICES (PVT.) LTD. | PAKISTAN ENGINEERING SERVICES (PVT.) LTD. | DOLSAR ENGINEERING INC.CO.

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**PROTECTION & METERING SYSTEM 132kV POWER TRANSFORMER SINGLE LINE DIAGRAM**

SCALE: AS SHOWN

DATE : MARCH, 2023

DRAWING No. ALHPP-SY-0607

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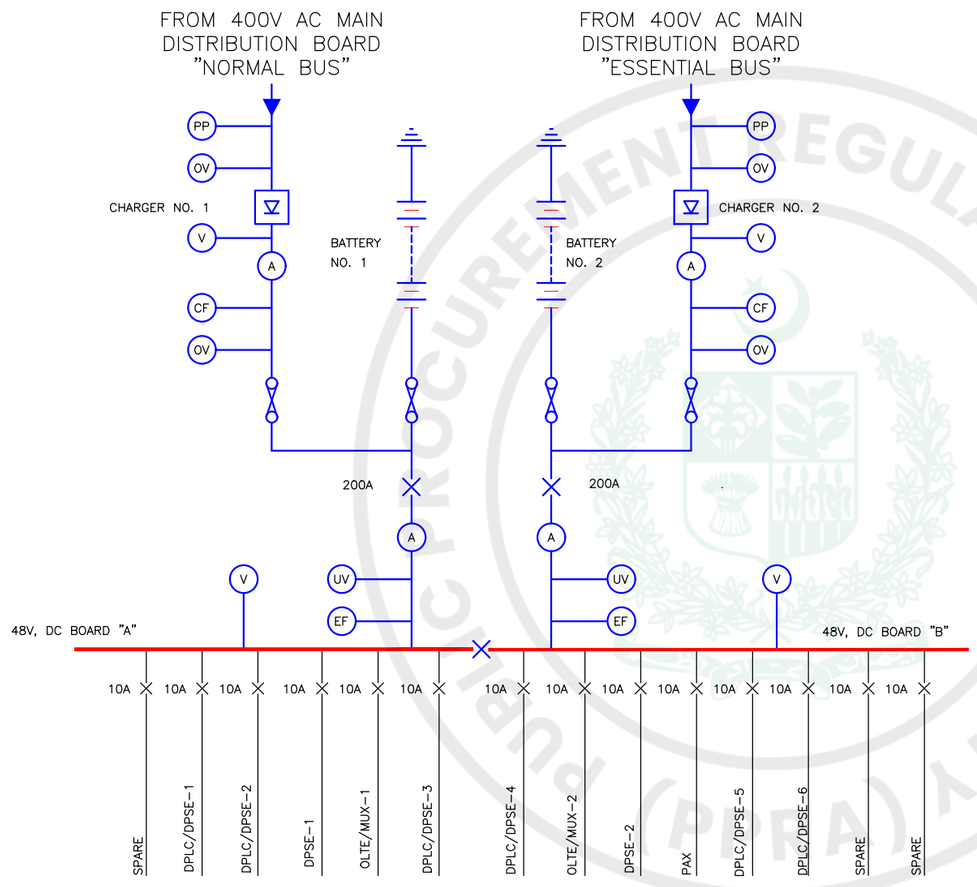


LEGEND:–

| SYMBOL | DESCRIPTION |
|---|---|
| | CHARGER |
| | MINIATURE CIRCUIT BREAKER |
| | FUSE |
| | BATTERY |
| V | VOLTMETER |
| A | AMMETER |
| UV | UNDERVOLTAGE RELAY |
| OV | OVERVOLTAGE RELAY |
| EF | EARTH FAULT RELAY |
| PP | PHASE FAILURE RELAY |
| CF | CHARGER FAILURE PROTECTION |

**DISCLAIMER:**

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CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF:
NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)
ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD.
BARQAAB CONSULTING SERVICES (PVT.) LTD.
PAKISTAN ENGINEERING SERVICES (PVT.) LTD.
DOLSAR ENGINEERING INC.CO.

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| DRAWN | ASIF SAMI |
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| CHD./VER. | - |
| APPROVED | - |

**132 kV SWITCHYARD 48V DC SYSTEM**

SCALE: AS SHOWN

DATE : MARCH, 2026

DRAWING No. ALHPP-TC-0701

REV. 0

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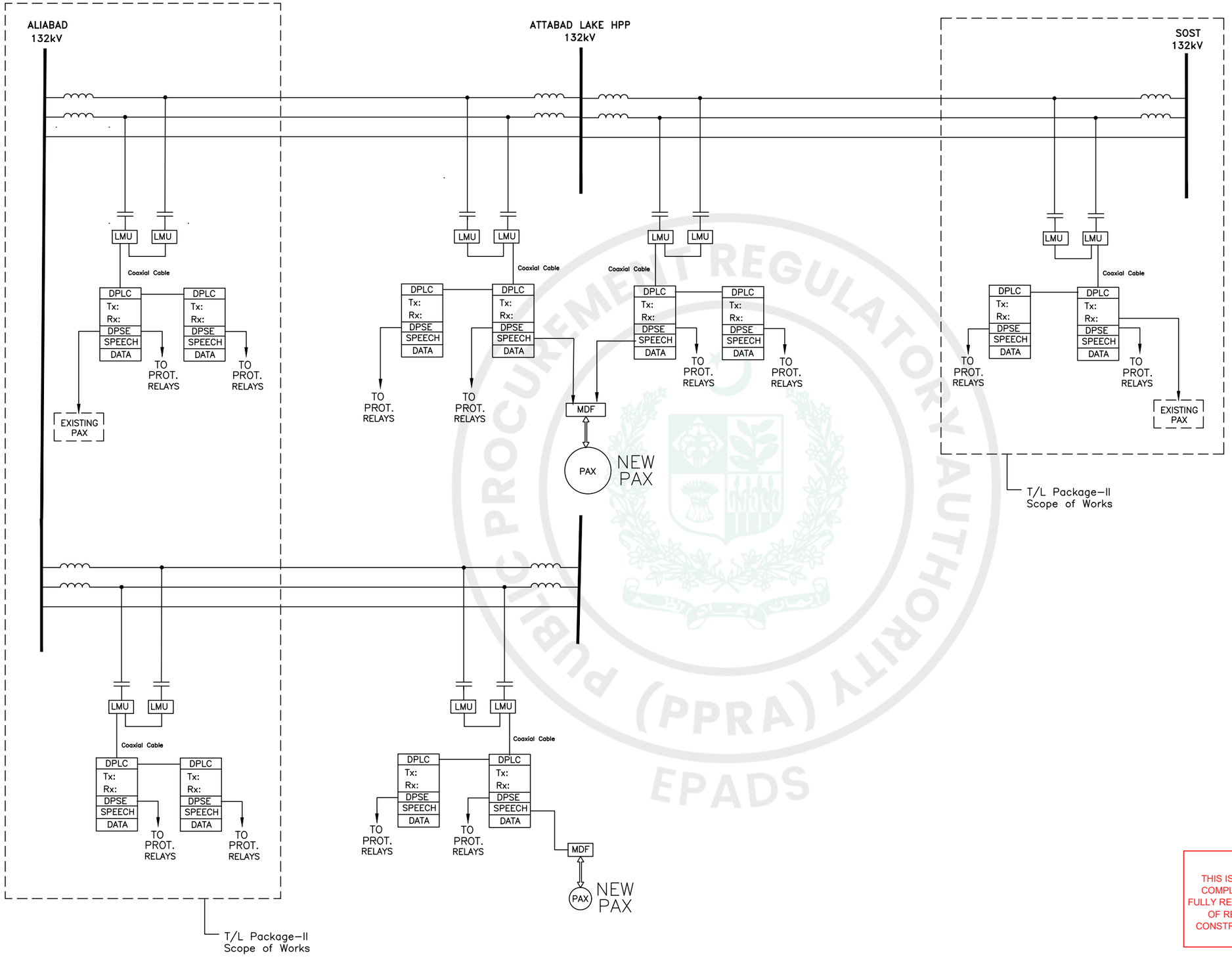


LEGEND:

| SYMBOL | DESCRIPTION |
|---|---|
| ~~~ | LINE TRAP |
| ⊣⊢ | CCVT/CVT |
| LMU | LINE MATCHING UNIT |
| SSB–SC<br>Tx: f2<br>Rx: f1<br>PSE<br>SPEECH<br>DATA | DIGITAL PLC TERMINAL<br>TRANSMIT FREQUENCY (f2 KHz)<br>RECEIVE FREQUENCY (f1 KHz)<br>PROTECTION SIGNALLING INTERFACE<br>VOICE INTERFACE<br>DATA INTERFACE |
| MDF | MAIN DISTRIBUTION FRAME |
| PAX | PRIVATE AUTOMATIC EXCHANGE |
| ⟺ | VF CHANNELS |
| – – – | EXISTING EQUIPMENT |

**DISCLAIMER:**

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CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF:
NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)
ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD.
PAKISTAN ENGINEERING SERVICES (PVT.) LTD.
BARQAAB CONSULTING SERVICES (PVT.) LTD.
DOLSAR ENGINEERING INC.CO.

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132 kV SWITCHYARD TELECOMMUNICATION NETWORK LAYOUT

SCALE: AS SHOWN

DATE : MARCH, 2026

DRAWING No. ALHPP-TC-0702

REV. 0

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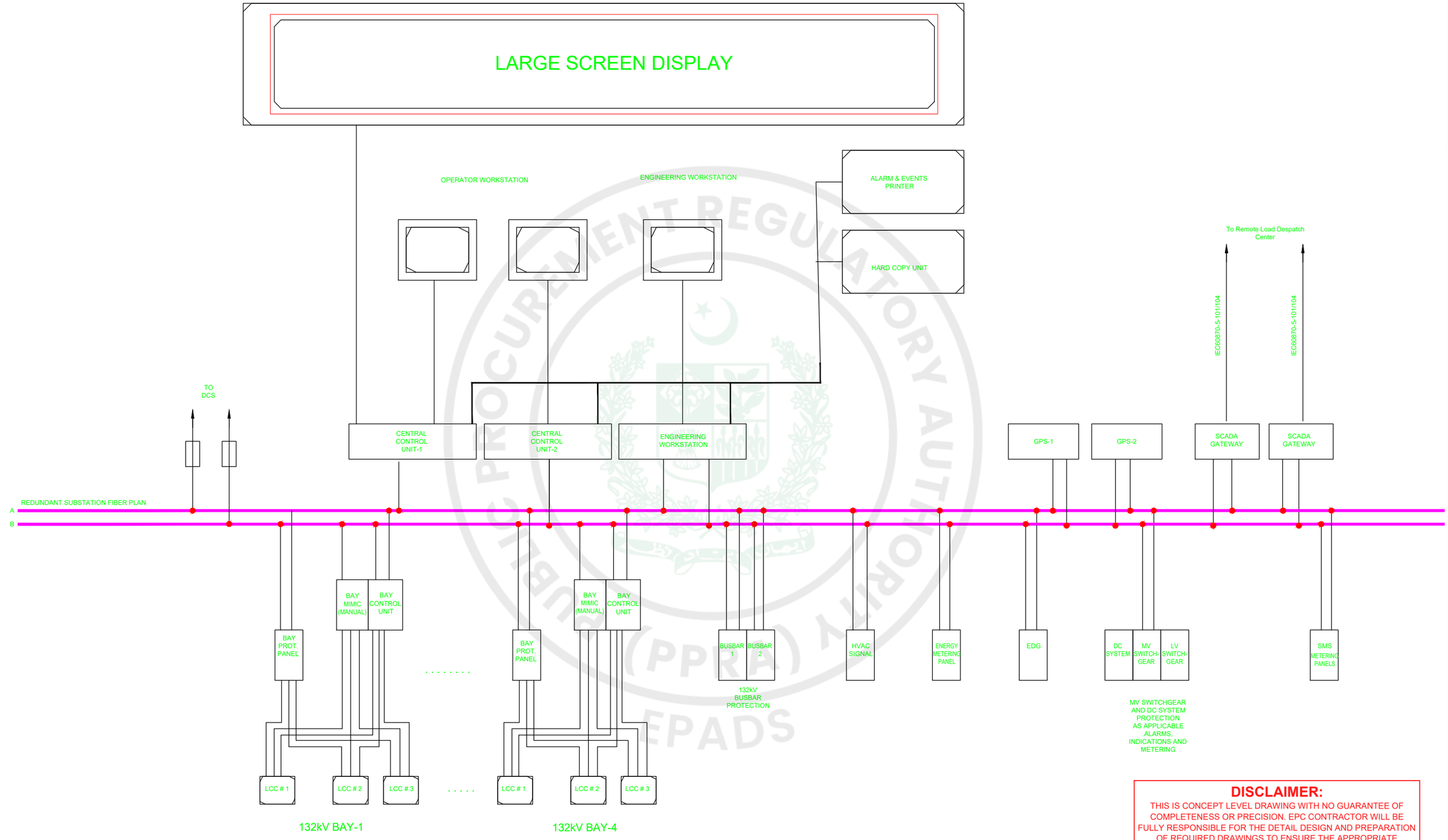


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CLIENT:
**PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY**

PROJECT:
**ATTABAD LAKE HYDROPOWER PROJECT (54 MW)**

CONSULTANT:
ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS
JOINT VENTURE OF:
NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)
ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD.
BARQAAB CONSULTING SERVICES (PVT.) LTD.
PAKISTAN ENGINEERING SERVICES (PVT.) LTD.
DOLSAR ENGINEERING INC.CO.

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| CHD./VER. | - |
| APPROVED | - |

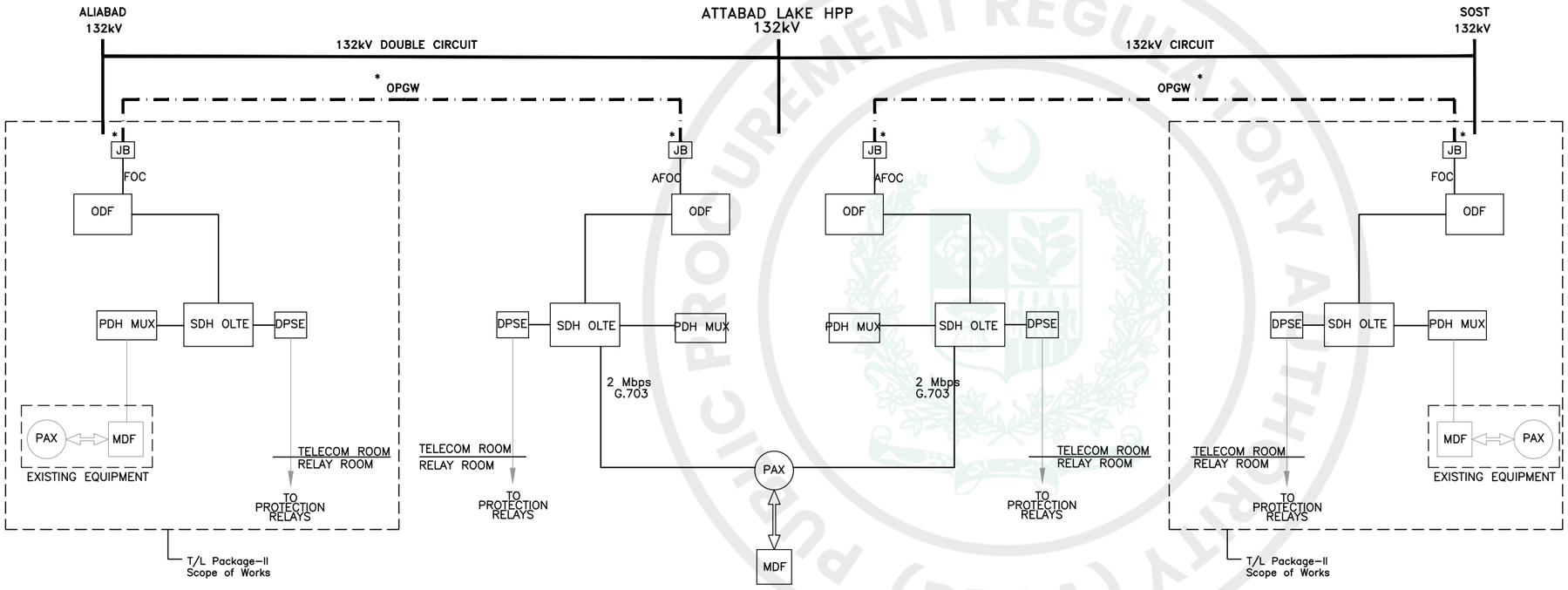
**132 kV SWITCHYARD SCADA SYSTEM**

SCALE: AS SHOWN

DATE : MARCH, 2026

DRAWING No. ALHPP-TC-0703

REV. 0




LEGEND:

| SYMBOL | DESCRIPTION |
|---|---|
| | OPGW CABLE |
| JB | JUNCTION BOX OP6W/FOC |
| JB1 | JUNCTION BOX OP6W/OPGW/OPGW |
| OA | OPTICAL AMPLIFIER 1+1 |
| SDH OLTE | OPTICAL LINE TERMINAL EQUIPMENT 1+1 |
| PDH MUX | DIGITAL MULTIPLEXER |
| DPSE | DIGITAL PROTECTION SIGNALLING EQUIPMENT |
| | VF CHANNELS |
| PAX | PRIVATE AUTOMATIC EXCHANGE |
| ODF | OPTICAL DISTRIBUTION FRAME |
| FOC | FIBER OPTIC APPROACH CABLE |
| * | TO BE SUPPLIED BY OTHERS |

**DISCLAIMER:**

THIS IS CONCEPT LEVEL DRAWING WITH NO GUARANTEE OF COMPLETENESS OR PRECISION. EPC CONTRACTOR WILL BE FULLY RESPONSIBLE FOR THE DETAIL DESIGN AND PREPARATION OF REQUIRED DRAWINGS TO ENSURE THE APPROPRIATE CONSTRUCTION, FUNCTIONALITY & EFFECTIVE OPERATION OF THE PROJECT (AS PER CONTRACT).

CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF:
NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)

ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD.
PAKISTAN ENGINEERING SERVICES (PVT.) LTD.
BARQAAB CONSULTING SERVICES (PVT.) LTD.
DOLSAR ENGINEERING INC.CO.

| REV. | DATE | DESCRIPTION | APPROVED |
|---|---|---|---|
| 04 | | | |
| 03 | | | |
| 02 | | | |
| 01 | | | |

| | |
|---|---|
| DRAWN | ASIF SAMI |
| RECOMMENDED | - |
| CHD./VER. | - |
| APPROVED | - |

132 kV SWITCHYARD FIBER OPTIC SYSTEM

SCALE: AS SHOWN

DATE : MARCH, 2026

DRAWING No. ALHPP-TC-0704

REV. 0

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# PAKISTAN

## WATER AND POWER DEVELOPMENT AUTHORITY

# ATTABAD LAKE HYDROPOWER PROJECT

# FEASIBILITY STUDY

# EXECUTIVE SUMMARY

**June 2021**

## HYDRO PLANNING ORGANIZATION

WAPDA, SUNNY VIEW ESTATE, LAHORE ☎ 99202717 🖷 99202722 ✉ gmhydroplanning@gmail.com

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## Table of Contents

**EXECUTIVE SUMMARY** .....

S.1 INTRODUCTION ..... 1

S.2 PROJECT ACCESS ..... 1

S.3 TOPOGRAPHIC & HYDROGRAPHIC SURVEYS ..... 2

S.4 CLIMATE OF THE PROJECT AREA ..... 2

S.5 HYDROLOGY ..... 3

S.6 SEDIMENTATION ..... 3

S. 7 POWER AND ENERGY ..... 4

S.8 GEOLOGY ..... 4

S.9 ALTERNATIVE PROJECT LAYOUT ..... 5

S.10 PROJECT LAYOUT ..... 5

S.11 CIVIL AND HYDRAULIC STRUCTURE DESIGN ..... 6

S.12 MECHANICAL WORKS ..... 6

S.13 POWER HOUSE ELECTRICAL WORKS ..... 7

S.14 POWER EVACUATION / TRANSMISSION LINE ..... 7

S.15 ENVIRONMENTAL IMPACT ASSESSMENT (EIA) ..... 8

S. 16 CONSTRUCTION PLANNING ..... 8

S. 17 COST ESTIMATE ..... 9

S.18 ECONOMIC AND FINANCIAL ANALYSIS ..... 9

S.19 SALIENT FEATURES OF THE PROJECT ..... 10

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

# List of Drawing

| Sr.# | Title | DWG No. |
|---|---|---|
| 1 | Project Location Map | AFS-GN-101 |
| 2 | Project Layout Map | AFS-LAY-404 |
| 3 | Project Longitudinal Cross Section | AFS-LAY-407 |
| 4 | Project Plan for Weir | AFS-WR-409 |
| 5 | Project Weir Longitudinal Sections | AFS-WR-410 |
| 6 | Penstock Plan and Longitudinal Profile | AFS-ST-430 |
| 7 | Project Cross-section for Power House | AFS-PH-435 |
| 8 | Project Implementation Schedule | AFS-CP-478 |

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

# EXECUTIVE SUMMARY

## S.1 INTRODUCTION

Attabad Lake Hydropower Project (ALHPP) has been identified on Hunza River downstream of Attabad Lake due to creation of dam due to land slide from right bank of Hunza River in January, 2010 20 km upstream of Aliabad, Hunza Valley, Gilgit-Baltistan. ALHPP is proposed on Attabad Lake which has live storage capacity of about 11 million $m^3$. Project Location is shown in Dwg. No: AFS-GN-101.

On Nov, 2015 Prime Minister announced the construction of ALHPP, Accordingly Ministry of Water and Power, Gilgit-Baltistan undertook its Feasibility Study through Annual Development Program (ADP) for Financial Year 2016-17. In the beginning Feasibility Study of ALHPP was carried out by local consultants, Design man Consulting Engineers (Pvt) Ltd, Islamabad in association with Mountain Infrastructure & Engineering Services, Gilgit, in March, 2017. The Project was finalised with an installed capacity of 32.5 MW and mean annual energy of 255 GWH. On August, 2017, Ministry of Water and Power, Gilgit-Baltistan wrote letter to the Chairman WAPDA to give expert opinion on the Feasibility Study of ALHPP. On July 2019, a meeting was held between Chairman, WAPDA and Chief Secretary, Gilgit-Baltistan. It was agreed that Feasibility Study would be reviewed by Hydro Planning Organization (HPO), WAPDA because of its expertise in the field of Hydropower. Water and Power Development, Gilgit-Baltistan shared the already carried out Feasibility Study with HPO, WAPDA in January, 2020. Feasibility Study has been examined by HPO, WAPDA and found that proposed layout is designed without diversion works and sediment flushing facility which are imperative for Project execution. Therefore, Feasibility Study has been again undertaken by HPO, WAPDA with additional investigation. The Terms of Reference (TOR) set for HPO, WAPDA by Govt. of Gilgit-Baltistan is to review Feasibility Study and preparation and submission of PC-I of ALHPP.

HPO, WAPDA prepared a new Feasibility Study with additional field investigations including topographic and hydrographic survey of Lake, 400 m onshore drilling, neotectonic studies and geological mapping with new layout. It enhanced its capacity to 54 MW with mean annual energy of 374 GWh with an estimated cost of Rs.21,246 million in order to meet the beside requirements of entire Hunza River valley but also fulfil the demand of Gilgit and Ghizar districts with peaking storage facility at Attabad Lake, the installed power of 54 MW can be generated throughout the year during peak hours..

ALHPP has been designed for an installed capacity of 54.0 MW with the design discharge and rated head of 60 $m^3/s$ and 106 m respectively. Project will provide mean annual electricity/energy of 374 GWh by using 3 vertical Francis turbines with a plant factor of 79%.

## S.2 PROJECT ACCESS

The Project is accessible from Federal Capital Islamabad connected to Gilgit along the existing N-35 Karakorum Highway (KKH) which leads to Project Area at Attabad Lake near Hunza. The route through KKH can be accessed via Motorways from Islamabad to Burhan Interchange near Hassanabdal (M-1 Islamabad-Peshawar Motorway – 44 km) and from Burhan Interchange to Thakot (M-15 Hazara Motorway – 186 km). From there, the access onward to Gilgit and



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Hunza continues as a part of KKH (Thakot to Gilgit– 390 km; Gilgit to Attabad Lake/ Hunza along Hunza River – 120 km). There is another route from Islamabad to Gilgit and Hunza via Babusar Pass, through National Highway (N-15). This route is although shortest than KKH through Besham, to reach upto Chilas but it usually remains closed for six months in a year due to heavy snowfall during the winter season.

Gilgit Airport is the nearest facility to the Project Area which is about 120 km from the Project Site. Domestic flights from Islamabad airport are schedule for Gilgit on daily basis but flight operation depends upon the weather conditions. Recently flights from Lahore and Karachi are also operational to Gilgit Airport.

## S.3 TOPOGRAPHIC & HYDROGRAPHIC SURVEYS

To determine the geographical conditions of the Project Area, the topographic survey has been performed by Survey Division, HPO, WAPDA, Peshawar during August & September, 2020. The satellite based survey with two fold approach i.e. Google Earth and Geographical Information System (GIS) has been adopted in addition to the conventional topographic survey. A comprehensive topographic survey of the Project Area has been carried out at a scale of 1:1000 to cover topographic features of ALHPP comprehensively. The topographic survey of the Project Area includes:

- Topographic survey of the Project Area of about 400 hectares, covering 4 km downstream of Weir Site along Hunza River.
- Longitudinal profile along Hunza River, 4 km downstream from Weir Site.
- Topographic survey of 21 valley cross sections along Hunza River, 4 km downstream of Weir Site at an interval of 200 m, covering the main river course and valley slopes (ranging from 175 to 250 m) on either side.

The hydrographic survey of the Attabad Lake has been carried out by International Sedimentation Research Institute (ISRIP), WAPDA, Pakistan during September & October, 2020 using echo sounding equipment. 40 Nos. cross-sections and longitudinal bed profile covering a total lake length of 12,450 m.

The present water surface area of lake at El. 2412 m.a.s.l is 1088.7 Acres (4.41 $km^2$).The storage capacity at an El. 2412 m.a.s.l comes to be 99,249 Acre Feet (122.42 $Mm^3$). The comparison of current Hydrographic survey data with previous survey data of year 2011 shows that on an average there is about 30 to 40 m deposition during last 9 years.

## S.4 CLIMATE OF THE PROJECT AREA

The Gilgit Meteorological Station is the nearest station to Hunza Valley that has a sound historical record covering more than five decades. Monthly temperature variations (maximum, minimum and mean) at Gilgit indicate parabolic trend with peak in the month of July. Summer prevails in months from June to August. In July and August, mean maximum and minimum temperatures are normally above 35˚C and 15˚C respectively. The winter is cold and chilly that starts from November and remain still end of March. The lowest temperatures are in the month of January when mean maximum and minimum temperatures reaches below 10˚C and (-) 2˚C respectively.



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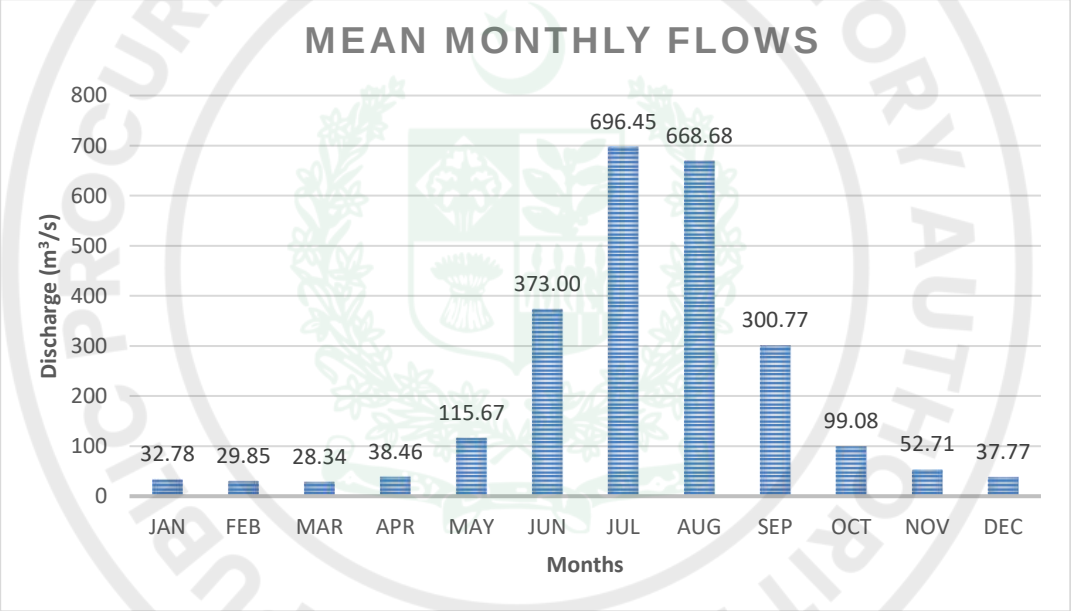
Precipitation data has not been available to depict the precipitation pattern of the Hunza Basin, therefore isohyetal map used to have a picture of precipitation distribution in the basin. That shows mean annual rainfall of the basin for the last 20 years (2000 – 2019) and the precipitation values vary from 88 to 485 mm.

## S.5 HYDROLOGY

The main tributaries of Hunza River are; Chapursan, Kilik, Bola Das joining the Hunza River from the west and Khunjerab along with Ghujerab, Simshal and Hispar Rivers joining river from the east of the valley. There is only one hydrological gauging station on Hunza River at Danyor Bridge being operated by SWHP-WAPDA. This station is located at about 107 km downstream of Attabad Landslide Dam. Therefore, river flows are transposed and estimated from documented discharge data from hydrological station at Danyor. Daily discharge data from 1966 to 2015 is available and processed for the calculations. Average value for mean annual flow has been calculated as 208.36 $m^3/s$.




**Mean Monthly Flows (1966-2015)**

Keeping in view the different types flood estimations and generation of high peaks due to GLOFs, it is recommended to adopt design flood of 10,000 years return period at weir site. Therefore, design flood of 3,250 $m^3/s$ at weir site has been assumed for the calculations of design of hydraulic structures.

## S.6 SEDIMENTATION

Average value of suspended sediment at Danyor comes out 33.43 MMT with data range 1966-2015 which falls on higher side and also differs from present scenario. To remain on realistic side, we choose the period of 2011-2015 for the calculation of suspended sediment and the average of suspended sediment comes out 20.06 MMT. Bed load has been considered as 20% of the total suspended load. Keeping the trap efficiency in view, reservoir life of the Attabad Lake is about 11 years without flushing.



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## S. 7 POWER AND ENERGY

Power and energy potential at the site have been estimated on average 10-daily basis using time series data from 1966 to 2015. Keeping in view historic data, optimized design discharge of 60 $m^3/s$ has been selected. Available head across the hydropower facility has been computed keeping in view the minimum and maximum operation water levels i.e. 2,012 to 2,014 m.a.s.l.

In the present study 10-Daily Power Curves, the optimum installed capacity would be 54.0 MW having mean annual energy of 374 GWh. The plant factor has been calculated as 79%. In previous studies, 32.5 MW capacity plant had been proposed for this Project, however, keeping in view the potential of the lake and availability of head, the power and energy optimization have been carried out to size the plant.

## S.8 GEOLOGY

Geologically site is located in Karakorum consists mostly of sedimentary, meta sedimentary, igneous and metamorphic rock, bounded by Karakorum Fault in the East, Chaman and Herat Fault in West (Zanchi 1993) ranging in age from Precambrian to Cretaceous. It is glacial originated valley modified later on by river system. Morphologically the valley is lithological as well as structurally controlled.

The site geology unit consists of slided mass and rock. Granitic gneiss and granodiorite rock are exposed which at higher elevations. Geological mapping and 400m drilling have been carried out to evaluate the surface and subsurface foundation conditions of main weir, under sluice/sediment flushing channel, power house and tailrace. 10 test pits have been excavated to analyze the slope and barrow area material to be used for construction material. Samples from bore holes, test pits and barrow area have been tested from CMTL, Lahore to find out the engineering properties along with their suitability to be used as construction material.

Being disastrous slided area due to active tectonics, neo-tectonics studies have been conducted to assess the operational active forces and distortion/deformation in recent sediments (0.1 Ma). Attabad slide commenced as a result of active deformational force, therefore, 30 km upstream and 30 km downstream along both banks of Hunza River have been traversed to gather the recent tectonic/deformational feature. Features found in recent deposits include folds, micro faults, jointing, horst and graben etc.

Both Probalistic Seismic Hazard Analysis (PSHA) and Deterministic Seismic Hazard Analysis (DSHA) approaches have been used to analyze the Seismic Hazard Analysis, keeping in view the on-site and regional tectonic scenario to recommend a suitable earthquake resistant design. This study has focused on the earthquake potential hazard and related ground motions and estimate the value of “g”. Peak Ground Acceleration (PGA) values for

Operating Basis Earthquake (OBE) at return period of 145 years are recomended as horizontal = 0.24 g & vertical = 0.17 g

while Safety Evaluation Eartquake (SEE) at return period of 10,000 years are recommended as horizontal = 0.44g and Vertical = 0.29 g.



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Ample quantity construction materials are available in the economic haulage of the Project Area. Sand from Shishkat village area and marble from Passu and RBGM from power house area may be crushed down for coarse aggregate. The boulders in slided mass, may be use as rip rap material while silt/clay is also available for impervious blanket.

## S.9 ALTERNATIVE PROJECT LAYOUT

The Project layout has been considered on either bank with powerhouse near Attabad. Options for structures location are limited due to land slided area, steep slope in reservoir area, and weak geological formation in the Project Area. Considering the aforementioned limitations Alternative Project Layout on the Left and the Right Bank have been studied.

Alternative-I: Project Layout on the Left Bank

Alternative-II: Project Layout on the Right Bank

After detail study Alternative-I Project Layout on the left bank came out to be a favourable option and further 2 options have been studied

a. Alternative -I A Headrace Tunnel Option

b. Alternative -I B Headrace with Embedded Pressure Pipe

Finally, Alternative -I A Headrace Tunnel Option has been selected for further studies. (Selected Project Layout is shown in Dwg.No.AFS-LAY-404 & Project Longitudinal X-Section in Dwg.No.AFS-LAY-407).

## S.10 PROJECT LAYOUT

An overflow weir/ungated spillway along sediment flushing channel has been proposed at existing site used as spillway of Attabad Lake. Water will be diverted to power house through power intake, low pressure headrace tunnel, surge tank and penstock on the left bank. The coordinates of weir & powerhouse sites are listed below:

| Site | Easting (m) | Northing (m) |
|---|---|---|
| Overflow Weir | 484036.834 | 4018143.837 |
| Powerhouse | 481645.920 | 4017963.719 |



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The proposed overflow weir/ ungated spillway is 60 m wide and a sediment flushing channel 19 m wide on its left side shown in Dwg.No: AFS-WR-409 & 410. The powerhouse site is about 2.5 km downstream of the proposed overflow weir along the left bank of Hunza River.

A design discharge of 60 $m^3/s$ will be diverted towards the powerhouse through intake left bank waterway located upstream side of overflow weir / ungated spillway. A 2.32 km long low pressure headrace tunnel having a diameter of 5.5 m would run along the left bank leading to a 10 m diameter and 49 m high surge tank. From there, a 470 m long embedded steel penstock with 3.5 m diameter shown in Dwg.No: AFS-ST-430 would be laid over the left bank slopes leading down to the surface power house to generate 54 MW with 03 Francis Turbines. From powerhouse, a 18 m long tailrace channel leading from each generating unit would discharge water back into the Hunza River.

## S.11 CIVIL AND HYDRAULIC STRUCTURE DESIGN

ALHPP is a Runoff River peaking scheme on Hunza River in Hunza Region. The Project is planned to develop the reach of river 2.5 km downstream of Attabad Lake to generate 54 MW power by proposing and Feasibility Level Design of the following Civil Engineering Structures has been carried out:

- Natural dam of 45 m height from river bed to act as diversion structure with low level outlet and an overflow ungated spillway.
- Power Intake structure is proposed on the left bank of river to take the design discharge of 60 $m^3/s$.
- Low pressure headrace tunnel having diameter of 5.5 m with total length of 2320 m.
- Vertical surge shaft of 10 m diameter with height of 49 m.
- Concrete lined pressure shaft of 3.6 m diameter having a length of 80 m.
- Steel penstock having a length of 470 m length and diameter of 3.5 m.
- Surface powerhouse with three (03) Francis units with an installed capacity of 54 MW and open switchyard.
- Tailrace channel of 18 m length.

## S.12 MECHANICAL WORKS

The powerhouse will be equipped with Three Vertical Shaft Francis turbines (18.0 MW each) X-Section of powerhouse shown in Dwg. No: AFS-PH-435. The total plant out capacity of ALHPP is 54.0 MW. The turbine shall be capable to operate within a wide range of head and discharges at maximum attributable efficiency.

| | |
|---|---|
| No. of Units | 03 (Vertical Francis) |
| Plant Discharge, $Q_{Total}$ ($m^3/sec$) | 60 |
| Rated Net Head, $H_n$ (m) | 106 |
| Plant Capacity, $P_{Total}$ (MW) | 54 |



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The turbine rated output is expressed by the following equation:

$P_t = 9.81 \times Q \times H_n \times \eta_t$

| | | | |
|---|---|---|---|
| Where | $P_t$ | Turbine out Power (KW) | |
| | Q | Discharge ($m^3$/sec) | 20 |
| | $H_n$ | Rated Net Head (m) | 106 |
| | $\eta_t$ | Efficiency of turbine | 91.50 % |
| | | 9.81*20*106*0.915 | 19000 KW |

Rated Turbine Output at shaft, P 19.0 MW with rated speed of 375 rpm

## S.13 POWER HOUSE ELECTRICAL WORKS

The design of the generator is determined by the construction, layout and speed of the turbine. The choice of a vertical shaft Francis turbines defines a vertical generator and appropriate guide bearings. Main parameters of the generators for power house are tabulated below:

| | |
|---|---|
| **Generator Shaft Orientation** | Vertically Coupled |
| **No. of Units** | 3 |
| **Nominal Capacity** | 21.2 MVA (18 MW) |
| **Rated Speed** | 375 RPM |
| **No. of Poles** | 16 |
| **Efficiency** | 98 % |
| **Unit Output Voltage** | 11 kV |
| **Frequency** | 50 Hz |
| **Power Factor** | 0.85 |
| **Insulation Class** | F |
| **Limit of Thermal Utilization** | B |
| **Excitation** | Static |
| **Excitation Voltage** | 220 V DC |
| **Runway speed** | 648 rpm |
| **Connection** | Y, Neutral Grounded through transformer resistance |
| **Cooling System** | Closed circuit Air-cooling system with surface type Air/Water Coolers |

## S.14 POWER EVACUATION / TRANSMISSION LINE

The power generated by the ALHPP shall be mainly supplied to the load centres in the central Hunza, Aliabad and the upper Hunza (Sost) through132 kV transmission lines. A double circuit 132 kV transmission line of 27 km will be connected to the proposed Aliabad Grid station to further disperse the power in the Regional Grid Network (RGN). Along with double circuit 132 kV transmission line to Aliabad, a 132 kV single circuit of 70 km transmission line is also proposed upto the existing 33 kV grid station which will be upgraded to 132/33/11 kV grid station. Rail conductor proposed for double circuit transmission line will be in accordance with WAPDA/NTDC Specification No.P-50:88.



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## S.15 ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

As ALHPP is planned for generation capacity of 54 MW and 132 kV power transmission lines, the Project falls within the category 'A' which requires full scale ESIA. The primary data have been collected and assessed with reference to different project components, i.e. dam site, reservoir area, powerhouse, construction camps etc. The data regarding climate, hydrology, geology, seismology, neo-tectonics and other physical features of the Project Area has also been obtained as part of the preparation of this Feasibility Study.

The secondary data have been collected from various offices and published reports of different organizations in the Gilgit-Baltistan. These organizations included W & P Dept., Education, Forest, Agriculture, Fisheries, Sanitation, Wildlife, Environmental Protection Agency, District Administration, Tehsil Offices, Local Councils and others. The studies are carried out on the information received during field visits of Project Area, data received from some NGOs, water samples collected from Project Area at various places and tested in Environmental Protection Agency Laboratory, Gilgit, climate data received from Metrological Department, and other data taken from earlier conducted Feasibility Study and other reports of projects.

A team of experts of Hydro Planning Organization (HPO) moved to Project Area for field investigations. The team hired services of one local graduate female and one local graduate man for questioning and answering with local people in their language. Additionally, the services of a local well educated female hired for the interviews and data collection covers the subjects of gender and women empowerment. The team spent more than three weeks to visit seven villages of upstream and two villages of downstream side of the Project Area. In this exercise both genders have been covered in field visits of Project Area. The field investigators (team) with interviewing skills minimize the sampling error and wrongly asked or interpreted or recorded answers to finalize a report with the respondents.

## S. 16 CONSTRUCTION PLANNING

ALHPP involves execution of considerable quantities of excavation and concreting for structures. Considering the magnitude and nature of construction activities, mechanized construction has been considered for all type of construction works to achieve specified quality at a faster rate for timely completion of the Project. The Project involves the construction of overflow weir, sediment flushing channel / under sluice, power intake, low pressure headrace tunnel, surge tank, penstock, powerhouse and tailrace channel.

Diversion works are mandatory for the commencement of the works on sediment flushing channel and overflow weir. The construction of low pressure headrace tunnel is very significant item in order to have timely completion of the Project. The construction of the access tunnels to the headrace tunnel near power intake and surge tank areas will help to make an early start on excavation of headrace tunnel which lies on the critical path.

The proposed implementation schedule takes account of the preliminary design of each structure and facilities, work quantities and site conditions. It is prepared on the basis of the construction plan, estimated construction progress, rate of each activity and work sequence. The proposed project implementation schedule spans over a period of 50 months, which includes 14 months for the pre-construction and 36 months for the construction activities construction plan is shown in Dwg.No: AFS-CP-478.



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## S. 17 COST ESTIMATE

The quantities of work items for ALHPP have been worked out on the basis of Layout Plan developed for the scheme on the actual topography of the area. Material quantities required have been computed using the engineering drawings consisting of plans and sections of all Project components. The unit cost is based on prevailing market rates. Considering the Exchange Rate of 1 US$ = Rs.157 (March 21, 2021). The Project Base Cost will be Rs. 20,499.565 Million (US $ 127.573 Million).

## S.18 ECONOMIC AND FINANCIAL ANALYSIS

The Project will yield Internal Economic Rate of Return (IERR) of 22.36 % by applying shadow prices. The benefits cost ratio comes to 1.55:1 at 12% discount rate which also reflect the economic viability of the proposed project. The financial benefits over the project life of 30 years calculated on certain assumptions depict an Internal Financial Rate of Return (IFRR) as 19.17% which makes the project significantly viable. Unit Cost (Cost/MW) comes out to be US $ 2.506 million (Rs.393.447 million) and cost/KWh US cent 3.61 (Rs. 5.67).

The Project is technically, socially, economically and financially viable, hence recommended for implementation.



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## S.19 SALIENT FEATURES OF THE PROJECT

| Parameters | | Units | Recommendation |
|---|---|---|---|
| Power house (PH) design discharge ($Q_d$) | | $m^3/s$ | 60 |
| Gross Head | | m | 112 |
| Rated head at design discharge of powerhouse | | m | 106 |
| Total Installed capacity (3 units) | | (MW) | 54 |
| Turbine Configuration, Francis vertical ( MW) | Runner diameter | m | 1.676 |
| | Unit Speed | (rpm) | 3 75 |
| Average annual energy generated | | (GWh) | 373.69 |
| Plant Factor | | (%age) | 79 |
| Project Base Cost | | Mill.US$ | 127.573 |
| Project Financial Cost | | Mill.US$ | 135.326 |
| Installed Cost/MW | | Mill. US $ | 2.506 |
| Energy Cost / KWh | | (US cent) | 3.610 |
| EIRR | | | 22.36% |
| FIRR | | | 19.17% |
| Benefit Cost ratio | | | 1.55:1 |



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# PAKISTAN
# WATER AND POWER DEVELOPMENT AUTHORITY

# ATTABAD LAKE HYDROPOWER PROJECT

## FEASIBILITY STUDY

## VOLUME 1
## MAIN REPORT

**JUNE 2021**

**GENERAL MANAGER (HYDRO) PLANNING**

WAPDA, SUNNY VIEW ESTATE, LAHORE

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# ATTABAD LAKE HYDROPOWER PROJECT
# LIST OF VOLUMES

**VOLUME – 1** **MAIN REPORT**

VOLUME – 2 DRAWINGS

VOLUME – 3 GEOLOGICAL AND GEOTECHNICAL STUDIES

VOLUME – 4 NEOTECTONICS STUDIES & SESIMIC HAZARDSN ANALYSIS

VOLUME – 5 BOREHOLE LOGS AND LABORTORY TESTING

VOLUME – 6 ENVIRONOMENTAL AND SOCIAL IMPACT ASSESSMENT

VOLUME – 7 APPENDICES

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

# LIST OF ABBREVIATION

| | |
|---|---|
| **A** | |
| ADB | Asian Development Bank |
| AKCSP | Aga Khan Cultural Service Pakistan |
| AKDN | Aga Khan Development Net Work |
| AKF | Aga Khan Foundation |
| AKHS | Aga Khan Health Service |
| AKRSP | Aga Khan Rural Support Programme |
| **C** | |
| CBM | Confidence-building measure |
| CBOs- | Community-based organizations |
| CPEC | China Pakistan Economic Corridor |
| **D** | |
| DLP | Defect Liability Period |
| **E** | |
| EIA | Environmental Impact Assessment |
| EL | Elevation Level |
| EMMP | Environment Monitoring Management Plan |
| EOT | Electric Overhead Bridge Type Traveling |
| EPA | Environment Protection Agency |
| ESIA | Environmental Impact Assessment |
| **G** | |
| G.B | Gilgit-Baltistan |
| GEF | Global Environment Facility |
| GHG | Green House Gases |
| GLOF | Glacial Lake Outburst Floods |
| GSP | Geological Survey of Pakistan |
| **H** | |
| ha | Hectare |
| HPO | Hydro Planning Organization |
| HPP | Hydropower Project |
| **I** | |
| ICT- | Information and Communication Technologies |
| IEE | Initial Environmental Examination |
| IRS | Indus River System |
| IUCN | International Union for Conservation of Nature |
| **K** | |
| KKH | Karakoram Highway |
| KNP- | Khunjerab National Park |
| KPK- | Khyber Pakhtunkhwa |
| **L** | |
| LAA | Land Acquisition Act |
| LGO | Local Government Ordinance |



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# LIST OF ABBREVIATION

| | |
|---|---|
| **M** | |
| M.A.S.L | Meters Above Sea Level |
| MBT | Main Boundary Thrust |
| MKT | Main Karakoram Thrust |
| MMM | Mitigation Management Matrix |
| MMT | Main Mantle Thrust |
| MW | Mega Watt |
| **N** | |
| NA | Northern Areas |
| NCS | National Conservation Strategy |
| NEQS | National Environment Quality Standards |
| NGO | Non- Governmental Organizations |
| NOC | No Objection Certificate |
| **P** | |
| PAP | Project Implementation and Resettlement of the Affected Persons |
| PEPA | Pakistan Environmental Protection Act |
| PEPC | Pakistan Environmental Protection Council |
| PMAC | Program for Mountain Areas Conservation |
| PPC | Pakistan Penal Code |
| **R** | |
| RAP | Resettlement Action Plan |
| RNR | Renewable Natural Resources |
| **S** | |
| SC | Supervisory Consultants |
| SWHP | Surface Water Hydrology Project |
| **T** | |
| TOR | Terms of Reference |
| **U** | |
| UNDP | United Nations Development Program |
| **V** | |
| VO | Village Organizations |
| **W** | |
| WAPDA | Water and Power Development Authority |
| WCSDO | Wildlife Conservation and Social Development Organizations |
| WCS | Wildlife Conservation Society |
| WHO | World Health Organization |
| WUO | Water Users' Organizations |
| WWF | World Wildlife Fund |



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## UNITS: CONVERSION FACTORS: SI TO FPS

| Length | To convert from | to | Multiply by |
|---|---|---|---|
| | m | ft | 3.281 |
| | cm | ft | 0.0328 |
| | km | ft | 3,280.84 |
| | m | mi | 0.0006214 |
| | km | mi | 0.6214 |
| **Area** | $m^2$ | $ft^2$ | 10.764 |
| | $km^2$ | $mi^2$ | 0.3861 |
| | $m^2$ | acre | 0.0002471 |
| | $km^2$ | acre | 247.105 |
| | hectare | acre | 2.471 |
| **Volume** | $m^3$ | $ft^3$ | 35.315 |
| | $m^3$ | US gal | 264.172 |
| | $m^3$ | UK gal | 219.969 |
| | L | $ft^3$ | 0.035315 |
| | $m^3$ | Acre Feet | 0.000810714 |
| **Velocity** | m/s | ft/s | 3.281 |
| | cm/s | ft/s | 0.03281 |
| | m/s | mi/h | 2.237 |
| | km/h | mi/h | 0.622 |
| **Acceleration** | $m/s^2$ | $ft/s^2$ | 3.281 |
| **Mass** | kg | $lb_m$ | 2.205 |
| | kg | ton | 0.00110 |
| **Pressure and Stress** | Pa or $N/m^2$ | psi | 0.000145 |
| **Discharge** | $m^3/s$ | $ft^3/s$ | 35.315 |
| | L/s | $ft^3/s$ | 0.035315 |
| | $m^3/s$ | US gal/min | 15850.3 |
| | $m^3/s$ | UK gal/min | 13198.2 |
| | L/s | US gal/min | 15.850 |
| | L/s | UK gal/min | 13.198 |



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## TABLES OF CONTENTS

1 INTRODUCTION....1-1
1.1 GENERAL....1-1
1.2 SALIENT FEATURES....1-5
1.3 CLIMATE....1-6
1.4 TRANSPORT AND COMMUNICATION....1-6
1.5 ACCESS TO THE PROJECT AREA....1-7
1.6 EXISTING POWER SUPPLY....1-7
1.7 ADMINISTRATIVE ORGANIZATION....1-7
2 POWER MARKET AND DEMAND FORECAST....2-1
2.1 INTRODUCTION....2-1
2.2 GILGIT-BALTISTAN POWER SECTOR OVERVIEW....2-1
2.2.1 Establishment of Regional Grids in Gilgit-Baltistan Phase-1 & 2....2-2
2.2.2 Power Generation in Gilgit-Baltistan....2-3
2.2.3 Hydropower Potential in Gilgit-Baltistan....2-7
2.3 POWER MARKET STUDY CONDUCTED BY WAPDA WITH GTZ....2-13
2.3.1 Methodology....2-14
2.3.2 Load Separation....2-14
2.3.3 Autonomous Load....2-14
2.4 POWER MARKET - PRESENT SCENARIO....2-17
2.4.1 Exploitation of Natural Resources....2-17
2.4.2 Tourism....2-18
2.4.3 Trade Route to China....2-18
2.4.4 Change in Social Life....2-18
2.4.5 Investment Incentive....2-18
2.4.6 Power Generation, Demand & Shortfall of Districts of Gilgit-Baltistan....2-18
2.4.7 Current Power Market HUNZA District....2-20
2.4.8 Load Shedding....2-21
2.4.9 Electricity Consumers in HUNZA District....2-22
2.5 POWER DEMAND FORECASTING....2-23
2.5.1 Determination and Forecast Power Demand....2-23
2.5.2 Basis of Load Demand Forecast....2-23
2.5.3 Parameters of Load Demand Forecast....2-26
2.5.4 Parameters Categorization....2-26



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2.5.5 Load Forecasting Results ....2-26
2.5.6 Estimated Power and Energy of Attabad Lake Hydropower Project ....2-32
**3 TOPOGRAPHIC AND HYDROGRAPHIC SURVEY ....3-1**
3.1 GENERAL....3-1
3.2 TOPOGRAPHY OF THE HUNZA RIVER....3-1
3.3 ATTABAD LAKE ....3-2
3.4 PROJECT AREA ....3-3
3.5 ACCESSIBILITY ....3-3
3.5.1 Roads Network ....3-3
3.5.2 Airport and Air Link ....3-3
3.5.3 Project Layout....3-3
3.6 TOPOGRAPHIC SURVEY....3-5
3.6.1 Available Topographic Information....3-5
3.6.2 Scope of Work ....3-6
3.6.3 Survey Standards and Requirements....3-7
3.7 METHODOLOGY APPLIED TO THE TOPOGRAPHIC SURVEY ....3-9
3.7.1 Reference System ....3-10
3.7.2 Instruments Used....3-10
3.7.3 DGPS Survey of Project's Reference Points....3-10
3.8 TERRESTRIAL TOPOGRAPHIC SURVEY OF PROJECT AREA....3-11
3.8.1 Horizontal Control ....3-12
3.8.2 Vertical Control ....3-13
3.8.3 Traverse Survey....3-13
3.8.4 Survey of Weir and Powerhouse Site....3-17
3.8.5 Survey of Valley Cross Sections and Longitudinal Profiles....3-17
3.8.6 Survey of Locations of Geotechnical Investigations ....3-17
3.9 RESULTS OF TERRESTRIAL TOPOGRAPHIC SURVEY ....3-18
3.9.1 The Attabad Lake Hydropower Project's Reference System ....3-18
3.9.2 Benchmarks of Attabad Lake Hydropower Project ....3-18
3.9.3 Detailed Topographic Maps ....3-19
3.9.4 Survey of Valley Cross Sections and Longitudinal Profiles....3-20
3.9.5 Survey of Locations for Geotechnical Investigations ....3-20
3.10 SATELLITE BASED SURVEY OF PROJECT AREA ....3-23
3.10.1 Google Earth Method....3-23



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3.10.2 Methodology ....3-23
3.10.3 Geographic Data....3-23
3.10.4 Geographic Information System (GIS) Method....3-23
3.11 HYDROGRAPHIC SURVEY ....3-30
3.11.1 Scope of Work ....3-30
3.12 METHODOLOGY APPLIED TO THE HYDROGRAPHIC SURVEY ....3-30
3.12.1 Instrument Used ....3-30
3.12.2 Horizontal and Vertical Control of Cross Sections....3-30
3.12.3 Hydrographic Survey ....3-30
3.12.4 Capacity Computations by TIN Method using ArcGIS ....3-32
3.13 RESULTS OF HYDROGRAPHIC SURVEY ....3-33
3.13.1 Cross Sections & Surveyed Plan of Lake....3-33
3.13.2 Comparison of Selected Cross Sections ....3-34
3.13.3 Longitudinal Bed Profile ....3-34
3.13.4 Thalweg Profile ....3-34
3.13.5 Capacity and Surface Area ....3-34
3.13.6 Discharge Measurement at Ganish Bridge....3-34
3.14 QUALITY CONTROL ....3-34
**4 HYDROLOGY AND SEDIMENTATION ....4-1**
4.1 GENERAL....4-1
4.2 HUNZA VALLEY ....4-2
4.2.1 Gojal Valley....4-2
4.3 HUNZA RIVER ....4-2
4.4 HUNZA RIVER CATCHMENT ....4-3
4.5 CLIMATE ....4-4
4.6 ISOHYETAL MAP OF ATTABAD LAKE CATCHMENT ....4-7
4.7 HYDROLOGY....4-8
4.7.1 Hydrologic Measurement Station ....4-8
4.8 FLOW MEASUREMENT....4-9
4.8.1 Flow Duration Curve (FDC)....4-11
4.9 WATER LEVELS ....4-12
4.9.1 Upstream Water Levels....4-12
4.9.2 Downstream Water Levels (Tail-water Rating Curve)....4-12
4.10 FLOOD ESTIMATION....4-13



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4.10.1 Flood Estimation by Flood Frequency Analysis (FFA) ....4-14
4.10.2 Flood Estimation by USACE HEC-SSP Model ....4-15
4.10.3 Statistical Model Analysis....4-16
4.10.4 Recommended Design Flood....4-17
4.11 HYDROLOGIC FLOOD ROUTING ....4-17
4.11.1 Establishment of the HEC-HMS Model ....4-17
4.11.2 Assumption for the Routing....4-18
4.11.3 Results of Flood Routing....4-18
4.12 GLACIAL LAKE OUT BRUST FLOOD (GLOFS)....4-21
4.12.1 Update on Glacial Hazards in the Upper Indus Basin....4-23
4.13 SEDIMENTATION STUDIES ....4-23
4.13.1 General....4-23
4.13.2 Suspended Sediment Concentration....4-24
4.13.3 Sediment Sampling....4-24
4.13.4 Sediment Grading ....4-25
4.13.5 Available Data....4-25
4.13.6 Suspended Discharge Rating Curve ....4-27
4.13.7 Sediment Yield....4-29
4.13.8 Initial Density of Deposited Sediment and its Consolidation ....4-32
4.13.9 Mean Annual Sediment Load....4-33
4.13.10 Bed Load ....4-33
4.13.11 Trap Efficiency....4-35
4.13.12 Life Assessment of Attabad HPP Reservoir ....4-36
**5 GEOLOGY AND GEO TECHINCAL STUDIES....5-1**
5.1 GENERAL....5-1
5.2 SCOPE OF WORK ....5-1
5.3 REGIONAL GEOLOGY....5-1
5.3.1 Stratigraphic Sequence....5-2
5.3.2 Misgar Unit (MU)....5-2
5.3.3 Sost Unit (SU)....5-2
5.3.4 Gojal Unit (GU) ....5-3
5.3.5 Karakorum Axial Batholith (KAB): ....5-3
5.3.6 Ganesh Formation: ....5-3
5.3.7 Hassanabad Granite: ....5-3



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5.3.8 Chalt Formation: ....5-3
5.4 REGIONAL TECTONICS....5-4
5.5 REGIONAL FAULTS....5-5
5.5.1 Karakorum Fault (KF) ....5-5
5.5.2 Upper Hunza Fault (UHF) ....5-5
5.5.3 Main Karakorum Thrust (MKT)....5-5
5.5.4 Main Mantle Thrust (MMT)....5-6
5.6 SITE GEOLOGY....5-6
5.6.1 Soil Units ....5-6
5.6.2 Rock units....5-6
5.7 GEOLOGICAL STRUCTURES ....5-7
5.8 GEOLOGICAL & GEOTECHNICAL INVESTIGATIONS....5-8
5.9 SURFACE INVESTIGATIONS....5-8
5.9.1 Surface Geological Mapping ....5-8
5.9.2 Neo-tectonics Study....5-8
5.10 SUBSURFACE INVESTIGATIONS....5-9
5.10.1 Drilling....5-9
5.10.2 Test Pits....5-10
5.10.3 Laboratory Testing....5-10
5.11 GEOLOGY AND FOUNDATION EVALUATION....5-11
5.12 WEIR SITE ....5-11
5.13 INTAKE AREA ....5-12
5.14 POWER TUNNEL....5-13
5.15 UNDER SLUICE SECTION/SEDIMENT FLUSHING CHANNEL....5-14
5.16 SURGE TANK AND PENSTOCK ALIGNMENT ....5-16
5.17 POWER HOUSE....5-17
5.18 TAILRACE CHANNEL ....5-19
5.19 CONSTRUCTION MATERIAL ....5-19
5.20 FINE AGGREGATE....5-19
5.20.1 Sand Quarry ....5-19
5.20.2 Silt and Clay Quarry....5-20
5.21 COARSE AGGREGATE ....5-21
5.21.1 Passu Area ....5-21
5.21.2 Power House Area....5-22



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5.21.3 Slided Mass ....5-23
5.22 BUILDING STONE....5-23
5.23 FILL MATERIAL....5-24
5.24 CEMENT AND STEEL....5-24
**6 NEO TECTONICS AND SEISMIC HAZARD ANALSIS ....6-1**
6.1 GENERAL....6-1
6.2 OBJECTIVES ....6-1
6.3 METHODOLOGY....6-1
6.4 FIELD OBSERVATIONS....6-2
6.4.1 Passu Village: ....6-3
6.4.2 Road section from Murradabad to Hussani Village:....6-6
6.4.3 At Sarat Village: ....6-8
6.4.4 Inside Tunnel 2: ....6-11
6.4.5 Power House area: ....6-12
6.4.6 At Murtazabad- Shahyar Road:....6-14
6.4.7 In Tashot Village: ....6-15
6.5 SEISMIC HAZARD ANALYSIS ....6-16
6.5.1 Probabilistic Hazard Analysis ....6-16
6.6 DETERMINISTIC SEISMIC HAZARD ANALYSIS (DSHA)....6-17
6.7 DETERMINISTIC RESPONSE SPECTRA....6-19
6.7.1 Deterministic Pseudo Spectral Acceleration (PSA) ....6-19
6.8 SELECTION OF SEISMIC DESIGN PARAMETERS ....6-20
6.8.1 Safety Evaluation Earthquake (SEE)....6-20
6.8.2 Operating Basis Earthquake (OBE) ....6-21
6.8.3 Uniform Hazard Spectra (UHS)....6-21
6.9 RESULTS ....6-22
**7 PROJECT LAYOUT....7-1**
7.1 GENERAL....7-1
7.2 ALTERNATIVE PROJECT LAYOUT....7-1
7.2.1 Alternative-I: Project Layout on the Left Bank ....7-1
7.2.2 Alternative-II: Project Layout on the Right Bank ....7-3
7.3 FIELD INVESTIGATIONS FOR PROJECT LAYOUT ....7-3
7.3.1 Alternative-I A Headrace Tunnel Option....7-4
7.3.2 Alternative-I B Headrace with Embedded Pressure Pipe....7-5



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7.4 EMBEDDED PENSTOCK VERSUS TUNNEL ....7-5
7.4.1 Geology along the Embedded Penstock Route ....7-6
7.4.2 Geology along the Tunnel Route ....7-6
7.5 POWERHOUSE LOCATION ....7-6
7.5.1 Geology of Powerhouse ....7-6
7.6 COST ESTIMATES ....7-6
7.7 SELECTED PROJECT LAYOUT ....7-8
**8 POWER POTENTIAL ....8-1**
8.1 GENERAL ....8-1
8.2 RESERVOIR OPERATION SYSTEM ....8-1
8.3 ATTABAD RESERVOIR ....8-2
8.4 WATER AVAILABILITY AT RESERVOIR ....8-4
8.4.1 Flow Duration Curve (FDC) ....8-5
8.5 WATER LEVELS ....8-6
8.5.1 Upstream Water Levels ....8-6
8.5.2 Downstream Water Levels ....8-6
8.6 POWER AND ENERGY STUDIES ....8-7
8.6.1 Power and Energy Potential ....8-7
8.6.2 Optimization of Power and Energy ....8-8
8.6.3 Plant Factor ....8-9
8.7 ESTIMATED POWER AND ENERGY ....8-11
**9 DESIGN OF STRUCTURES ....9-1**
9.1 INTRODUCTION ....9-1
9.2 HYDRAULIC MODELLING OF RESERVOIR ....9-2
9.2.1 Input Data ....9-3
9.2.2 Analysis and Conclusions ....9-6
9.3 NATURAL DAMMING ON HUNZA RIVER ....9-9
9.4 HYDRAULIC DESIGN ....9-10
9.4.1 Hydraulic Design of Weir/Spillway and Stilling Basin ....9-10
9.4.2 Flushing Outlets ....9-14
9.4.3 Freeboard Calculations ....9-17
9.5 DESIGN OF RIVER DIVERSION WORKS ....9-18
9.6 DISCHARGE CAPACITY OF RIVER DIVERSION WORKS ....9-18
9.7 POWER INTAKE STRUCTURE ....9-19



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9.7.1 General ..... 9-19
9.7.2 Hydraulic Design ..... 9-20
9.7.3 Power Intake Settings ..... 9-22
9.7.4 Trashrack Cross-sectional Area ..... 9-22
9.8 LOW PRESSURE TUNNEL ..... 9-23
9.8.1 Criteria for design ..... 9-23
9.8.2 Low Pressure Headrace Tunnel ..... 9-25
9.9 SURGE TANK ..... 9-26
9.9.1 Hydraulic Design of Surge Tank ..... 9-27
9.9.2 Load Case Maximum Upsurge ..... 9-28
9.9.3 Results of Surge Tank Simulation ..... 9-29
9.10 WATER HAMMER ANALYSIS IN PENSTOCKS ..... 9-30
9.10.1 Water hammer calculations for single Penstock ..... 9-30
9.10.2 Pressure wave velocity ..... 9-30
9.10.3 Water hammer Pressure (Allievi chart) ..... 9-31
9.11 POWER COMPLEX ..... 9-31
9.11.1 General ..... 9-31
9.11.2 Sizing of Powerhouse ..... 9-32
9.11.3 Powerhouse Building ..... 9-32
9.12 TAILRACE CHANNEL ..... 9-33
**10 GEOTECHNICAL & STRUCTURAL STABILITY ANALYSIS ..... 10-1**
10.1 GENERAL ..... 10-1
10.2 PROJECT NARRATIVE FOR USE OF GEOTECHNICAL SOFTWARE ..... 10-1
10.3 GEOLOGY OF THE SLOPES ..... 10-2
10.4 SCOPE OF THE ANALYSIS ..... 10-2
10.5 DESCRIPTION OF THE SLOPE STABILITY ANALYSIS ..... 10-2
10.5.1 Ordinary Method of Slices ..... 10-3
10.5.2 Bishop method of Slices ..... 10-6
10.5.3 Spencer method ..... 10-6
10.5.4 Janbu Method ..... 10-7
10.5.5 Morgenstern-Price method ..... 10-7
10.6 PROS AND CONS OF SLOPE STABILITY METHODS-SUMMARY ..... 10-8
10.7 SLOPE STABILITY INPUT PARAMETERS ..... 10-8
10.8 Methodology Adopted For Slope Stability Slope/ W Analysis ..... 10-9



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10.9 CONCLUSIONS FOR SLOPE STABILITY SLOPE/ W ANALYSIS .....10-9
10.10 FUTURE RECOMMENDATION.....10-10
10.11 GEOTECHNICAL STABILITY OF OVERFLOW SPILLWAY STRUCTURE..10-10
10.11.1 Seepage Analysis.....10-10
10.11.2 Flow Law .....10-11
10.11.3 Governing Equation of Seepage Analysis.....10-11
10.11.4 Geology at Overflow Weir/Ungated Spillway.....10-11
10.11.5 Drilling results at weir site .....10-12
10.11.6 Seepage Line of Defenses.....10-13
10.11.7 Selection of Stabilized Soil.....10-13
10.11.8 Material Description and Input Parameters .....10-16
10.11.9 Geostudio (SEEP/W Analysis).....10-16
10.12 MONITORING AND SURVILANCE OF SLOPES.....10-26
**11 HYDRO MECHANICAL EQUIPMENT .....11-1**
11.1 INTRODUCTION .....11-1
11.1.1 BACKGROUND .....11-1
11.1.2 Location .....11-1
11.1.3 Parameters .....11-1
11.2 POWER HOUSE MECANICAL WORKS .....11-2
11.2.1 General.....11-2
11.2.2 Introduction.....11-2
11.3 STANDARDS AND BASIC DESIGN CRITERIA.....11-3
11.4 MAIN DESIGN PARAMETERS.....11-3
11.4.1 Water Flow.....11-3
11.4.2 Head Calculation.....11-4
11.4.3 Water Head.....11-4
11.4.4 Site Elevation.....11-4
11.4.5 Water Temperature.....11-4
11.4.6 System frequency .....11-4
11.4.7 Plant Capacity.....11-5
11.5 POWERHOUSE MECHANICAL EQUIPMENT .....11-5
11.6 TURBINES.....11-6
11.6.1 Turbine Selection Criteria.....11-6
11.6.2 Specific Speed.....11-8



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11.6.3 Number of units ....11-9
11.7 TURBINE LAYOUT AND SIZING....11-11
11.8 MAIN DATA ....11-13
11.8.1 Turbine Speed ....11-14
11.8.2 Runner diameter ....11-14
11.8.3 Runaway speed ....11-14
11.8.4 Setting ....11-14
11.8.5 Components Dimensions ....11-15
11.8.6 Special design criteria ....11-15
11.8.7 Overpressure ....11-15
11.8.8 Over-speed ....11-15
11.8.9 Runaway speed ....11-15
11.8.10 Critical speed ....11-15
11.9 TURBINE MAJOR COMPONENTS ....11-16
11.9.1 Runner ....11-16
11.9.2 Turbine shaft and Coupling ....11-16
11.9.3 Bearings ....11-16
11.9.4 Spiral casing ....11-17
11.9.5 Guide Vanes ....11-17
11.9.6 Operating Mechanism ....11-17
11.9.7 Guide Vane Servomotor ....11-17
11.9.8 Top Cover/ Side Cover ....11-17
11.9.9 Draft Tube ....11-17
11.10 TURBINE MODEL TESTS ....11-18
11.11 GOVERNOR SYSTEM ....11-18
11.11.1 Governor Head ....11-19
11.11.2 Electronic Equipment ....11-19
11.11.3 Hydraulic Systems ....11-20
11.11.4 Water Hammer within High Pressure Conduit ....11-20
11.12 TURBINE INSTRUMENTATION, CONTROL AND SAFETY DEVICES ....11-20
11.13 INLET VALVE ....11-20
11.13.1 Operating Mechanism ....11-21
11.13.2 Control and Safety Devices ....11-21
11.14 AUXILIARY SYSTEMS ....11-22



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11.14.1 General....11-22
11.14.2 Plumbing Works....11-22
11.14.3 Water Supply System....11-22
11.14.4 Waste and Sewerage water....11-22
11.14.5 Dewatering and drainage system....11-23
11.14.6 Compressed Air System....11-23
11.14.7 Oil Handling System....11-24
11.14.8 Heating, Ventilation and Air Conditioning System....11-25
11.14.9 Fire Protection System....11-27
11.14.10 Powerhouse Crane....11-31
11.14.11 Mobile crane....11-33
11.14.12 Power House Elevator....11-33
11.14.13 Workshop Equipment and Tools....11-34
11.15 HYDRAULIC STEEL STRUCTURE....11-35
11.15.1 General....11-35
11.15.2 Power Intake Gate Equipment....11-36
11.15.3 Trashracks....11-41
11.15.4 Trashrack Cleaning Machines....11-41
11.15.5 Pressure Shaft....11-42
11.15.6 Surge Shaft....11-42
11.15.7 Draft Tube Gate Equipment....11-43
11.16 Mechanical Cost Estimation....11-44
**12 ELECTRICAL EQUIPMENT....12-1**
12.1 GENERAL....12-1
12.2 STANDARDS AND REGULATIONS....12-1
12.3 GENERATOR....12-1
12.3.1 Type & Description....12-2
12.3.2 Design....12-3
12.3.3 Rotor....12-4
12.3.4 Stator....12-4
12.3.5 Generator Bearings....12-5
12.3.6 Condition Monitoring System....12-7
12.3.7 Excitation System....12-7
12.3.8 Generator Circuit Breaker....12-9



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12.4 OTHER ELECTRICAL EQUIPMENT ....12-9
12.5 POWER TRANSFORMERS ....12-9
12.6 STATION SERVICE TRANSFORMER ....12-10
12.7 AUXILIARY TRANSFORMERS ....12-11
12.8 SWITCHGEAR SYSTEM ....12-11
12.8.1 132kV Switchgear ....12-11
12.8.2 11kV Switchgear ....12-12
12.8.3 400 Volt Switchgear ....12-12
12.9 CONTROL, INSTRUMENTATION AND PROTECTION EQUIPMENT ....12-13
12.9.1 Instrumentation & Control ....12-13
12.9.2 Protection Equipment ....12-14
12.10 SYNCHRONIZING ....12-16
12.10.1 Automatic Synchronizer ....12-16
12.10.2 Manual Synchronizing Facilities ....12-16
12.11 MEASURING EQUIPMENT ....12-16
12.11.1 Current Transformers (CT) ....12-16
12.11.2 Voltage Transformers (VT) ....12-17
12.12 SURGE ARRESTERS ....12-18
12.13 DC POWER SUPPLY ....12-18
12.14 CABLES ....12-18
12.14.1 Power Cables ....12-19
12.14.2 Control Cables ....12-19
12.14.3 Telecommunication Cables ....12-19
12.14.4 Fiber Optics Cables ....12-20
12.15 ILLUMINATION AND SMALL POWER ....12-21
12.15.1 Lighting/Illumination System ....12-21
12.15.2 Emergency Lighting: ....12-23
12.16 EMERGENCY DIESEL GENERATORS ....12-23
12.17 ELECTRICAL WORKSHOP ....12-23
12.18 GROUNDING SYSTEM ....12-24
12.19 SCADA AND TELECOM SYSTEM ....12-24
12.19.1 Functional Overview ....12-24
12.19.2 Station Instrumentation and Control (I&C) System ....12-24
12.19.3 Interface with Existing NTDC SCADA System ....12-25



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12.19.4 SCADA Facilities for Tele-Control by NPCC ....12-25
12.19.5 Local/Remote Switches ....12-27
12.19.6 SCADA Control Philosophy ....12-27
12.19.7 Telecommunication System ....12-27
12.19.8 Teleprotection ....12-28
12.19.9 Public Address System ....12-28
12.19.10 Un-Interruptible Power Supplies (UPS) ....12-28
12.19.11 Time Synchronization ....12-29
12.19.12 Video Surveillance System (CCTV) ....12-29
**13 TRANSMISSION LINE STUDY ....13-1**
13.1 GENERAL ....13-1
13.2 EXISTING GILGIT BALTISTAN TRANSMISSION SYSTEM ....13-2
13.3 ESTABLISHMENT OF REGIONAL GRID ....13-2
13.4 PARAMETERS FOR TRANSMISSION LINE STUDY ....13-3
13.5 TRANSMISSION LINE FROM ATTABAD LAKE HPP ....13-3
13.6 TRANSMISSION VOLTAGE ....13-4
13.7 LOADABILITY CHARACTERISTICS ....13-4
13.8 NUMBER OF CIRCUITS ....13-5
13.9 TRANSMISSION LINE ROUTE ....13-5
13.10 CLIMATIC CONDITIONS ....13-7
13.11 SELECTION OF CONDUCTOR ....13-7
13.11.1 TENSILE STRENGTH ....13-8
13.11.2 POWER TRANSFER CAPABILITY ....13-8
13.11.3 POWER LOSSES ....13-9
13.11.4 RECOMMENDATION ....13-9
13.12 TOWERS ....13-9
13.12.1 TYPE AND BASIC DATA ....13-9
13.12.2 TOWER CONFIGURATION ....13-10
13.12.3 MIX OF DIFFERENT TYPES OF TOWERS ....13-10
13.12.4 ADDITIONAL LOADINGS DUE TO ICE AND WIND ....13-11
13.12.5 WAPDA / NTDC SPECIFICATIONS ....13-11
13.12.6 FOUNDATIONS ....13-11
13.12.7 INSULATORS ....13-12
13.12.8 MISCELLANEOUS ITEMS ....13-12



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13.13 OPTICAL OVERHEAD GROUND WIRE (OPGW) ..... 13-12
13.14 ENVIRONMENTAL ASPECTS ..... 13-13
13.14.1 CORONA LOSSES ..... 13-13
13.14.2 AUDIBLE NOISE ..... 13-13
13.14.3 Surface Gradient ..... 13-13
13.15 MINIMUN CLEARANCE OF 132 kV TRANSMISSION LINE ..... 13-13
**14 PROJECT QUANTITIES AND COST ESTIMATES ..... 14-1**
14.1 GENERAL ..... 14-1
14.1.1 Basic Assumptions ..... 14-1
14.2 COST ESTIMATION ..... 14-1
14.2.1 Price Index ..... 14-1
14.2.2 Development of Unit Rates ..... 14-1
14.2.3 Rate Analysis ..... 14-2
14.2.4 Basis for Unit Rates ..... 14-3
14.2.5 Civil Works Quantities ..... 14-3
14.3 BREAKDOWN OF ESTIMATES ..... 14-3
14.3.1 Land Acquisition and Environmental Mitigation ..... 14-3
14.3.2 Preparatory Works ..... 14-4
14.3.3 Main Weir ..... 14-4
14.3.4 Sediment Flushing Section ..... 14-4
14.3.5 Power Intake ..... 14-4
14.3.6 Low Pressure Headrace Tunnel ..... 14-4
14.3.7 Surge Tank ..... 14-4
14.3.8 Penstock ..... 14-4
14.3.9 Powerhouse and Tailrace Channel ..... 14-4
14.3.10 Watershed Management at Shimshal Nullah ..... 14-4
14.3.11 Hydraulic Steel Structures ..... 14-5
14.3.12 Hydro-Mechanical Works ..... 14-5
14.3.13 Electrical Works ..... 14-5
14.3.14 Switchyard Works ..... 14-5
14.3.15 Transmission Lines ..... 14-5
14.3.16 Transportation Charges ..... 14-5
14.3.17 Erection & Commissioning ..... 14-5
14.3.18 Engineering and Supervision ..... 14-5



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14.3.19 Physical and Numerical Modeling ....14-6
14.3.20 Physical Contingencies ....14-6
14.3.21 Admin, Audit, Accounts, Legal and Client's Expenses ....14-6
14.3.22 Authority Overheads ....14-6
14.3.23 Insurance Cost ....14-6
14.3.24 Local and Foreign Components ....14-6
14.4 PROJECT COST ....14-7
14.5 PROJECT PHASING ....14-7
**15 CONSTRUCTION PLANNING AND COST ESTIMATES ....15-1**
15.1 GENERAL ....15-1
15.2 PROJECT LOCATION ....15-1
15.3 ACCESSIBILITY TO PROJECT AREA ....15-1
15.3.1 Roads Access ....15-1
15.3.2 Access by Air ....15-3
15.4 MANPOWER AVAILABILITY ....15-3
15.4.1 Unskilled ....15-3
15.4.2 Unskilled ....15-3
15.5 FACTORS AFFECTING PROGRESS OF CONSTRUCTION WORKS ....15-3
15.5.1 Non-Productive Periods ....15-3
15.5.2 Procurement and Storage of Materials ....15-4
15.5.3 General Construction Equipment ....15-6
15.6 PRE-CONSTRUCTION PHASE ....15-6
15.6.1 Land Acquisition ....15-6
15.6.2 Contract Award on EPC Basis ....15-7
15.7 PREPARATORY WORKS ....15-7
15.7.1 Contractor’s Camp ....15-7
15.7.2 Construction Plant Facilities ....15-8
15.7.3 Other Site Facilities ....15-8
15.7.4 Residential Colony ....15-9
15.7.5 Access Roads to Main Work Sites ....15-9
15.7.6 Additional Survey & Investigations ....15-10
15.7.7 Detailed Engineering Design ....15-10
15.8 CONSTRUCTION PLANNING AND METHODOLOGY ....15-10
15.8.1 Care and Handling of Water ....15-11



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15.8.2 Sediment Flushing Channel / Undersluice ....15-11
15.8.3 Power Intake....15-12
15.8.4 Overflow Weir / Ungated Spillway ....15-13
15.8.5 Access Tunnels / Adits for Headrace Tunnel....15-14
15.8.6 Low Pressure Headrace Tunnel....15-14
15.8.7 Surge Tank ....15-15
15.8.8 Penstock....15-16
15.8.9 Powerhouse Civil Works ....15-17
15.8.10 Unit Erection....15-17
15.8.11 Mechanical & Electrical Installations ....15-17
15.8.12 Tailrace Channel....15-19
15.8.13 Switchyard ....15-19
15.8.14 Transmission Lines....15-19
15.8.15 Transportation, Assembly of Electro-Mechanical Equipment ....15-20
15.8.16 Testing and Commissioning....15-20
15.9 PROJECT IMPLEMENTATION SCHEDULE ....15-20
15.10 CONSTRUCTION MANAGEMENT....15-20
15.10.1 Project Executing Agency....15-20
15.10.2 Consultants....15-21
Annexure - A ....15-22
**16 ENVIRONOMENTAL IMPACT ASSESSMENT ....16-1**
16.1 GENERAL....16-1
16.2 ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT (ESIA)....16-2
16.3 PROJECT CATEGORIZATION....16-2
16.4 SCOPE AND LIMITATIONS OF ESIA....16-3
16.4.1 Scope ....16-3
16.4.2 Limitations....16-3
16.5 APPROACH AND METHODOLOGY ....16-3
16.5.1 Review of Previous Studies ....16-3
16.5.2 Acquisition of Secondary Data ....16-4
16.5.3 Collection of Primary Data ....16-4
16.6 BASELINE CONDITIONS....16-7
16.7 PHYSICAL ENVIRONMENT....16-7
16.7.1 Physiography. ....16-7



e-Pak Acquisition and Disposal System (EPADS) generated document | © 2026 

16.7.2 Demography ....16-7
16.7.3 Climate ....16-8
16.7.4 Precipitation ....16-8
16.7.5 Temperature ....16-8
16.7.6 Geology ....16-9
16.7.7 Seismology ....16-9
16.7.8 Landslides, Erosion and Sedimentation ....16-10
16.7.9 Land Use ....16-10
16.7.10 Mining ....16-10
16.7.11 Agriculture ....16-10
16.7.12 Fruits ....16-11
16.7.13 Livestock ....16-11
16.7.14 Hydrology ....16-12
16.7.15 Surface Water Availability & Quality ....16-13
16.7.16 Groundwater ....16-13
16.7.17 Air Quality and Noise ....16-13
16.7.18 Greenhouse gases ....16-14
16.7.19 Waste ....16-14
16.8 BIOLOGICAL ENVIRONMENT ....16-14
16.8.1 Flora ....16-14
16.8.2 Forestry ....16-15
16.8.3 Fauna ....16-15
16.8.4 Insects ....16-16
16.8.5 Protected Area ....16-16
16.8.6 Aquatic Ecology ....16-17
16.8.7 Fisheries ....16-17
16.9 SOCIAL AND ECONOMIC ENVIRONMENT ....16-18
16.9.1 Population ....16-18
16.9.2 Languages ....16-19
16.9.3 Ethnic Groups and Religions ....16-20
16.9.4 Administrative Setup ....16-20
16.9.5 Health Facilities and Common Diseases ....16-20
16.9.6 Education and Literacy ....16-20
16.9.7 Infrastructure and Recreation ....16-20



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16.9.8 Professions and Source of Income ....16-21
16.9.9 Tourism and Cultural Heritage ....16-21
16.10 ESIA AND MITIGATION MEASURES....16-21
16.11 IMPACT ASSESSMENT PROCEDURE ....16-21
16.11.1 Sensitivity ....16-21
16.11.2 Magnitude....16-22
16.12 IMPACTS DURING CONSTRUCTION AND OPERATIONAL STAGE....16-22
16.12.1 Impacts on Topography ....16-22
16.12.2 Impact on Seismicity....16-23
16.12.3 Impact on Geology....16-23
16.12.4 Impacts on Landslides ....16-23
16.12.5 Impacts on Land Use....16-24
16.12.6 Impacts on Infrastructure ....16-24
16.12.7 Impact on Climate....16-24
16.12.8 Impacts on Hydrology ....16-25
16.12.9 Impacts on Sedimentation ....16-25
16.12.10 Impacts on Flooding ....16-25
16.12.11 Impacts on Groundwater....16-25
16.12.12 Impacts on Air Quality....16-26
16.12.13 Impacts on Terrestrial Flora and Fauna ....16-26
16.12.14 Impacts on Employment Opportunities ....16-26
16.12.15 Impacts on Regional Safety and Health ....16-26
16.12.16 Impacts on Occupational Health and Safety ....16-27
16.12.17 Impacts on Resources ....16-27
16.12.18 Impacts on Cultural Heritage and Archaeology ....16-27
16.13 CONFIDENCE BUILDING MEASURES (CBM) ....16-29
16.14 ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN ....16-29
16.15 MITIGATION MANAGEMENT MATRIX ....16-29
16.16 MANAGEMENT OF DIRECT CONSTRUCTION IMPACTS ....16-30
16.17 SITE RESTORATION PLAN....16-30
16.18 RESERVOIR MANAGEMENT PLAN ....16-31
16.19 IMPACT MONITORING PROGRAM....16-31
16.19.1 Objectives of the Impact Monitoring Plan....16-31
16.19.2 Monitoring Strategy....16-32



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16.19.3 Monitoring Parameters and Frequency ..... 16-32
16.20 Constitution Ofprojectenvironment Management Committee ..... 16-33
16.21 LAND REQUIREMENTS FOR THE PROJECT ..... 16-33
**17 ECONOMIC AND FINANCIAL ANALYSIS ..... 17-1**
17.1 INTRODUCTION ..... 17-1
17.2 ECONOMIC ANALYSIS ..... 17-1
17.2.1 Introduction ..... 17-1
17.3 CUSTOM DUTY ..... 17-1
17.4 INTEREST DURING CONSTRUCTION (IDC) ..... 17-1
17.5 EXCHANGE RATE ..... 17-1
17.6 OPERATION AND MAINTENANCE COST ..... 17-2
17.7 AUTHORITY OVERHEADS ..... 17-2
17.8 ANNUAL RECURRING COST ..... 17-2
17.9 LOCAL ESCALATION ..... 17-2
17.10 FOREIGN ESCALATION ..... 17-2
17.11 ERECTION & COMMISSIONING, LC, INSURANCE & SECURITY COST ..... 17-2
17.12 ANNUAL O&M COSTS ..... 17-3
17.13 PROJECT BENEFITS AND ANALYSIS ..... 17-3
17.14 FINANCIAL BENEFITS ..... 17-3
17.15 ECONOMIC BENEFITS ..... 17-3
17.16 SOCIAL BENEFITS ..... 17-3
17.17 BENEFITS OF THE PROJECT ..... 17-4
17.17.1 Quantifiable Benefits ..... 17-4
17.17.2 Non-Quantifiable Benefits ..... 17-4
17.18 CLEAN DEVELOPMENT MECHANISM (CDM) BENEFITS ..... 17-5
17.19 FINANCIAL ANALYSIS ..... 17-6
17.19.1 Unit Cost Analysis ..... 17-9
17.19.2 Breakeven Point (BEP) ..... 17-11
17.19.3 Payback Period ..... 17-11
17.19.4 Fuel Price ..... 17-11
17.20 ECONOMIC ANALYSIS ..... 17-11
17.21 SHADOW PRICING ..... 17-12
17.22 COST OF CAPITAL ..... 17-12
17.23 COST OF LABOUR ..... 17-12



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17.24 COST OF MATERIAL ....17-13
17.25 ECONOMIC COST ....17-13
17.26 DERIVATION OF THERMAL EQUIVALENCE ....17-14
17.27 EMPLOYMENT ANALYSIS ....17-17
17.28 SENSITIVITY ANALYSIS....17-17
17.29 CONCLUSION....17-20
**18 CONCLUSIONS AND RECOMMENDATION....18-1**

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# LIST OF FIGURES

Figure 1-1 Map of Central Hunza (Source: Google Map) ....1-2
Figure 1-2 Site Plan (Source: Own Compilation from Google)....1-4
Figure 1-3 Location Map (Source: NHA Pakistan)....1-5
Figure 2-1 Map of Gilgit-Baltistan....2-1
Figure 2-2 Installed Power in Gilgit-Baltistan....2-5
Figure 2-3 Percentage of District wise Hydel Power Generation in Gilgit-Baltistan....2-5
Figure 2-4 Percentage of District wise Thermal Power Generation in Gilgit-Baltistan....2-5
Figure 2-5 Percentage Wise Power Sharing in Gilgit....2-5
Figure 2-6 Percentage Wise Power Sharing in Gilgit....2-5
Figure 2-7 Percentage Wise Power Sharing in Ghizer ....2-6
Figure 2-8 Percentage Wise Power Sharing in Astore....2-6
Figure 2-9 Percentage Wise Power Sharing in Nagar ....2-6
Figure 2-10 Percentage Wise Power Sharing in Hunza....2-6
Figure 2-11 Percentage Wise Power Sharing in Shiger....2-7
Figure 2-12 Percentage Wise Power Sharing in Diamer ....2-7
Figure 2-13 Percentage Wise Power Sharing in Kharmang ....2-7
Figure 2-14 Percentage Wise Power Sharing in Ghance ....2-7
Figure 2-15 Location Map of Hydropower Power Projects in Gilgit-Baltistan ....2-11
Figure 2-16 Conservative Load Forecast ....2-16
Figure 2-17 Intermediate Load Forecast ....2-16
Figure 2-18 Optimistic Load Forecast ....2-16
Figure 2-19 District wise Summer Power Scenario in Gilgit-Baltistan....2-20
Figure 2-20 District wise Winter Power Scenario in Gilgit-Baltistan ....2-20
Figure 2-21 District wise Overall Power Demand in Gilgit-Baltistan....2-20
Figure 2-22 Installed Capacity in Hunza....2-21
Figure 2-23 Electricity Consumers in Hunza ....2-23
Figure 2-24 Power Demand Forecast Gilgit (2021-50) ....2-28
Figure 2-25 Power Demand Forecast Ghizer (2021-50)....2-28
Figure 2-26 Power Demand Forecast Nagar (2021-50)....2-28
Figure 2-27 Power Demand Forecast Hunza (2021-50) ....2-29
Figure 2-28 Power Demand Forecast Diamer (2021-50)....2-29
Figure 2-29 Power Demand Forecast Astore (2021-50) ....2-29
Figure 2-30 Power Demand Forecast Skardu(2021-50) ....2-30



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Figure 2-31 Power Demand Forecast Ghance (2021-50) ..... 2-30
Figure 2-32 Power Demand Forecast Shiger (2021-50) ..... 2-30
Figure 2-33 Power Demand Forecast Kharmang (2021-50) ..... 2-31
Figure 2-34 10-Daily Power Graph for Average Year (1998) ..... 2-32
Figure 2-35 10-Daily Power Graph for Wet Year (2011) ..... 2-33
Figure 2-36 10-Daily Power Graph for Dry Year (1996) ..... 2-33
Figure 2-37 Mean Annual Energy from (1996 to 2015) ..... 2-34
Figure 2-38 Monthly Energy Comparison (Wet, Average & Dry Years ..... 2-34
Figure 3-1 A view of Attabad Lake ..... 3-2
Figure 3-2 Survey of Project's Permanent Reference Benchmark BM-1 ..... 3-11
Figure 3-3 Terrestrial Topographic Survey in progress ..... 3-12
Figure 3-4 Control Network Diagram ..... 3-16
Figure 3-5 Valley Cross Sections along Hunza River ..... 3-22
Figure 3-6 Google Earth Model ..... 3-24
Figure 3-7 Landsat 8 Panchromatic Image ..... 3-27
Figure 3-8 Digital Elevation Model ..... 3-29
Figure 3-9 Observation of under-water Cross-Sections ..... 3-31
Figure 3-10 Equipment showing continuous Trace of Bed Profile ..... 3-31
Figure 3-11 Cross-sectional Points and Triangles formed from Hydrographic Data ..... 3-32
Figure 3-12 Elevation Map ..... 3-33
Figure 4-1 Attabad Landslide Area & Extent of Lake ..... 4-1
Figure 4-2 Hunza River ..... 4-3
Figure 4-3 Attabad Lake Catchment Area with Landsat Imagery ..... 4-4
Figure 4-4 Mean Max, Mean Min and Mean Precipitation at Gilgit ..... 4-7
Figure 4-5 Isohyetal Map of Hunza Catchment ..... 4-8
Figure 4-6 Mean Annual Flows ..... 4-9
Figure 4-7 Mean Monthly Flows ..... 4-10
Figure 4-8 Mean Daily Flows ..... 4-10
Figure 4-9 Mean, Maximum & Minimum Daily Flows ..... 4-11
Figure 4-10 Attabad Lake Flow Duration Curve (FDC) ..... 4-11
Figure 4-11 Tailwater Rating Curve ..... 4-13
Figure 4-12 Instantaneous Peak Flows at Attabad Lake HPP Site ..... 4-13
Figure 4-13 Flood Frequency Analysis Graphs ..... 4-15
Figure 4-14 Flood Estimation using HEC-SSP Model ..... 4-15



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Figure 4-15 HEC-SSP Model Graph ....4-16
Figure 4-16 Attabad Lake Catchment Area Marked in HEC-HMS ....4-18
Figure 4-17 Attabad Lake Flood Routing Graph ....4-19
Figure 4-18 Major Glaciers in Hunza River Watershed....4-22
Figure 4-19 Danyor Sediment Concentration Data....4-28
Figure 4-20 Suspended Sediment Rating Curve at Danyor Station ....4-29
Figure 4-21 Average Annual Suspended Sediment Load at Danyor Gauging Station. ....4-32
Figure 5-1 Graphical Representation of CR Vs Depth of BH-01. ....5-12
Figure 5-2 Graphical Representation of RQD&CR Vs Depth of BH-04. ....5-14
Figure 5-3 Graphical Representation of CR Vs Depth of BH-02. ....5-15
Figure 5-4 Graphical Representation of CR Vs Depth of BH-03. ....5-16
Figure 5-5 Graphical Representation of CR Vs Depth of BH-05. ....5-18
Figure 5-6 Graphical Representation of Depth Vs CR of BH-06. ....5-18
Figure 6-1 Development of Normal Faults under compressional regime. ....6-6
Figure 6-2 Total Hazard Curve for Attabad HPP ....6-17
Figure 6-3 Earthquake Hazard by Seismic Sources, showing spectral response. ....6-17
Figure 6-4 Deterministic Spectra at 50$^{th}$ percentile level weighted average ....6-19
Figure 6-5 Deterministic Spectra at 84$^{th}$ percentile. ....6-19
Figure 6-6 Deterministic pseudo spectral acceleration (g) at 5% Damping. ....6-20
Figure 6-7 Deterministic Spectra at 66$^{th}$ percentile level of SEE. ....6-21
Figure 6-8 (UHS) showing mean hazard for various return periods. ....6-22
Figure 6-9 Deaggregation of Mean Hazard, Mean Magnitude and Mean Distance....6-22
Figure 7-1 Alternative Project Layout on the Left and Right Bank ....7-3
Figure 7-2 Project Layout on the Left bank with Tunnel and Penstock Options ....7-5
Figure 8-1 Area Capacity Curve ....8-2
Figure 8-2 Mean Annual Flows ....8-4
Figure 8-3 Mean Monthly Flows ....8-5
Figure 8-4 Mean, Maximum & Minimum Daily Flows ....8-5
Figure 8-5 Attabad Lake Flow Duration Curve (FDC) ....8-6
Figure 8-6 Tailwater Rating Curve....8-7
Figure 8-7 Headwater Level Variations (Wet, Average & Dry Years)....8-10
Figure 8-8 Tailwater Level Variations (Wet, Average & Dry Years) ....8-11
Figure 8-9 10-Daily Power Graph for Average Year (1998) ....8-12
Figure 8-10 10-Daily Power Graph for Wet Year (2011) ....8-12



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Figure 8-11 10-Daily Power Graph for Dry Year (1996)....8-13
Figure 8-12 Mean Annual Energy Graph from 1966 to 2015....8-14
Figure 9-1 Reservoir Area showing River Cross Sections and Location of Weir....9-3
Figure 9-2 Extrapolated Flow Hydrograph....9-5
Figure 9-3 Extrapolated Flow Hydrograph....9-5
Figure 9-4 Maximum Water Surface Elevation (WSE) against Design Flood....9-6
Figure 9-5 3D Perspective Plot against Max WSE....9-7
Figure 9-6 Weir Section with Maximum Water Surface Elevation....9-7
Figure 9-7 Discharge Capacity of Overflow Spillways....9-11
Figure 9-8 Tail Water Rating Curve Downstream of Stilling Basin....9-14
Figure 9-9 Tail Water Rating Curve at Flushing Channel....9-17
Figure 9-10 Optimization of Headrace Tunnel Diameter....9-26
Figure 9-11 Surge Tank: Combined Load Case Maximum Upsurge....9-29
Figure 9-12 Surge Tank: Combined Load Maximum Upsurge and Downsurge....9-29
Figure 10-1: Cross Section at Chainage 0+50....10-2
Figure 10-2: Sliding Mass – ordinary method of Slices....10-5
Figure 10-3: Slice Orientation – Spencer Method....10-7
Figure 10-4: Selected weir cross section with all seepage line of Defenses....10-13
Figure 10-5: Sieve Analysis of Soil used for Stabilization....10-14
Figure 10-6: Stress Strain Results of test immediately after mixing cement....10-14
Figure 10-7: Stress Strain Results of test immediately after 7 days of mixing cement....10-15
Figure 10-8: Stress Strain Results of test immediately after 14 days of mixing cement....10-15
Figure 10-9 Weir Structure at Minimum Pond Level (El : 2414m.a.s.l)....10-17
Figure 10-10: Cross Section details of Slope Indicator (Top view)....10-28
Figure 10-11: Cross Section details of Slope Indicator (cross section)....10-28
Figure 11-1 Attabad Lake Flow Duration Curve (FDC)....11-3
Figure 11-2 Generalized Turbine Operation Limits....11-6
Figure 11-3 Turbine Operating Regimes....11-7
Figure 11-4 $N_s$ Versus Head:....11-7
Figure 11-5 Turbine Output Specifications....11-11
Figure 11-6 Intake, Draft tube and Shaft Arrangement....11-11
Figure 11-7 Distributor Section....11-12
Figure 11-8 Figure 11-8 Intake and Draft tube Layout....11-12
Figure 11-9 Generator to Shaft Coupling Layout....11-12



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Figure 13-1 Transmission line route -Project Site to Aliabad G/S .....13-6
Figure 13-2 Transmission line route -Project Site to Sost G/S.....13-7
Figure 16-1 District and Tehsil Boundaries of Gilgit-Baltistan .....16-1
Figure 16-2 Mean Monthly Flows .....16-12
Figure 16-3 Instantaneous Peak Flows at ALHPP.....16-13

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# LIST OF PHOTOS

Photo 5-1 Surface Geological Mapping ..... 5-8
Photo 5-2 Drilling Rig at BH-02 Sediment Flushing Channel ..... 5-10
Photo 5-3 View of Weir Site. ..... 5-11
Photo 5-4 Proposed Intake Area for Power Tunnel ..... 5-13
Photo 5-5 Intake Area of Sediment Flushing Channel. ..... 5-15
Photo 5-6 Proposed Area for Surge Tank. ..... 5-16
Photo 5-7 Proposed Alignment of Penstock ..... 5-17
Photo 5-8 Proposed Power House Aarea. ..... 5-17
Photo 5-9 Quarry Area Selected for Sand Near Shishkat Bridge. ..... 5-20
Photo 5-10 TP-3, Excavated for Clayey Silt in P/H area. ..... 5-20
Photo 5-11 View of Clayey Silt in P/H area. ..... 5-21
Photo 5-12 Exposure of Marble in Passu Village Area. ..... 5-22
Photo 5-13 View of RBGM in TP-2 at P/H Area. ..... 5-22
Photo 5-14 View of Slided Mass in TP-6 at Left Side Slope of Hunza River. ..... 5-23
Photo 5-15 Fill Material (Boulder and Gravels) in Slided Mass. ..... 5-24
Photo 6-1 Inclined Gravel Layer Under Effect of Shearing. ..... 6-3
Photo 6-2 Recumbent Fold Strata with Crenulation in Limbs in Clay Strata. ..... 6-4
Photo 6-3 Stylolite/Pressure Solutions in Clay Strata. ..... 6-4
Photo 6-4 Micro Fault in Clay Beds. ..... 6-5
Photo 6-5 Horst and Graben Structure along Micro Fault in Clay Beds. ..... 6-5
Photo 6-6 View of Brecciated Rock Upstream of Passu Village. ..... 6-6
Photo 6-7 View of Folded ABGM Just Upstream of Passu Village. ..... 6-7
Photo 6-8 Change of Dip along Shear joint. ..... 6-7
Photo 6-9 View of Vertical and Oblique Joints in Clayey Silt at Sarat Village. ..... 6-8
Photo 6-10 Tiltness in Clayey Silt Beds, Left Side of Road at Sarat Village. ..... 6-9
Photo 6-11 Tiltness in Clayey Silt Beds, Right Side of Road at Sarat Village. ..... 6-9
Photo 6-12 Folded and Sheared Clayey Silt at Sarat Village. ..... 6-10
Photo 6-13 Sheared and Smeared Clayey Silt at Sarat Village. ..... 6-10
Photo 6-14 Fault Breccia just D/S of Suspension Bridge at Sarat Village. ..... 6-10
Photo 6-15 View of Recently Generated Joints Tunnel-2. ..... 6-11
Photo 6-16 View of Recently Generated Joints Between Tunnel-2 & 3. ..... 6-11
Photo 6-17 Micro thrust fault in clayey silt beds near helipad. ..... 6-12
Photo 6-18 Inclination of Clayey Silt near Helipad. ..... 6-12



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Photo 6-19 Folding in Clayey Silt near Helipad/Power House Area. ....6-13
Photo 6-20 Development of Parallel Joints near SCO Building. ....6-13
Photo 6-21 Inclination in Clay Silt and Gravels. ....6-14
Photo 6-22 Ramp and Flat Geometry along Fault. ....6-14
Photo 6-23 Development of Micro Faults in Sand. ....6-15
Photo 6-24 Development of Micro Faults in Clayey Silt. ....6-15
Photo 6-25 Inclination in RBGM in Tashot Village along Road. ....6-16

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# LIST OF TABLES

Table 1-1 Salient Features of Attabad Lake Hydropower Project .....1-9
Table 1-2 Hydropower/Thermal Stations Operational, under Construction and Proposed .....1-10
Table 2-1 District Wise Installed Power Potential in Gilgit-Baltistan.....2-3
Table 2-2 Installed Hydel Power Potential in Gilgit-Baltistan .....2-8
Table 2-3 Hydropower Projects in GILGIT-BALTISTAN by W&P Dept. .....2-10
Table 2-4 Hydropower Projects in GILGIT-BALTISTAN by W&P Dept. (Gilgit-Baltistan) .....2-12
Table 2-5 Surveyed Region.....2-13
Table 2-6 Load Forecast Projected by WAPDA & GTZ .....2-15
Table 2-7 Projected Load Forecast in HUNZA .....2-17
Table 2-8 Current Power Scenario of Gilgit-Baltistan .....2-19
Table 2-9 Installed Power in Hunza.....2-21
Table 2-10 Load Shedding Hours in Hunza.....2-22
Table 2-11 Forcosted Population Growth Rate Per Annum (2.74%) in Million (2021-2050)...2-25
Table 2-12 Load demand parameters Rural Consumers.....2-26
Table 2-13 Load Demand parameters Urban Consumers.....2-26
Table 2-14 Load Demand Forecast (MW) Gilgit-Baltistan upto 2050.....2-27
Table 3-1 Traverse Station / Control Points Coordinates.....3-13
Table 3-2 Permanent Benchmarks in the Project Area.....3-18
Table 3-3 Coordinates of Left and Right End Points of Valley Cross Sections .....3-21
Table 4-1 Annual & Monthly Distribution of Precipitation (mm) At Gilgit (1951 to 2014).....4-5
Table 4-2 Average Max & Min Monthly Temperature at Gilgit .....4-6
Table 4-3 hydrologic Measurement Station at Hunza River.....4-8
Table 4-4 Flow Duration Curve Results.....4-11
Table 4-5 Tailwater Curve Analysis.....4-12
Table 4-6 Flood Frequency Analysis .....4-14
Table 4-7 HEC-SSP Model Results.....4-16
Table 4-8 Attabad Lake Flood Routing Table .....4-20
Table 4-9 Major Glaciers of Hunza River Watershed .....4-22
Table 4-10 Historical GLOFs in Gilgit-Baltistan .....4-23
Table 4-11 Suspended Sediment Load Observations at Danyor .....4-25
Table 4-12 Mean Fractions of Sand, Silt and Clay at Danyor Station .....4-27
Table 4-13 Percentage of Sediment yield to Total Yield of Year.....4-29
Table 4-14 Annual Suspended Load of each year at Danyor .....4-31



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Table 4-15 Lane and Borland Guidelines for Estimating Bed Load....4-34
Table 4-16 USBR Guidelines for Estimating Bed Load....4-35
Table 5-1 Co-ordinates of Boreholes....5-9
Table 5-2 Permeability Values in Soil and Rock....5-12
Table 6-1 Seismic Source Parameters for Probabilistic Analysis....6-17
Table 6-2 The Controlling Faults with Quantitative Features (input values of DSHA)....6-18
Table 7-1 Estimated Project Base Cost....7-7
Table 7-2 Comparison of Alternatives....7-7
Table 8-1 Area-Elevation-Capacity Data....8-3
Table 8-2 Flow Duration Curve Results....8-6
Table 8-3 Tailwater Curve Analysis....8-7
Table 8-4 Efficiency Coefficients of Various Power Plant Components....8-8
Table 8-5 Summary of Power & Energy Potential....8-9
Table 8-6 Total Hydraulic Loss at Different Discharges....8-10
Table 8-7 Power and Energy Calculations for Average Year (1998)....8-15
Table 8-8 Power and Energy Calculations for Wet Year (2011)....8-16
Table 8-9 Power and Energy Calculations for Dry Year (1996)....8-17
Table 9-1 Maximum Water Surface Elevation at each Surveyed Cross Section....9-8
Table 9-2 Variation of Stilling Basin Length with Flood Discharge....9-14
Table 9-3 Diversion Channel Discharge Rating....9-19
Table 9-4 Surge Tank Dimensions....9-27
Table 9-5 Extreme Water Levels in Surge Tank....9-30
Table 10-1 Results of SLOPE/W Methods....10-9
Table 10-2 core recovery CR (%) and permeability test results....10-12
Table 10-3 Borehole Drilling Summary at Weir Site....10-16
Table 11-1 Flow Duration Curve Results....11-4
Table 11-2 Power Output with Different no. of Units for Attabad HPP....11-9
Table 11-3 Key Turbine Parameters....11-10
Table 11-4 Survey of Fire Protection System to be Installed....11-29
Table 11-5 Design and Performance Criteria of Intake Gates....11-38
Table 11-6 Design and Performance Criteria of Gate Hoist....11-39
Table 11-7 Design and Performance Criteria for Stop Logs....11-40
Table 11-8 Gantry Crane and Lifting Beam....11-40
Table 11-9 Trash racks & Trash rack Cleaning Machines....11-41



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Table 11-10 Design and Performance Criteria of Draft Tube Gates .....11-43
Table 12-1 Main Parameters of the Generators .....12-3
Table 12-2 Recommended parameters of the Transformers .....12-10
Table 13-1 Monthly Max. and Min. Temperatures .....13-7
Table 13-2 Comparison of ACSR Lynx, Panther and Rail Conductors .....13-8
Table 14-1 Unit Rates for different Items.....14-7
Table 14-2 Quantities of Main Civil Works Items .....14-8
Table 14-3 Summary of the Cost Estimate.....14-9
Table 14-4 Cost Estimate for Land Acquisition and Environmental Mitigation .....14-12
Table 14-5 Cost Estimate for Preparatory Works .....14-12
Table 14-6 Cost Estimate for Main Weir.....14-13
Table 14-7 Cost Estimate for Undersluices .....14-14
Table 14-8 Cost Estimate for Power Intake .....14-15
Table 14-9 Cost Estimate for Low Pressure Headrace Tunnel .....14-15
Table 14-10 Cost Estimate for Surge Tank .....14-16
Table 14-11 Cost Estimate for Penstock .....14-16
Table 14-12 Cost Estimate for Powerhouse .....14-16
Table 14-13 Cost Estimate for Tailrace Channel.....14-17
Table 14-14 Cost Estimate for Hydraulic Steel Structures.....14-19
Table 14-15 Cost Estimate for Hydro-Mechanical Equipment .....14-19
Table 14-16 Cost Estimate for Electrical Equipment .....14-20
Table 14-17 Cost Estimate for 132 kV Switchyard Equipment.....14-21
Table 14-18 Cost Estimate for 132 kV Transmission Line .....14-21
Table 14-19 Phasing of Cost Estimate .....14-22
Table 15-1 Public Holidays .....15-4
Table 15-2 Cement Production Capacities in various Factories .....15-4
Table 16-1 Average Max & Min Monthly Temperature and Mean Precipitation at Gilgit .....16-9
Table 16-2 Summary of Land Use in Gilgit-Baltistan .....16-10
Table 16-3 District Wise Agriculture Land of Gilgit-Baltistan.....16-11
Table 16-4 Range of Gaseous Pollutant Concentration & Noise Emission Level.....16-14
Table 16-5 Fauna available in Gilgit-Baltistan .....16-16
Table 16-6 Potential Fisheries Resources in District Hunza .....16-18
Table 16-7 Population of the Area (2017).....16-19
Table 16-8 Land Requirements for ALHPP .....16-34



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Table 17-1 Estimate of Annual CDM Benefits .....17-6
Table 17-2 Attabad Lake Hydropower Project Financial Analysis With CDM Benefits.....17-7
Table 17-3 Attabad Lake Hydropower Project Financial Analysis Without CDM Benefits.....17-8
Table 17-4 Cost Per KWh and MW .....17-10
Table 17-5 Fuel Price kWh.....17-11
Table 17-6 Derivation of Standard Conversion Factor.....17-13
Table 17-7 Comparison of Economic Cost of the Project .....17-14
Table 17-8 Economic Analysis with CDM benefits .....17-15
Table 17-9 Economic Analysis Without CDM Benefits .....17-16
Table 17-10 Risk / Sensitivity Analysis With CDM Benefits .....17-18
Table 17-11 Risk / Sensitivity Analysis With CDM Benefits .....17-19

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# 1 INTRODUCTION

## 1.1 GENERAL

Gilgit-Baltistan of Pakistan is blessed with abundant renewable hydropower resources. More than 95% of Pakistan hydel potential is located in mountainous areas of Gilgit-Baltistan (Gilgit-Baltistan), Khyber Pakhtunkhwa (KPK) and Azad Jammu and Kashmir (AJK). The reconnaissance study of hydel potential for whole Gilgit-Baltistan is almost complete, and identified potential sites are still to be optimized in terms of capacity, cost and need of power for growing load centres. A study for identification and ranking of potential sites on tributaries of Indus river was carried out during 1992 to 1997. Out of 122 identified sites, 17 promising sites were selected to meet local/regional power demand of Gilgit-Baltistan.

On Nov, 2015 Prime Minister announced the construction of Attabad Lake Hydropower Project (ALHPP), Accordingly Govt. of Gilgit-Baltistan undertook its Feasibility Study through Annual Development Programme (ADP) for Financial Year 2016-17. In the beginning Feasibility Study of ALHPP of 32.5 MW was carried out by local consultant of Gilgit-Baltistan, Design man Consulting Engineers (Pvt.) Ltd, Islamabad in association with Mountain Infrastructure & Engineering Services Gilgit, in March 2017. On Aug 2017, Ministry of Water and Power had written letter to the Chairman WAPDA to give expert opinion on construction of ALHPP. On July 2019, a meeting was held between Chairman WAPDA and Chief Secretary Gilgit-Baltistan. It was agreed that Feasibility Study would be again carried out by Hydro Planning Organization (HPO), WAPDA because of its expertise in the field of Hydro Power Planning. Water and Power Development Department, Gilgit-Baltistan shared the already carried out Feasibility Study with HPO, WAPDA in Jan 2020. Feasibility Study was examined by HPO, WAPDA and found the proposed layout is designed without diversion works which is essential part for project execution. Therefore, Feasibility Study was again undertaken by HPO, WAPDA for comprehensive Study with additional investigation.

The Central Hunza is located on the right bank of Hunza River, extending from Murtazabad up to Attabad Village (Figure-1). Central Hunza is the hub of tourism in Gilgit-Baltistan. National and international tourists flow remain at peak during summer season. As a result, hotel industry is booming, whereby, other small-scale businesses i.e. transport sector, cottage industry, local markets and automobile workshops are most likely to flourish in the near future. The increase in tourism industry has significantly enhanced the energy demand of the area. The current demand is expected to increase exponentially in the years to come. Furthermore, the area is having multiple business opportunities due to its location on the China Pakistan Economic Corridor (CPEC), which will result in fast growth of economic activities, thus increase in the energy demand being interlinked with each other.



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**Figure 1-1 Map of Central Hunza (Source: Google Map)**

The Gilgit-Baltistan Govt. has developed three hydropower projects on Hassanabad Nullah in Hunza with an installed capacity of 1.9 MW. The electricity from these hydropower projects is supplied to the Central and Lower Hunza through a 11-kV local distribution network. The supply from these hydropower projects is currently not sufficient to meet the existing demand, therefore it is supplemented through standby diesel generators of 3.2 MW installed capacity during peak hours, mostly in winter season. Due to abrupt surge of Shishper Glacier situated in the catchment of Hasanabad Nullah, the powerhouses on Hassanabad Nullah are under the threat of glacier lakes outburst flood (GLOF). Therefore, it is necessary to develop projects on other water resources to facilitate central Hunza.

In addition to this, there exists a community-owned hydropower project of 0.450 MW capacity on Ahmadabad stream, which is managed and operated by a Community based Public Utility Company in Ahmadabad village. This community owned and operated hydropower project is currently supplying electricity to village Ahmedabad, Altit, Mominabad, Faizabad, and Salmanabad in Central Hunza. The Ahmadabad community-owned Public Utility Company is currently refurbishing and upgrading another hydropower project with 0.370 MW capacity, which is in cascade with the existing hydropower project.

Meanwhile, the Water & Power Department (W&PD), Hunza has completed another 0.5 MW hydropower Project at village Mayans in Lower Hunza. This Project will feed into the existing 11-kV distribution network of Hunza. Furthermore, Gilgit-Baltistan Govt. has conducted a Feasibility Study of a 32.5 MW hydropower project at Attabad Lake requested WAPDA for its updation. Presently, there is high supply and demand gap; therefore, load shedding is common in summer, while it becomes very acute in winter. The commercial and industrial demand is partly fulfilled from privately owned diesel generators. The diesel generators are mainly used by the hotels, small businesses, banks and other consumers which can afford the high running cost. Apart from the cost the use of these diesel generators is creating environmental pollution (i.e. noise and air), which is also affecting the tourism in the area.



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The expected fast growth in tourism industry will immensely increase the electricity demand in future, if not planned properly and addressed timely, it will most likely create a crisis like situation in the near future. The shortage of electricity in Central Hunza and vulnerability of Hasanabad Hydropower Projects from any untoward situation of GLOF and normal floods is further increasing the risk of energy crisis in this area.

The Govt. has limited resources to address the issue of sustainable electricity supply in the area. The private sector is reluctant to invest in Gilgit-Baltistan's energy sector, which is due to absence of a Power Policy and non-connectivity of the area with the National Grid. The Power Policy of Gilgit-Baltistan Govt. is currently under appraisal and approval. Aga Khan Development Network (AKDN) institutions are supplementing and complimenting the efforts of the Govt. in Gilgit-Baltistan. Small scale micro hydels have been established in remote off-grid rural areas from donor funding, while urban centres like central Hunza are beyond their scope.

The Industrial Promotion Services (IPS)/NPAK Energy is collaborating with the Govt. of Gilgit-Baltistan to improve the distribution system of Central Hunza by replacing bare AAC/ACSR conductors by ABC Cable. Considering the energy shortage in central Hunza, they intend to develop hydropower project(s) in the area to address the energy crisis. The Govt. of Gilgit-Baltistan has already indicated a concession area (from Ganish Bridge to Salmanabad village) on Hunza River to IPS/NPAK Energy to study the prospects for development of hydropower projects.

Govt. of Gilgit-Baltistan has engaged WAPDA (HPO) to update the Feasibility Study of 32.5 MW ALHPP. WAPDA is using its in-house capacity to review Feasibility Study. After thorough field investigations WAPDA has updated the proposed installed capacity to 54 MW with a 2320 m long headrace low pressure tunnel on the left side of Hunza River. The tunnel will off take from the left bank upstream of existing outlet of Attabad Lake. For this fields investigations have been carried out.

Attabad Lake was formed on January 4, 2010, when a huge mass from the right bank of Hunza River slided down near Attabad Village and blocked Hunza River for about 2 km . The inflow filled upstream valley created a reservoir 22 km long till the end of May 2010. The estimated lake initial storage was about 310 million $m^3$ and presently its capacity reduced to 125 million $m^3$.

For drainage of impounded flows of Hunza River through slided area, the excavation of material was carried out (24 m deep and 45 m wide) to form as spillway. The excavation works for the spillway was completed in the mid of May and the overflow of River flow began on May 29, 2010. The pattern of outflows was observed at downstream Ganish Bridge. The flows in summer 2010 were as a result of snow melt, no abrupt change in flows observed till to date.

Extensive field reconnaissance, topographical survey, hydrological and geo-technical investigations and engineering studies have been carried out for updating the Feasibility Study, in order to establish a Project that could provide power supply from Hunza Valley to Gilgit and Sost.

ALHPP (54 MW) has been planned to meet the winter power demand of Hunza Valley by utilizing the peaking storage facility at existing Attabad Lake. The installed power would remain available throughout the year during peak hours. As a result of the assessment of field investigations and engineering studies, it is concluded that the Project of 54 MW is technically,



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economically feasible and environmentally safe. The Project can further enhance due to available potential at the location of Hunza River once the Regional and National Grids established.

The most promising project layout as assessed is located at the Attabad Lake on the left bank of Hunza River at a distance of about 20 km from Karimabad, 120 km from Gilgit and 735 km from Islamabad.

The deep diversion and flushing structures are proposed to be located at the existing outlet/spillway of the Attabad Lake. The weir site is available having narrow span and firm rock strata on right side of River Hunza. The headrace tunnel is proposed along the left bank of the River along existing link road from intake to powerhouse. The powerhouse is located well above the highest flood level. The coordinates of the weir and powerhouse site are as follows:

| | | | |
|---|---|---|---|
| Overflow Weir/Ungated Spilway: | 484036.834 m E | 4018143.837 m N | 2414 m.a.s.l |
| Powerhouse: | 481645.920 m E | 4017963.719 m N | 2300 m.a.s.l |

The Project area is to be constructed on marginal lands owned by the community of Ahmadabad village where minimum environmental and social issues have been anticipated. The Project google site plan and location map are shown in the Figure 1.2 and Figure 1.3.

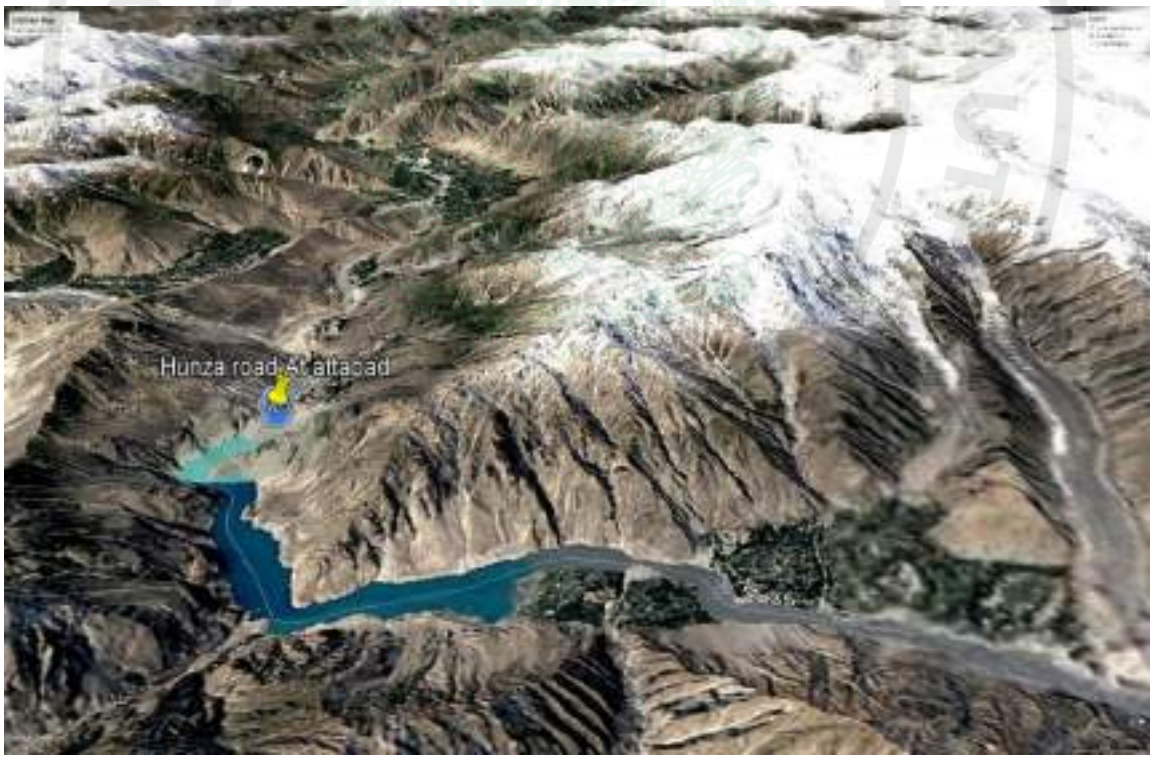


**Figure 1-2 Site Plan (Source: Own Compilation from Google)**



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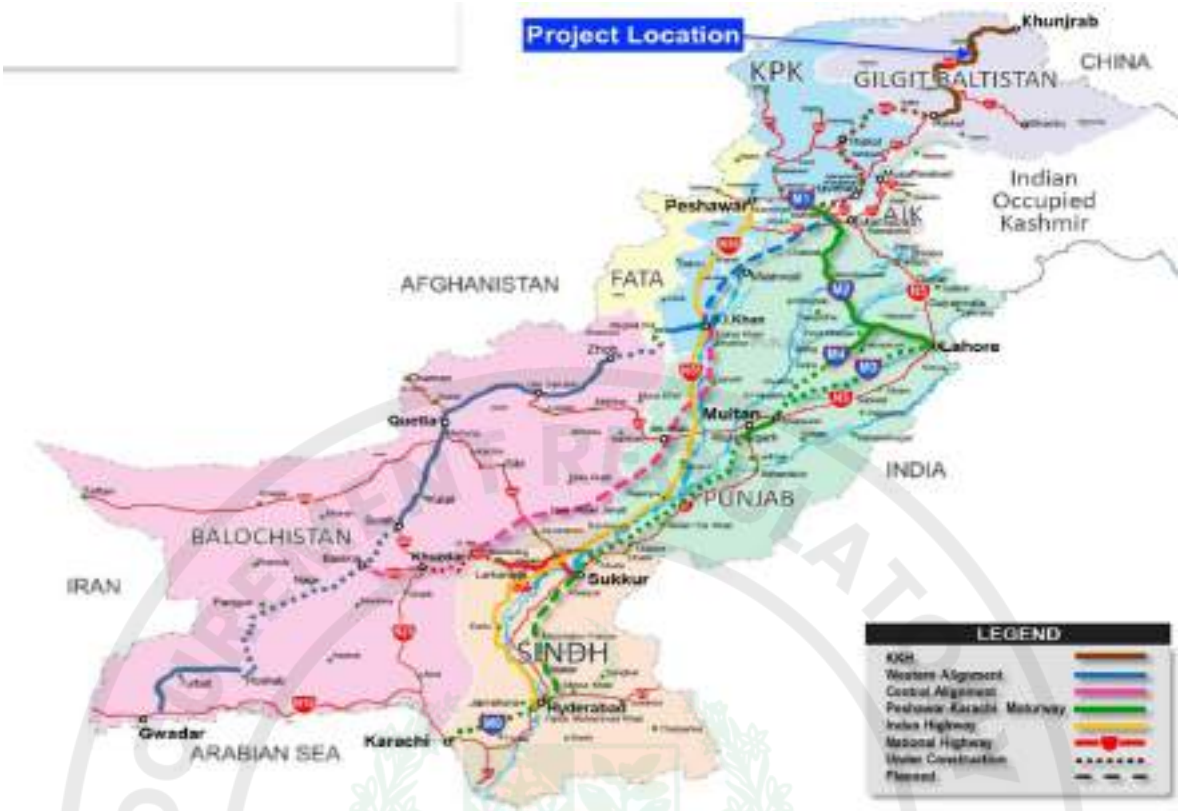


**Figure 1-3 Location Map (Source: NHA Pakistan)**

## 1.2 SALIENT FEATURES

ALHPP, a run off river Project, was initially planned to generate about 32.5 MW power in two phases, by diverting the flow of Hunza River, a major tributary of Gilgit River, into a power tunnel and ultimately releasing into Hunza River. This was designed to take care of power and energy needs of the Hunza-Nagar districts for next two decades as an isolated scheme. However, the connection of the Hunza Nagar districts to the Regional Grid makes the Project to be studied for its enhanced potential. A number of alternatives are studied and based upon the conclusions of these studies; it is finally decided to design the scheme for the generation of 54 MW (installed capacity) consisting of three units with an average annual energy of about 374 GWh.

An overflow weir will be constructed to divert the flow of Attabad Lake at Hunza River into power intake. Before construction of weir, a deep sediment flushing channel/ under sluice will be constructed this will act as a diversion channel during construction of weir. After the construction of the Project at operational stage under sluice will act as sediment flushing channel. The diverted water enters into the head race tunnel about 2320 m long. The tunnel is followed by surge shaft. Water will enter into 470 m long penstock pipe branching into three units at the end through manifold. These high-pressure penstock pipes and feed three turbines, 18 MW each.

The Project is proposed to be developed on Hunza River at Attabad Lake with design discharge 60 $m^3/s$ to generate the rated power round the year. This Project will enhance the generation capacity and augment the power supply network of entire Hunza-Nagar Valleys and Gilgit Town.



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Once completed and operational this Project will help to improve the power supply situation in the Region.

The Salient features of the envisaged power supply Project are given as follows:

| | |
|---|---|
| Type of Development: | High Head Run of River with Peaking |
| Gross Head: | 112.0 m |
| Net Head: | 106.0 m |
| Installed Capacity: | 54 MW |
| Type of Turbine: | Francis (Vertical) |
| No. of Units: | 03 |
| Design Discharge (Qd): | 60.00 $m^3$/s (20 $m^3$/s to each unit) |
| Length of Weir: | 55 m |
| Length of Power tunnel: | 2320 m |
| Type of Powerhouse | External |
| Annual Energy: | 374 GWh |
| Plant Factor: | 79 % |

## 1.3 CLIMATE

The climate of the district is nearly dry. The summer season is cool while winter is chilly. Wide spread snow fall occurs in winter. During winter the northern winds blow constantly bringing the temperature down considerably.

At Hunza, the mean temperature is 30.20°C in July, the hottest month and the coldest month is January with an average temperature of -3.5 °C. The mean minimum temperatures are 21.9°C in July and -7.3°C in January respectively. Hunza like other areas in extreme north-west of Pakistan receives only 136 mm precipitation of which 40% occurs in Winter and Spring.

Climate of the Hunza District is moderate with average minimum and maximum temperatures of 16 and 35.9 °C, respectively. The annual average rainfall in the study area is 136.2 mm with minimum 2.1 mm in November and maximum 28.3 mm in April.

## 1.4 TRANSPORT AND COMMUNICATION

The means of transportation and communication are the necessary infra-structures for movement of goods and people and play a vital role in the economic development of any region.

All the Union Council centers except few are connected with each other by metalled roads, nevertheless, there are certain parts of these roads which must be improved and for transportation during winter, the district remains connected throughout the year with the rest of country through Karakoram Highway (KKH).

There is transportation through KKH between Gilgit, Hunza upto Sost and Khunjrab Pass towards China by buses and trucks. The road is in excellenet condition and asphalted, although the traffic remains suspended due to heavy snowfall during December to March at Khunjerab Pass, which lies at an altitude of about 4693 m.a.s.l. The road is characterized by bends and steep slopes while descending from top to Hunza Valley.



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## 1.5 ACCESS TO THE PROJECT AREA

The present available access to the Project area by Motorway from Islamabad to Thakot and afterwards by KKH from Thakot to Project Area is very good. Power house site is located on the left bank of Hunza River near Salmanabad Village. Access to the Project Site, along the Attabad Lake is very easy with steep slopes and moderate bends. It will not create problem with the transportation of heavy construction and permanent equipment for the Project as well as the heavy construction materials. These difficulties may significantly affect the overall construction schedule. However, the road towards Power House Site needs improvement involving rock blasting and widening of the track to cater for the transportation of the heavy construction material and machinery.

## 1.6 EXISTING POWER SUPPLY

The present installed capacity of hydropower and thermal power stations is 5.6 MW for peak hours. Although the consolidated installed capacity of Hassanabad hydropower projects is 1.9 MW, but over the time, the efficiency of these projects have reduced due to high amount of silt in the Hassanabad Nullah, resulting in regular need for overhauling of the turbines at least twice a year. The diesel generators with a consolidated installed capacity of 3.2 MW are used as standby. These diesel generators are operated during peak hours only, and are subject to the availability of funds for purchase of fuel & oil for their operation. The list of projects in district Hunza which are under operations, under construction and proposed are given in the Table-1.2

The available output from the existing hydropower stations and diesel generators is evacuated through 11-kV lines to the load centers. Further distribution is made after stepdown through 11/400-kV transformers and 400/230 V, LV distribution lines. The existing 11-kV distribution system is overloaded resulting in high voltage drops, especially at the end users' premises. The technical losses are very high and accounted for more than 30%. Hence, the net supply available for the consumers is well below the installed capacity.

At present the conservative demand of Central Hunza is estimated at being 7.0 MW during summer and 10 MW in winters. However, the optimistic demand of consumers is estimated as 12 MW during summer and 18 MW in winter season, details of which has been given in the Chapter No-3 "Power Market & Demand Forecast".

In Gilgit-Baltistan, most of the power generation, transmission and distribution system is being maintained and operated by Water & Power Deptt. Gilgit-Baltistan.

## 1.7 ADMINISTRATIVE ORGANIZATION

Hunza is one of the fourteen districts constituting the Gilgit-Baltistan of Pakistan. The highest administrative authority is the Deputy Commissioner, who is assisted by Assistant Commissioners of two sub-divisions. Administratively, the Hunza District comprises two tehsils, the Aliabad Tehsil and the Gojal Tehsil. The villages of lower Hunza and central Hunza are located in the Aliabad Tehsil, whereas the villages from the Attabad Lake up to the Khunjerab Passare located in the Gojal Tehsil. In lower Hunza, Shinais the main language, whereas in central Hunza, the dominant language is Burushashki, and in upper Hunza, Wakhiis the main language. District administration is exercised by the Deputy Commissioner (DC), with the assistance of an assistant commissioner. The Hunza police force is commanded by the Superintendent of Police (SP).



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These institutions have technical support of various departments of Govt. of Gilgit-Baltistan in Hunza town such as Communication, Roads, Agriculture, Irrigation, Fishing, Education, Health, Revenue, Food, Social Welfare Office and Forest Division. All are located in Hunza town.

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**Table 1-1 Salient Features of Attabad Lake Hydropower Project**

| | | | |
|---|---|---|---|
| Location | Attabad village, Hunza District, Gilgit-Baltistan of Pakistan, 120 km west of Gilgit & 735 km north- of Islamabad | Design Discharge<br>Gross head<br>Net head<br>Installed Capacity<br>Mean Annual Energy<br>Plant Factor | 60 $m^3/s$<br>112.0 m<br>106.0 m<br>54 MW<br>373.69 GWh<br>79 % |
| River<br>Catchment Area<br>Mean Annual Flow<br>Mean Annual Vol. | Hunza<br>8901 $km^2$<br>209 $m^3/s$<br>6591 M $m^3$ | Penstock<br>Length<br>Diameter<br>Thickness | 1No.<br>470 m<br>5.5 m<br>15 mm |
| Weir<br>Crest elevation<br>Crest length<br>Weir height<br>Design Flood<br>Max. Flood level<br>Sediment Flushing Channel<br>Sill level<br>Nos. and Gate size | Overflow Weir/ Ungated Spilway<br>2414 m.a.s.l<br>60 m<br>30 m<br>3250 $m^3/s$ (1:10,000 returned period)<br>2421 m.a.s.l<br>UnderSluice/Diversion Channel<br>2402 m.a.s.l<br>3 & 5m x 5m | Powerhouse<br>Size<br>Height<br>Type of units<br>No. of units<br>Speed<br>No. of Generator<br>No. of Transformer | External Slope type<br>45 m x 18 m<br>22 m<br>Francis<br>3<br>375 rpm<br>3, 21.2 MVA<br>3, 222 MVA |
| Attaabad Lake length<br>Lake width<br>Lake depth | 14000 m<br>400 to 600 m<br>50 to 60 m | Tailrace<br>Turbine level<br>Max. Flood level | 18 m, concrete lined<br>2300.0 m.a.s.l<br>2307.0 m.a.s.l |
| Tunnel length<br>Diameter of Tunnel<br>Typel | 2320 m<br>5.5 m<br>Horse shoe | Firm Power<br>Off peak winter<br>Peak Summer | 26 MW<br>18 MW<br>54 MW |
| Peaking storage<br>Full supply level<br>Minimum supply level<br>Gross Storage | 5 M $m^3$<br>2414 m.a.s.l<br>2412 m.a.s.l<br>125 M $m^3$ | Distance up to Gilgit<br>Voltage Level<br>Transmission Line<br><br><br><br>Areas to be served | 120 km<br>132 KV<br>70 km single circuit upto Sost & 27 km double circuit upto Aliabad.<br><br>Hunza, Gilgit & Ghizar Region |



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**Table 1-2 Hydropower/Thermal Stations Operational, under Construction and Proposed**

| S# | Name | Installed Capacity (MW) | AvailableCapacity (MW) | |
|---|---|---|---|---|
| | | | Summer | Winter |
| **Hydropower Stations under Operation** | | | | |
| 1 | SHP Hassanabad Ph-I | 1.20 | 1.00 | 1.00 |
| 2 | SHP Hassanabad Ph-II | 0.20 | 0.16 | 0.11 |
| 3 | SHP Hassanabad Ph-III | 0.50 | 0.35 | 0.30 |
| 4 | SHP Ahmadabad | 0.45 | 0.45 | 0.25 |
| | **Sub Total** | **2.35** | **1.96** | **1.66** |
| Thermal Stations under Operation (Operational during peak hours subject to availability of funds) | | | | |
| 1 | Hassanabad I | 1.00 | 1.00 | 1.00 |
| 2 | Hassanabad II | 1.00 | 1.00 | 1.00 |
| 3 | Ganish | 1.00 | 1.00 | 1.00 |
| 4 | Khizerabad Shinaki | 0.20 | 0.20 | 0.20 |
| | **Sub Total** | **3.20** | **3.20** | **3.20** |
| **Under Construction Hydropower Projects** | | | **Remarks** | |
| 1 | SHP SHP Mayun | 0.50 | Recently construction completed | |
| 2 | SHP Hassanabad Nullah | 2.00 | Abandoned due to Shishper Glacier | |
| 3 | SHP Ahmadabad | 0.37 | Under Construction community project | |
| | **Sub Total** | 2.87 | | |



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# 2 POWER MARKET AND DEMAND FORECAST

## 2.1 INTRODUCTION

An optimized planning for energy load forecasting is always the crucial part to determine future power demand for any developing region. In the power sector, reliable planning/load forecasting is the threshold to cater the future electricity demand. Power Infrastructure design including generation, transmission and distribution can be proposed on a power plan with improvising scenarios. Poor forecasting and planning could be rankled to manage the load demand while precise forecasting could be savvy to overcome the underestimations & overestimations of load management, which avoid financial and social-economic impact.

Thus, power market survey (short, medium and long period Load Forecast) contributes to overcome the energy shortage and facilitate all type of patrons including Residential, Commercials & Industrial.

This chapter describes and evaluates the future power demand in Gilgit-Baltistan, based on figures of the GDP and an expected increase in per capita consumption. For the design of the transmission & interconnection system, this information is advantageous as one of the chief matters for the layout of the Attabad Hydropower Project is to determine the future power demand in the Hunza district and the whole Gilgit-Baltistan.

The Gilgit-Baltistan being far off from National Grid has been facing severe shortages of power supply. Because electricity from fossil fuel is not only expensive moreover it causes pressure on foreign exchange reserves of Pakistan, hydropower being renewable resource constitutes is the best option which needs to be exploited in a rational manner. The tributaries and rivers of Gilgit-Baltistan have been considered for the development of hydropower resources to meet the local energy requirements and eventually to transfer the power to national grid.

## 2.2 GILGIT-BALTISTAN POWER SECTOR OVERVIEW

Gilgit-Baltistan had ten districts (Gilgit, Ghizer, Nagar, Hunza, Diamer, Astore, Skardu, Ghanche, Shigar and Kharmang).

**Figure 2-1 Map of Gilgit-Baltistan**



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Power Network System in Gilgit-Baltistan is based on foresaid ten districts. This chapter presents the district wise current Demand, Generation, Energy Deficit & Load Forecast studies of electricity demand from the year 2021 to 2050, a planning horizon of 30 years.

In order to provide electricity to the isolated network of the Gilgit-Baltistan areas, the Northern Areas Public Works Department (NAPWD) was established, which is responsible for the generation and distribution of electricity. The NAPWD is divided into two departments. The Water and Power Department responsible for Hydropower Projects and Public Works Department responsible for roads and infrastructure of the Gilgit-Baltistan area. Water and Power Department has constructed various mini hydropower stations in the region and the lines for the transmission of power to consumers.

### 2.2.1 Establishment of Regional Grids in Gilgit-Baltistan (Phase-1 & 2)

Water and Power Department of Gilgit-Baltistan has prepared PC-I regarding “Establishment of Regional Grids in Gilgit-Baltistan Phase-1 & 2” wherein the future expansion plan and establishment of regional grids are consisted on 10 valleys of Gilgit-Baltistan based on population and its growth, industrialization and consumption patterns. The model forecasts demand for electricity as the consolidated sum of demands from households of each domestic consumption (divided into three income groups), commercial centers, and public service units and from small industries.

The plan of Establishment of Regional Grids in Gilgit-Baltistan “Phase-I & II” relate to transmission planning, Grid stations & up-gradation of the existing power network of Gilgit-Baltistan. Its objective is to interconnect the following hydropower projects to efficiently utilize the generated electrical energy.

- 18 MW Hydro Power Project Nalter IV.
- 16 MW Hydro Power Project Nalter III.
- 14 MW Hydro Power Project Nalter V.
- 20 MW Hydro Power Project Hanzel Gilgit.
- 34.5 Mw Hydro Power Project Harpo Skardu.
- 80 MW Hydro Power Project Phander Ghizer.
- 100MW Hydro Power Project KIU Gilgit.
- 32.5 MW Hydro Power Project Attabad Hunza (power enhanced upto 54MW)
- 26 MW Hydro Power Project Shagharthang Skardu.

Another purpose of the above plan is to attract private investors to take interest in the development of Hydropower projects to harvest maximum hydro potential. The proposed project of phase1 caters to the power demand in these districts (Gilgit, Hunza/Nagar and Skardu & Astore).



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Existing Regional Grid of Gilgit-Baltistan is not connected with National Grid of Pakistan, mostly small hydro and thermal unit installed by the local Govt. are having the energy contribution to a local level. Large Hydropower projects are in the studies & construction stage which will be committed to meet the national and regional energy crisis.

Different interconnection schemes are under consideration by the NTDCL planning department to interconnect the regional Gilgit-Baltistan grid to National Grid, and to evacuate from the upcoming mega hydropower projects. In future bulk supply will be fed from Mega Hydropower Project i.e. Diamer Basha and Bunji while medium and small hydropower projects i.e. Phandar, Attabad & Harpo to overcome the demand in Gilgit-Baltistan and surplus power after then could be drawn to the national grid.

Hydel is the major contributor in Gilgit-Baltistan to produce electricity. WAPDA and Water and Power Department, Gilgit-Baltistan intend to commission mega to small scale hydropower projects to supply clean and cheap electricity at the regional and national level. Many small and medium hydropower projects have been installed and some are in construction stage while others are in the feasibility & design stage.

32.5 MW Attabad Hydropower Project was also part of the aforesaid plan, but after the revised study being conducted by WAPDA, the project is upgraded upto 54 MW and needs to redefine the Interconnection and power evacuation plan after 1.67 times enhanced power.

### 2.2.2 Power Generation in Gilgit-Baltistan

The power demand in Gilgit-Baltistan is mostly covered by small hydropower plants (<20 MW). Electrical energy is transmitted over short distances through 66 kV, 33 kV and 11 kV gridlines and is further distributed to the consumers through 400 V LT systems. Due to the geographical boundaries, the existing grid is a regional one with no link to the national grid. Indeed, in the future, it is planned to link the existing regional grid to the national grid. However, this requires the completion of both planned Mega-Projects “Diamer Basha” (in construction stage) and “Bunji” (investors for funding are required to construct the project). In Gilgit-Baltistan, Total 118 nos. power stations have been commissioned with total 194.55 MW installed capacity. Table 2-1 shows the district wise installed power & Figure 2-2 shows the no. of installed power plants in different regions of Gilgit-Baltistan.

**Table 2-1 District Wise Installed Power Potential in GILGIT-BALTISTAN**

| District | Hydel Stations | Thermal Stations | Hydro Power | Thermal Power | Total Installed Capacity |
|---|---|---|---|---|---|
| | Nos. | Nos. | MW | MW | MW |
| Gilgit | 19 | 13 | 58.37 | 9.41 | 67.78 |
| Diamer | 10 | 5 | 15.48 | 2.90 | 18.38 |
| Skardu | 19 | 7 | 36.90 | 6.00 | 42.9 |
| Ghizer | 14 | 3 | 15.37 | 0.90 | 16.27 |
| Ghanche | 12 | 2 | 11.94 | 0.40 | 12.34 |
| Astore | 9 | 2 | 5.62 | 0.70 | 6.32 |
| Nagar | 9 | 2 | 6.00 | 0.75 | 6.75 |
| Hunza | 8 | 4 | 6.08 | 3.51 | 9.59 |
| Shiger | 7 | 0 | 4.70 | 0.00 | 4.70 |
| Kharmang | 11 | 0 | 10.50 | 0.00 | 10.50 |



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| | | | | | |
|---|---|---|---|---|---|
| **Total** | **118** | **38** | **169.98** | **24.57** | **194.55** |

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**Figure 2-2 Installed Power in Gilgit-Baltistan**

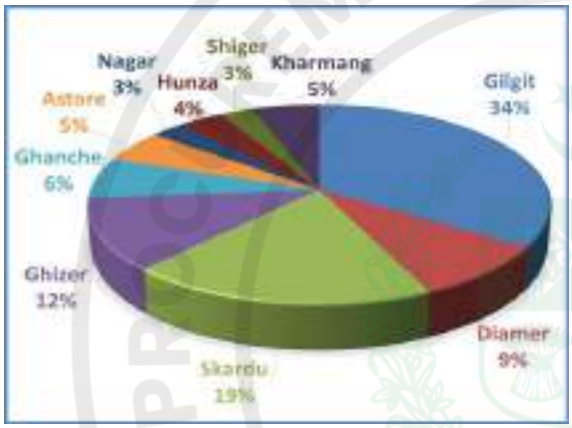


**Figure 2-3 Percentage of District wise Hydel Power Generation in Gilgit-Baltistan**

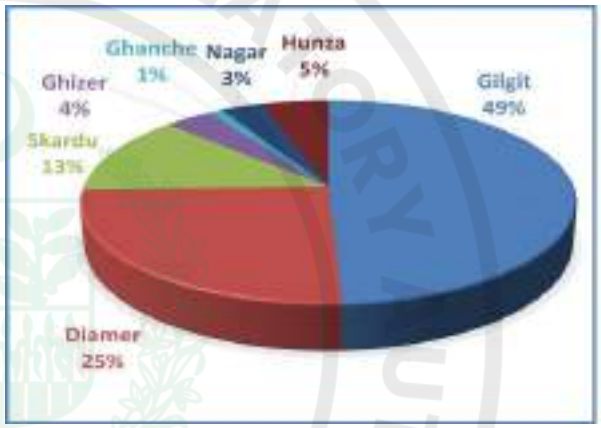


**Figure 2-4 Percentage of District wise Thermal Power Generation in Gilgit-Baltistan**

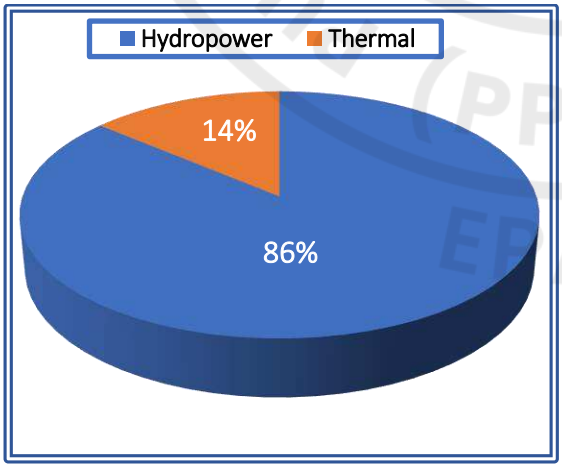


**Figure 2-5 Percentage Wise Power Sharing in Gilgit**

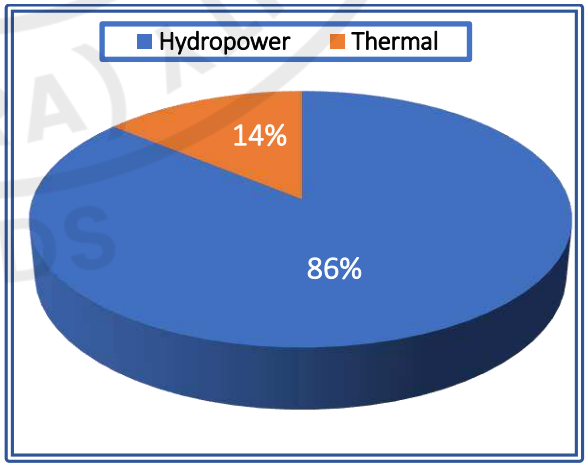


**Figure 2-6 Percentage Wise Power Sharing in Gilgit**



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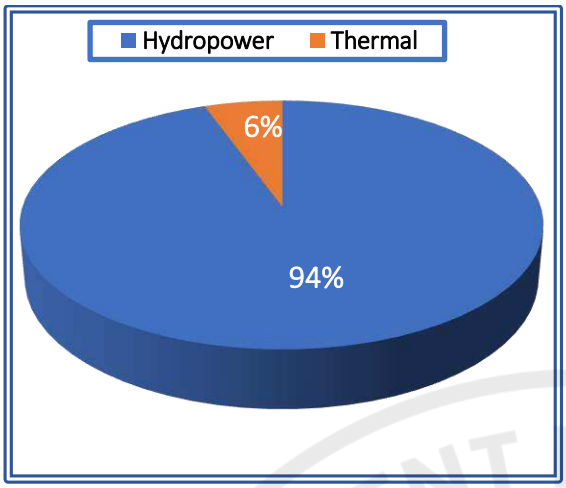


**Figure 2-7 Percentage Wise Power Sharing in Ghizer**

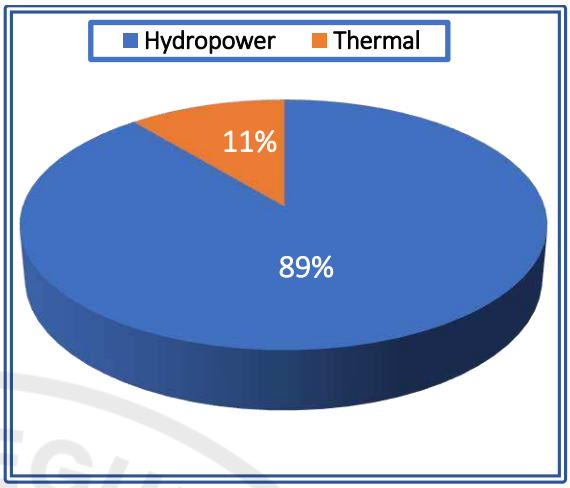


**Figure 2-8 Percentage Wise Power Sharing in Astore**

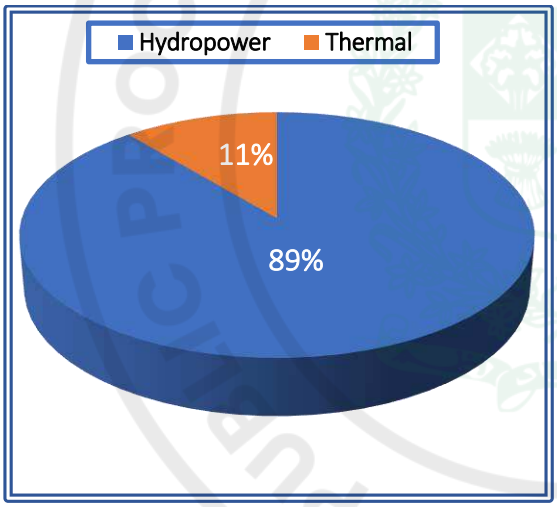


**Figure 2-9 Percentage Wise Power Sharing in Nagar**

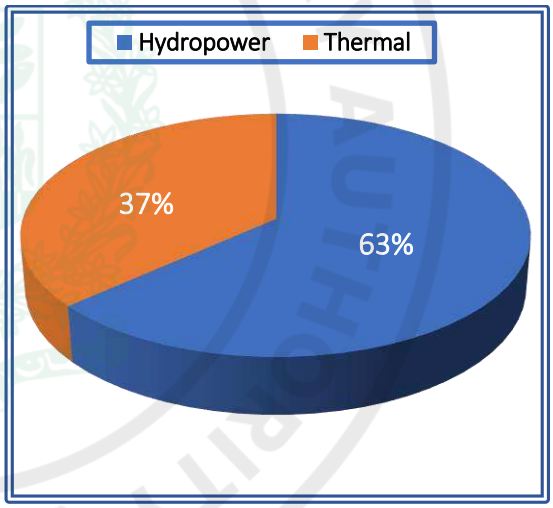


**Figure 2-10 Percentage Wise Power Sharing in Hunza**



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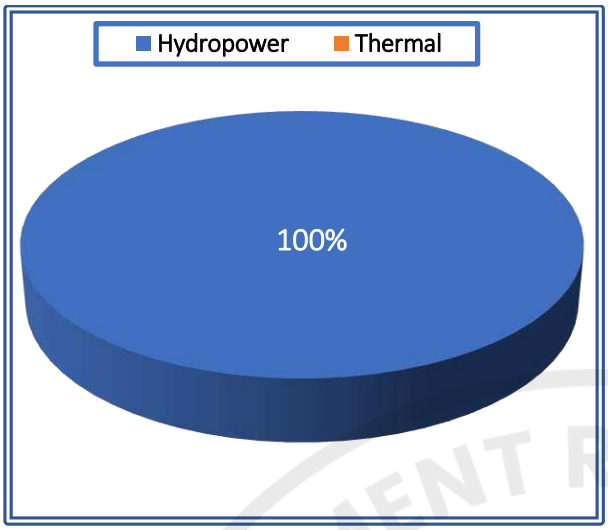


**Figure 2-11 Percentage Wise Power Sharing in Shiger**

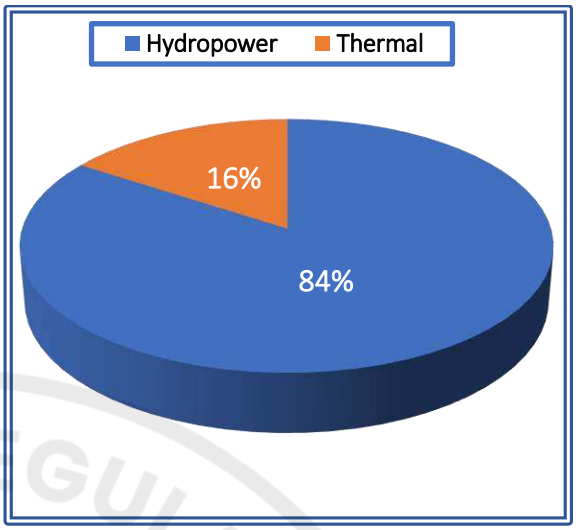


**Figure 2-12 Percentage Wise Power Sharing in Diamer**

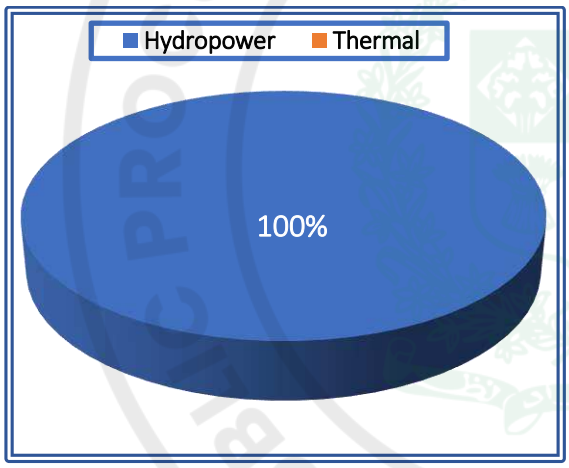


**Figure 2-13 Percentage Wise Power Sharing in Kharmang**

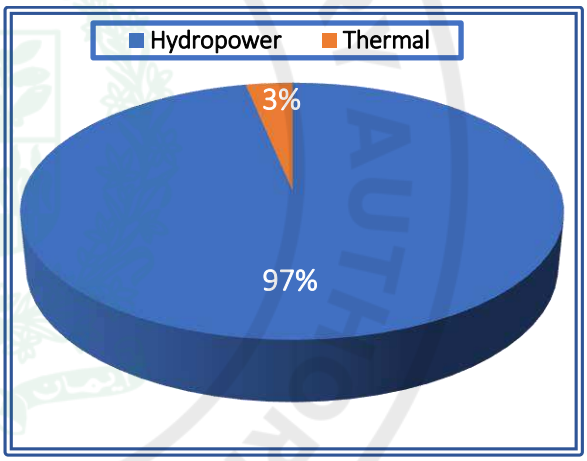


**Figure 2-14 Percentage Wise Power Sharing in Ghance**

### 2.2.3 Hydropower Potential in Gilgit-Baltistan

The entire region of Gilgit-Baltistan is enriched with natural resources. Nature has blessed Gilgit-Baltistan with minerals, attractive weathers, world high peaks, glaciers, water torrents, rivers & tributaries, sunlight and other natural resources.

Although, Gilgit-Baltistan is producing electricity by two means (Hydel & Thermal) but it has potential to produce electricity from other renewable resources. The Govt. of (GILGIT-BALTISTAN) is also willing to get untainted energy from renewable resources. The inception studies to get power from renewable resources are under progress by Water & Power Dept. Gilgit-Baltistan and will be made part of Power Plan in future.

The main rivers and tributaries in the Gilgit-Baltistan Area have been divided into three regions, i.e. the Eastern, Northern and Southern Regions.



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**Eastern Region**: The Eastern Region comprises on Kharmang (River Kharmang and its tributaries), Shyok (River Shyok and its tributaries), Skardu (River Braldu, River Bashu, River Shigar and River Indus) and Rondu/ Haramosh (River Indus and its regional tributaries).

**The Northern Region**: Comprises of Gilgit (River Gilgit, River Naltar and its tributaries), Hunza (River Boladas, River Hunza and other tributaries), Ishkuma (River Ishkuman and Ghizar and their tributaries), Khunjerab (River Khunjarab, River Kilik and its tributaries) and Yasin (River Yasin, River Gilgit and their tributaries).

**Southern Region: The** Southern Region comprises the Chilas (River Indus and its tributaries) and Astore (River Astore and its tributaries) Total 118 Hydel Power Stations are in operation in Gilgit-Baltistan, mostly of projects have been listed in Table 2-2:

**Table 2-2 Installed Hydel Power Potential in Gilgit-Baltistan**

| Sr. | Hydel Station | Location | Power (MW) |
|---|---|---|---|
| 1 | Naltar | Gilgit | 18 |
| 2 | Satpara | Skardu | 16 |
| 3 | Gilgit | Gilgit | 10.63 |
| 4 | Skardu-I | Skardu | 6.96 |
| 5 | Chilas-I | Chilas | 5.62 |
| 6 | Hunza | Hunza | 5.13 |
| 7 | Shyok | Shyok | 4.85 |
| 8 | Kar Gah Phase VI | Gilgit | 4 |
| 9 | Astore | Astore | 3.11 |
| 10 | Kachura Phase II | Skardu | 3 |
| 11 | Ghizar | Ghizar | 2 |
| 12 | Thak | Chilas | 2 |
| 13 | Phandar | Distt. Ghizar | 2 |
| 14 | Bordas | Ghanche | 2 |
| 15 | Kharmang | Kharmang | 1.89 |
| 16 | Yasin | Distt Ghizar | 1.61 |
| 17 | Rondu | Rondu | 1.52 |
| 18 | Bunnar Chilas | Chilas, Distt. Diamer | 1.5 |
| 19 | Dumsum | Gha, Distt. Ghanche | 1.5 |
| 20 | Balagond | Gha, Dstt. Ghanche | 1.5 |
| 21 | Ishkuman-I | Ishkuman | 1.38 |
| 22 | Kar Gah Phase V | Gilgit | 1.2 |
| 23 | Singul | Gilgit | 1.2 |
| 24 | Sher Qila | Gilgit | 1.11 |
| 25 | Parishing/ Lous | Astore | 1 |
| 26 | Darel Phase II | Chilas | 1 |
| 27 | Bunner | Chila | 1 |
| 28 | Tangir | Chilas | 1 |
| 29 | Kar Gah Phase VII | Gilgit | 1 |
| 30 | Jalalabad | Gilgit | 1 |
| 31 | Hassanabad Phase V | Hunza | 1 |
| 32 | Hisper Phase I | Hunza | 1 |



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| Sr. | Hydel Station | Location | Power (MW) |
|---|---|---|---|
| 33 | Ishkuman-II | Ishkuman | 1 |
| 34 | Naz Bar | Yasin | 1 |
| 35 | Jaglot Phase-II | Gaglot/Gilgit | 1 |
| 36 | Chalt | Nagar Valley/Gilgit | 1 |
| 37 | Khyber-II | Hunza/Gilgit | 1 |
| 38 | Shigar | Skardu | 1 |
| 39 | Shirting | Skardu | 1 |
| 40 | Skardu Phase III | Skardu | 1 |
| 41 | Pion | Distt. Ghanche/Gha | 1 |
| 42 | Haramosh | Gilgit | 1 |
| 43 | Sermik | Skardu | 1 |
| 44 | Basho Phase I | Skardu | 0.8 |
| 45 | Tormic Phase I | Rondu | 0.8 |
| 46 | Skardu Phase II | Skardu | 0.64 |
| 47 | Bubind | Astore | 0.64 |
| 48 | Kar Gah Phase III | Gilgit | 0.6 |
| 49 | Kar Gah Phase IV | Gilgit | 0.6 |
| 50 | Boladas Phase I | Hunza | 0.6 |
| 51 | Khunjerab | Gujrab river | 0.59 |
| 52 | Gol | Skardu | 0.4 |
| 53 | Harpo Phase I | Rondu | 0.4 |
| 54 | Harchu | Astore | 0.4 |
| 55 | Hassanabad Phase II | Hunza | 0.4 |
| 56 | Hassanabad Phase IV | Hunza | 0.4 |
| 57 | Kar Gah Phase I | Gilgit | 0.32 |
| 58 | Danyor | Gilgit | 0.32 |
| 59 | Gurikot | Astore | 0.25 |
| 60 | Kayo | Skardu | 0.24 |
| 61 | Dango Das | Astore | 0.22 |
| 62 | Manthoka | Khamang | 0.2 |
| 63 | Astore | Astore | 0.22 |
| 64 | Gulmit | Ishkuman | 0.22 |
| 65 | Tolti Phase I | Kharmang | 0.2 |
| 66 | Khaplu Phase II | Shyok | 0.2 |
| 67 | Kachura Phase I | Skardu | 0.2 |
| 68 | Darel Phase I | Chilas | 0.2 |
| 69 | Hassanabad Phase III | Hunza | 0.2 |
| 70 | Khaibar Phase-I | Khunjerab | 0.2 |
| 71 | Khaibar Phase-II | Khunjerab | 0.2 |
| 72 | Parishing/Mushke | Astore | 0.19 |
| 73 | Rattu | Astore | 0.19 |
| 74 | Misgar | Khunjerab | 0.19 |
| 75 | Ghandus | Kharmang | 0.16 |
| 76 | Kiris Phase I | Shyok | 0.16 |
| 77 | Thally Phase I | Shyok | 0.16 |



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| Sr. | Hydel Station | Location | Power (MW) |
|---|---|---|---|
| 78 | Mendi | Rondu | 0.16 |
| 79 | Stak | Rondu | 0.16 |
| 80 | Tangir Phase I | Chilas | 0.16 |
| 81 | Chilas-II | Chilas | 0.16 |
| 82 | Hassanabad Phase-I | Hunza | 0.16 |
| 83 | Hayul | Ishkuman | 0.16 |
| 84 | Khaplu Phase-I | Shyok | 0.13 |
| 85 | Sumayar Phase I | Hunza | 0.13 |
| 86 | Mehdabad | Kharmang | 0.11 |
| 87 | Nomal | Gilgit | 0.11 |
| 88 | Pari | Gilgit | 0.11 |
| 89 | Jaglot Sai | Gilgit | 0.11 |
| 90 | Sermik Phase-I | Kharmang | 0.1 |
| 91 | Olding Phase I | Kharmang | 0.1 |
| 92 | Thore | Chilas | 0.1 |
| 93 | Minapin Phase-I | Hunza | 0.1 |
| 94 | Naltar | Gilgit | 0.08 |
| 95 | Ahmadabad Phase I | Hunza | 0.05 |
| 96 | Ahmadabad Phase II | Hunza | 0.05 |
| 97 | Chalt Phase-I | Hunza | 0.04 |
| 98 | Sost | Yasin | 0.01 |

About planned 26,000 MW is shown in table 2-3 with current status.

**Table 2-3 Planned Hydropower Projects in Gilgit-Baltistan**

| PROJECT NAME | POWER CAPACITY (MW) | GROSS/LIVE STORAGE (MAF) | TRIBUTARY/ RIVER | STATUS |
|---|---|---|---|---|
| **MEGA & LARGE HYDROPOWER PROJECTS** | | | | |
| Diamer Basha | 4500 | 8.1/6.4 | Indus | Under Const. |
| Bunji | 7,100 | RoR | Indus | DED completed |
| Yulbo | 2,800 | RoR | Indus | DS completed |
| Tungas | 2,200 | RoR | Indus | DS completed |
| Skardu | 1500 | 3.2/2.2 | Indus | DS completed |
| Thorgonar | 600 | RoR | Indus | Identified |
| Sermik | 600 | RoR | Indus | Identified |
| Kharmang | 1,100 | RoR | Indus | Identified |
| Shyok | 640 | 1.2 | Shyok | FS completed |
| Lower Astore | 300 | RoR | Astore | Identified |
| Middle Astore | 400 | RoR | Astore | Identified |
| Upper Astore | 600 | RoR | Astore | Identified |



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| | | | | |
|---|---|---|---|---|
| Altit | 250 | RoR | Hunza | Identified |
| Kanch | 188 | RoR | Kunhar | Identified |
| Doyian | 490 | RoR | Astore River | FS completed |
| Gilgit River (7 Schemes) | 2,500 | RoR | Gilgit | Identified |
| **Subtotal** | **25,768** | | | |
| **MEDIUM & SMALL HYDROPOWER PROJECTS** | | | | |
| **Satpara** | **17.3** | **0.093/ 0.053** | **Satpara** | **In Operation** |
| Basho | 40 | RoR | Basho Nala | FS completed |
| Harpo | 34.5 | RoR | Harpo Nala | FS completed |
| Phandar | 80 | RoR | Ghizar | DED completed |
| Nasirabad | 96 | RoR | Hunza | Identified |
| Tangir | 52 | RoR | Tangir | Identified |
| Sher Qila | 88 | RoR | Gilgit River | Identified |
| Attabad lake | 54 | RoR | Hunza | FS in progress |
| Tormik | 40 | RoR | Tormik Gah | Identified |
| Tallu | 25 | RoR | Talu Lugma | Identified |
| Kachura | 20 | RoR | Kachura Lake | Identified |
| Shaghartung | 25 | RoR | Shagartung | Identified |
| **Subtotal** | **569.8** | | | |
| **Total** | **26,337.8** | | | |

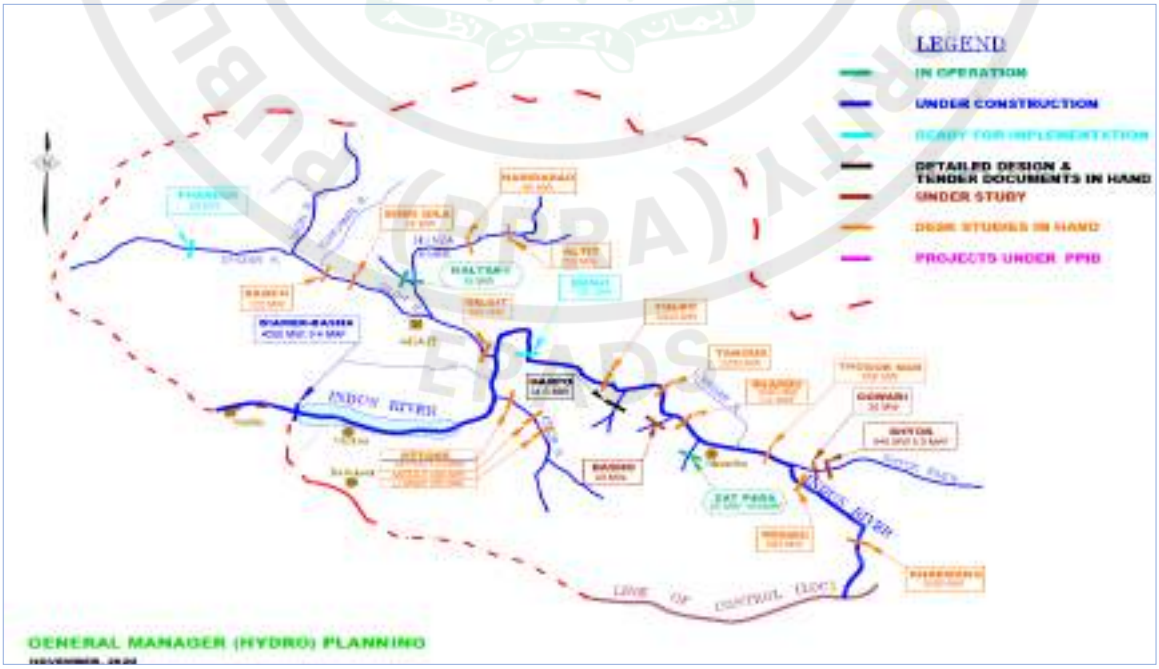


**Figure 2-15 Location Map of Hydropower Power Projects in Gilgit-Baltistan**



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Many small Hydropower projects (Table 2-4) have been commission by Govt. of GILGIT-BALTISTAN with time. Some hydropower projects are in the construction stage while some are in the study stage and to be commissioned in the future.

**Table 2-4 Small Hydropower Projects in Gilgit-Baltistan by W&P Dept.**

| Sr. No | Project Name | Power Capacity (MW) | Location |
|---|---|---|---|
| **PROPOSED HYDROPOWER STATION** | | | |
| **District Skardu** | | | |
| 1 | Hydro Power Project Cane | 3.20 | Cane Kargah Gilgit |
| 2 | Hydro Power Project Sai | 3.00 | Sai Juglote Gilgit |
| 3 | Hydro Power Project Bagarote | 2.00 | Bagarote Gilgit |
| 4 | Hargosil | 1.00 | Kharmang skardu |
| 5 | Shigar Phase-III | 2.00 | Shigar Skardu |
| 6 | Mehdi Abad Ph-II | 1.30 | Kharmang Skardu |
| 7 | Nar and Ghoro | 1.00 | Skardu |
| **SUB TOTAL** | | **13.5** | |
| **Ghanche Valley** | | | |
| 1 | Power Project (Phase-II) | 2.00 | Thalay Ghanche |
| 2 | Hydro Power Project | 0.70 | Hassanabad |
| 3 | Hydro Power Project | 2.00 | Kondus Ghanche |
| 4 | Hydropower project Kundus | 2.00 | Kundus Ghanche |
| **SUB TOTAL** | | **6.70** | |
| **TOTAL** | | **20.2** | |
| **Projects under FPSDP expected to be completed** | | | |
| 1 | Hydro Power Project Nalter-III | 16.00 | Nalter Gilgit |
| 2 | Hydro Power Project Nalter-V | 14.00 | Nalter Gilgit |
| 3 | Hydro Power Project Skardu Shagharthang | 26.00 | Skardu |
| 4 | Hydro Power Project Thak | 4.00 | Thak Chilas |
| **TOTAL** | | **60.00** | |
| **New Hydropower Projects completed** | | | |
| 1 | District Gilgit (03 Nos) | 6.70 | |
| 2 | District Skardu (05 Nos) | 4.60 | |
| 3 | District Diamer (04 Nos) | 5.00 | |
| 4 | District Ghizer (03 Nos) | 3.50 | |
| 5 | District Ghanche (04 Nos) | 5.50 | |
| 6 | District Hunza-Nagar (04 Nos) | 2.50 | |
| 7 | District Astore (03 Nos) | 3.40 | |
| **TOTAL** | | **31.20** | |
| **Solicited Hydro Power Projects** | | | |
| 1 | Hydro Power Project Hanzel | 20.00 | Hanzel Gilgit |
| 2 | Hydro Power Project Hassanabad | 5.00 | Hassanabad Hunza |
| 3 | Hydro Power Project Tormic | 10.00 | Tormic Skardu |
| 4 | Hydro Power Project Ghowari | 30.00 | Ghowari Skardu |
| 5 | Hydro Power Project Darmadar | 2.60 | Darmadar Ghizer |
| **TOTAL** | | **67.60** | |
| **Un-solicited Hydro Power Projects** | | | |
| **Skardu Valley** | | | |



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| | | | |
|---|---|---|---|
| 1 | Ganji | 3.00 | Ganji Skardu |
| 2 | Doro/Shilla | 3.00 | Kharmang Skardu |
| 3 | Basha (Dogro) | 5.00 | Shigar Skardu |
| 4 | Turghun Kharmong | 2.00 | Kharmang Skardu |
| 5 | Mehdiabad | 2.00 | Kharmang Skardu |
| 6 | Manthoka Kharmong | 2.00 | Kharmang Skardu |
| 7 | Stak Rundu | 10.00 | Rundu Skardu |
| 8 | Mendi Phase-II | 2.00 | Rundu Skardu |
| 9 | Gultri | 1.00 | Skardu |
| 10 | Talu Phase-II | 2.00 | Rundu Skardu |
| 11 | Harpo Phase-III | 2.00 | Rundu Skardu |
| **SUB TOTAL** | | **34.00** | |
| **Ghanche Valley** | | | |
| 1 | Thallay Phase-III | 3.00 | Thalay Ghanche |
| 2 | Hushay (River) | 3.00 | Hushay Ghanche |
| **SUB TOTAL** | | **6.00** | |
| **TOTAL** | | **40.00** | |

## 2.3 POWER MARKET STUDY CONDUCTED BY WAPDA WITH GTZ

Comprehensive planning of hydropower resources on tributaries of Indus River in Northern Areas was started in July 1992, by Hydro Planning Organization (HPO) before known as Hydro Electric Planning Organization (HEPO) WAPDA, in collaboration with the German Agency for Technical Corporation (GTZ) from the Public Federal Republic of Germany. In the study, project areas were divided into 12 regions which are listed below.

**Table 2-5 Surveyed Region**

| Sr. No | Region | Area |
|---|---|---|
| 1 | Region-3 | Gilgit |
| 2 | Region-4 | Hunza |
| 3 | Region-5 | Ishkuman |
| 4 | Region-6 | Yasin |
| 5 | Region-12 | Ghizer |
| 6 | Region-7 | Skardu |
| 7 | Region-11 | Khunjerab |
| 8 | Region-8 | Shyok |
| 9 | Region-9 | Harmosh |
| 10 | Region- 1 | Chilas |
| 11 | Region-2 | Astore |
| 12 | Region-10 | Kharmang |



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### 2.3.1 Methodology

Studies were followed the DIPO system, a methodology for technically and economically optimum development of proximal hydropower potentials for regional power development mainly in isolated rural areas, by

- Definition of requirements and Objectives
- Identification of Power Demand and matching Hydro Potential
- Planning of Regional Power Supply Systems
- Execution of the planned installations
- Operation of the systems

The system was developed within different projects of German Technical Cooperation over a period of 17 years; Burundi, Peru and then in Pakistan prepared for Current and Future Development as a permanent dynamic planning instrument.

The study presented the available sources of energy, demand forecast upto the year 2014 for identified potential. Demand Forecast was carried out analytically.

### 2.3.2 Load Separation

Possible Load (electricity demand) was categorized in two main types;

I. Autonomous Load: The load normally in such areas for domestic, commercial, crafts and public services (DCCP).

II. Promoted Load: Resulting from special incentives etc. given to utilize electricity e.g. for heating, baking and cooking (HBC-Load) to protect forest and /or for prospective development Projects.

### 2.3.3 Autonomous Load

It is the normal demand of the people which increases with the growth of population, with more people in a locality more power would be consumed. The demand automatically increases due to development in agricultural, industry health facilities educational opportunities communication system. These development activities lead to change in income level and people start using new products and appliances.

The population growth rate was the main determining factor for future load development. As autonomous load is essentially the demand of power of the people in the locality, it is essential to give the basis of growth rate for the years 1994-2004. Taking into consideration the Govt. policies, it is likely that in medium and long (10-20 years) the growth rate was declined. But future rates of growth cannot be defined exactly, and assumptions were made. To make a sensitivity analysis, three alternatives were made.

For estimating the power demand, the autonomous load for power and energy was considered. This load generally develops if electricity is provided to any region. It had three basic characteristics.



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**Optimistic (High):** The increase in population during 1994-2004 was assumed at the same rate as experienced during 1981-94.

**Intermediate (Medium):** The same growth rate during 1994-2004, but the decrease of 0.5 percent was expected for the next year 10 years from 2004 to 2014.

**Conservative (Low):** The growth rate is assumed to be decreased by 0.5 per annum during 1994-2004 and it is further declined by 0.5 percent per annum on average from 2004-2014.

Table 2-6 shows the projected load demand from 1994 to 2014, forecasted for all regions.

**Table 2-6 Load Forecast Projected by WAPDA & GTZ**

| SECTORS | | OPTIMISTIC LOAD (kW) | | | INTERMEDIATE LOAD (kW) | | | CONSERVATIVE LOAD (kW) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 1994 | 2004 | 2014 | 1994 | 2004 | 2014 | 1994 | 2004 | 2014 |
| Region 1 | Chilas | - | - | - | 3158 | 11304 | 18520 | 5581 | 9817 | 15426 |
| Region 2 | Astore | 4353 | 8570 | 1641 | 3875 | 7628 | 13959 | 3488 | 6553 | 11428 |
| Region 3 | Gilgit | 13841 | 26799 | 48710 | 12441 | 24127 | 42329 | 11343 | 21227 | 36105 |
| Region 4 | Hunza | 5115 | 9937 | 17609 | 4478 | 8705 | 14760 | 3981 | 7379 | 11922 |
| Region 5 | Ishkuman | 1772 | 3394 | 6180 | 1570 | 3011 | 5223 | 1418 | 2579 | 4263 |
| Region 6 | Yasin | 2025 | 4018 | 7218 | 1827 | 3618 | 6193 | 1665 | 3140 | 5122 |
| Region 7 | Skardu | 10007 | 18604 | 34655 | 9193 | 17124 | 30822 | 8533 | 15379 | 27024 |
| Region 8 | Shyok | 11164 | 15952 | 23817 | 9934 | 14180 | 20202 | 8943 | 12191 | 16592 |
| Region 9 | Rondu/ Harmosh | 1757 | 3160 | 5794 | 1555 | 2801 | 4897 | 1398 | 2398 | 3992 |
| Region 10 | Kharmang | 4644 | 8819 | 15848 | 4140 | 7856 | 13427 | 3731 | 6752 | 11017 |
| Region 11 | Khunjerab | 406 | 777 | 7038 | 376 | 711 | 1204 | 350 | 637 | 1026 |
| Region 12 | Ghizer | 595 | 1176 | 2120 | 542 | 1062 | 1824 | 491 | 922 | 1509 |
| Total | | 55679 | 101206 | 170630 | 53089 | 102127 | 173360 | 50922 | 88974 | 145426 |



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**Figure 2-16 Conservative Load Forecast**

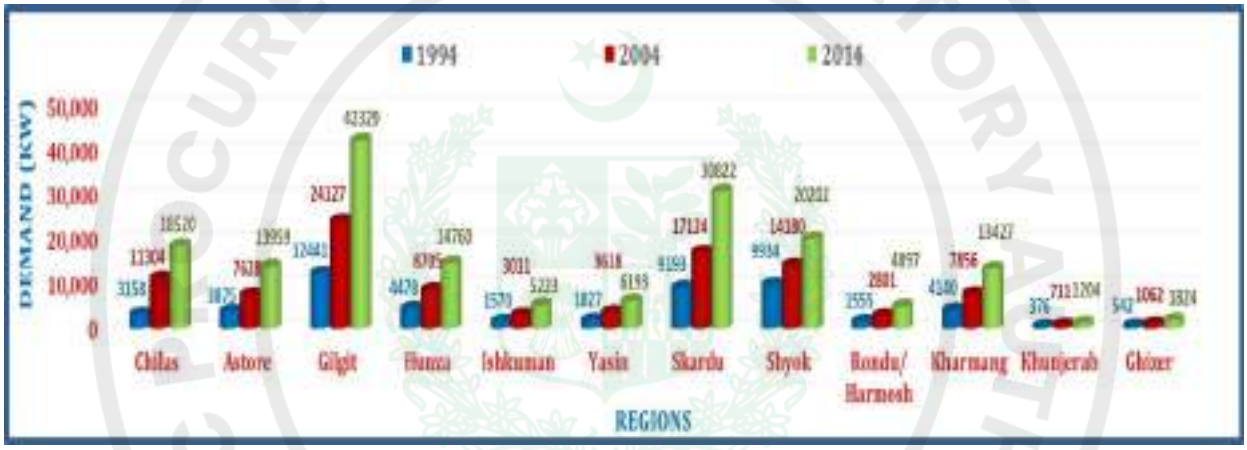


**Figure 2-17 Intermediate Load Forecast**

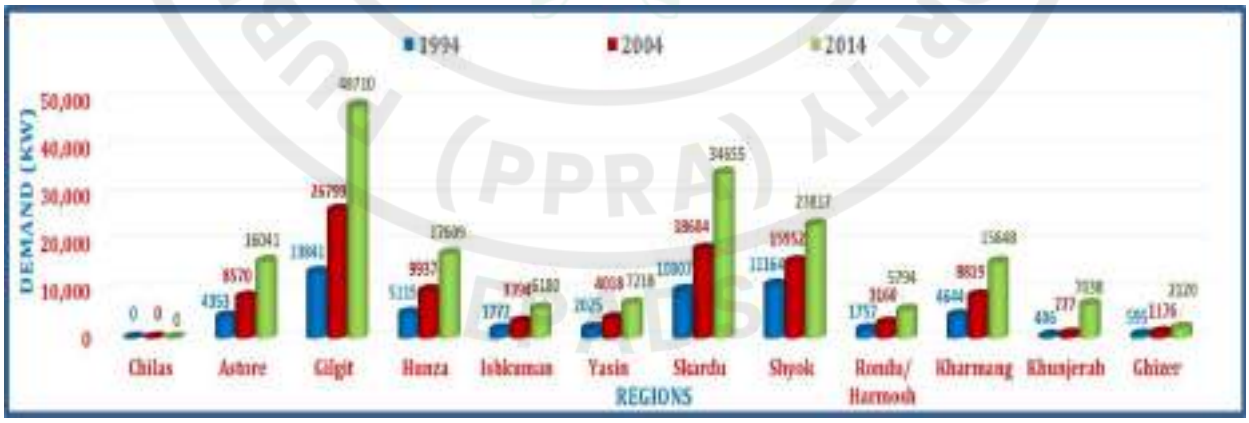


**Figure 2-18 Optimistic Load Forecast**



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**Table 2-7 Projected Load Forecast in Hunza**

| LOAD CENTERS | OPTIMISTIC DEAMAND (kW) | | | INTERMEDIATE DEAMAND (kW) | | | CONSERVATIVE DEAMAND (kW) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1993 | 2003 | 2013 | 1993 | 2003 | 2013 | 1993 | 2003 | 2013 |
| CHALT | 187 | 338 | 549 | 170 | 307 | 471 | 154 | 263 | 388 |
| CHAPROT | 141 | 255 | 415 | 128 | 230 | 356 | 117 | 198 | 295 |
| BUDELAS | 59 | 105 | 167 | 52 | 94 | 144 | 48 | 81 | 120 |
| BAR | 115 | 203 | 329 | 103 | 183 | 284 | 95 | 159 | 232 |
| SKINDARABAD | 90 | 175 | 316 | 80 | 157 | 267 | 72 | 136 | 221 |
| NILT | 213 | 421 | 755 | 189 | 375 | 640 | 171 | 321 | 522 |
| GULMIT | 121 | 216 | 351 | 106 | 189 | 294 | 94 | 160 | 237 |
| MINAPIN | 124 | 224 | 365 | 109 | 196 | 304 | 96 | 166 | 245 |
| FAKKAR | 296 | 615 | 1116 | 260 | 539 | 931 | 230 | 457 | 751 |
| SUMAYAR | 523 | 942 | 1539 | 450 | 808 | 1256 | 394 | 674 | 998 |
| NAGAR | 481 | 998 | 1817 | 421 | 874 | 1516 | 374 | 740 | 1222 |
| HOPER | 268 | 583 | 1114 | 230 | 502 | 912 | 201 | 417 | 724 |
| NASIRABAD | 93 | 207 | 408 | 84 | 188 | 354 | 77 | 165 | 296 |
| KHANABAD | 82 | 158 | 282 | 73 | 144 | 244 | 67 | 126 | 203 |
| HUSSAINABAD | 69 | 133 | 238 | 63 | 122 | 205 | 58 | 106 | 173 |
| MURTAZABD | 189 | 371 | 662 | 169 | 329 | 560 | 152 | 282 | 457 |
| ALIABAD | 368 | 721 | 1357 | 328 | 641 | 1152 | 296 | 551 | 944 |
| HYDERABAD | 224 | 440 | 787 | 200 | 391 | 667 | 180 | 337 | 546 |
| GANISH | 183 | 359 | 642 | 157 | 308 | 527 | 137 | 257 | 418 |
| KARIMABAD | 495 | 963 | 1731 | 425 | 832 | 1494 | 372 | 694 | 1190 |
| ALTIT | 211 | 436 | 821 | 182 | 374 | 670 | 159 | 313 | 533 |
| AHMADABAD | 74 | 151 | 283 | 63 | 129 | 230 | 56 | 108 | 184 |
| ATTABAD | 84 | 172 | 325 | 73 | 150 | 265 | 63 | 125 | 212 |
| AYUNABAD | 93 | 165 | 269 | 80 | 143 | 219 | 70 | 120 | 174 |
| GULKIN | 206 | 350 | 571 | 80 | 300 | 467 | 154 | 252 | 374 |
| PASSU | 69 | 122 | 197 | 59 | 105 | 163 | 52 | 88 | 129 |
| SHIMSHAL | 57 | 114 | 203 | 47 | 98 | 168 | 42 | 83 | 134 |
| *SOST | 57 | 115 | 206 | 52 | 101 | 174 | 47 | 88 | 144 |
| TOTAL | 5,172 | 10,052 | 17,815 | 4,433 | 8,809 | 14,934 | 4,028 | 7,467 | 12,066 |

## 2.4 POWER MARKET - PRESENT SCENARIO

Life in Gilgit-Baltistan is predominantly agrarian. Farming has continued to be a major occupation of the people. Agriculture is dependent upon vagaries of climatic conditions as winters are long and harsh. The farm sizes are small, fragmentation is taking place and the household incomes are on a subsistence level. There is the migration of workforce to cities and towns in the down country, and also as far as to Karachi in the south to sustain meager livelihood.

### 2.4.1 Exploitation of Natural Resources

Agriculture is a major occupation of the people in Gilgit-Baltistan which depends upon whims of climatic conditions as winters are long and harsh. The non-availability of electricity is a major constraint to undertake farm cultivation program on a large scale. There are no cold storage facilities to preserve fruits which can earn substantial income to the orchard growers. Hunza and Nagar valleys have precious mineral resources which have remained unexploited. The incomes are on a subsistence level, thus making pavement for the migration of workforce to cities and towns in the down country to sustain meager livelihood. The availability of electricity will certainly develop a set up on large scale to preserve fruits and for exploration of minerals.



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### 2.4.2 Tourism

The Gilgit-Baltistan region and its valleys are tourist's paradises for tracking and mountaineering. There is a great potential for business and employment prospects in this sector. At present a few opportunities under Govt.'s social and infrastructure development programs are available for the educated and skilled workforce in various trades. The reliable energy sources and transmission network are key factors for the development tourism and mountaineering.

### 2.4.3 Trade Route to China

The opening up of Gilgit-Baltistan region to China has provided an incentive to the local entrepreneurs for self-employment and outlets for income generation. This has resulted in job creations for educated young people. Hunza is developing into a central city for economic activities for tourism. With the provision of the basic infrastructural facility of electricity, Hunza and its surrounding towns have the potential for development in the coming years. Sost is the last town of Gojal, Upper Hunza inside Pakistan on the Karakoram Highway before the Khunjerab Border. This town has importance due to the dry port. The Silk Route Dry Port is functional since 2002. Sost dry port is the first formal port at China-Pakistan border, facilitating customs clearance and other formalities for goods moving between China & Pakistan. Currently, this region is also facing the shortfall of electricity and only Misghar power station is installed nearby this town. After commissioning the Attabad Hydro Power Project, current electricity shortfall scenario will be changed and routine trade will be accelerated.

### 2.4.4 Change in Social Life

Many social and economic changes have taken place at the macro level in the Gilgit-Baltistan region. The people desire to get education and obtain skills in trades and vocations, and also development and improvements in transport and communication have opened new avenues of income generation. The improvement in these sectors has continued to grow with time. The requirements of electricity have increased in homes, both public and private offices, education institutions, hospitals, and health care centers in towns and habitats in the remote rural areas of valleys in Gilgit-Baltistan region.

### 2.4.5 Investment Incentive

Electric power is a prerequisite to any other investments. Without electricity both human and physical resources will remain unutilized for increasing welfare of the masses for providing income opportunities at or near the level being available to people in the developed part of the country. The elaboration of social, cultural and the people's desire to be prosperous has necessitated the present update of the power demand estimation in the isolated power supply area of Gilgit-Baltistan.

### 2.4.6 Power Generation, Demand & Shortfall of Districts of Gilgit-Baltistan

According to the statistics provided by Water & Power Division GILGIT-BALTISTAN, the power generation & demand is grouped for two seasons like summer and winter. In the Gilgit region 49 & 33.6 MW produced in summer & winter respectively with demanded power of 49.89 & 94.51 MW. Gilgit has faced the short fall of 0.89 & 60.91 MW. Diamer has produced 10.59 & 10.75 MW while the present demand noted 36.02 & 50.34 MW with the shortfall of 25.43 &



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39.59 MW. In the Skardu region 20.30 & 16.20 MW produced in summer & winter respectively with demanded power of 50.6 & 94.47 MW. Skardu has faced the short fall of 30.3 & 78.27 MW.

Ghizer has produced 12.50 & 9.38 MW while the present demand noted 38.88 & 71.34 MW with the shortfall of 26.38 & 61.96 MW. In the Ghanche 8.09 & 5.16 MW produced in summer & winter respectively with demanded power of 25.5 & 48.52 MW. Ghanche has faced the short fall of 17.41& 43.36 MW. Astore has produced 4.50 & 4.0 MW while the present demand in 2020 noted 14.83 & 24.53 MW with the shortfall of 10.33 & 20.53 MW. In the Nagar 4.56 & 2.53 MW produced in summer & winter respectively with demanded power of 9.27 & 16.97 MW. Nagar has faced the short fall of 4.71 & 14.44 MW in summer and winter respectively. Hunza has produced 4.71 & 3.58 MW while the present demand noted 12.83 & 20.61 MW with the shortfall of 8.12 & 17.03 MW. In the Shiger 3.50 & 2.0 MW produced in summer & winter respectively with demanded power of 10.35 & 18.36 MW. Shiger has faced the short fall of 6.85 & 16.36 MW in summer and winter respectively. Khermang has produced 4.61 & 4.07MW while the present demand in 2020 noted 6.65 & 12.54 MW with the shortfall of 2.04 & 8.47 MW. The district wise power values are mentioned in Table 2.8.

**Table 2-8 Current Power Scenario of Gilgit-Baltistan**

| District | Present Generation (MW) | | | | | | Present Demand (MW) | | Present Shortfall (MW) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Summer | | | Winter | | | Summer | Winter | Summer | Winter |
| | Hydel | Thermal | Total | Hydel | Thermal | Total | | | | |
| Gilgit | 49.00 | 0.00 | 49.00 | 25.80 | 7.80 | 33.6 | 49.89 | 94.51 | 0.89 | 60.91 |
| Diamer | 9.79 | 0.80 | 10.59 | 6.75 | 4.00 | 10.75 | 36.02 | 50.34 | 25.43 | 39.59 |
| Skardu | 20.30 | 0.00 | 20.30 | 14.20 | 2.00 | 16.20 | 50.6 | 94.47 | 30.3 | 78.27 |
| Ghizer | 12.50 | 0.00 | 12.50 | 8.80 | 0.58 | 9.38 | 38.88 | 71.34 | 26.38 | 61.96 |
| Ghanche | 8.09 | 0.00 | 8.09 | 5.00 | 0.16 | 5.16 | 25.5 | 48.52 | 17.41 | 43.36 |
| Astore | 4.50 | 0.00 | 4.50 | 4.00 | 0.00 | 4.00 | 14.83 | 24.53 | 10.33 | 20.53 |
| Nagar | 4.56 | 0.00 | 4.56 | 2.03 | 0.50 | 2.53 | 9.27 | 16.97 | 4.71 | 14.44 |
| Hunza | 3.91 | 0.80 | 4.71 | 2.78 | 0.80 | 3.58 | 12.83 | 20.61 | 8.12 | 17.03 |
| Shiger | 3.50 | 0.00 | 3.50 | 2.00 | 0.00 | 2.00 | 10.35 | 18.36 | 6.85 | 16.36 |
| Khermang | 4.61 | 0.00 | 4.61 | 4.07 | 0.00 | 4.07 | 6.65 | 12.54 | 2.04 | 8.47 |
| **Total** | **120.76** | **1.60** | **122.36** | **75.43** | **15.84** | **91.27** | **254.82** | **452.19** | **132.46** | **360.92** |

In figure 2-19, Power scenario is sketched out for the summer 2020, which shows that due to bulk supply of water in summer deficit between demand and generation is less than from winter power scenario which has shown in figure 2-20.



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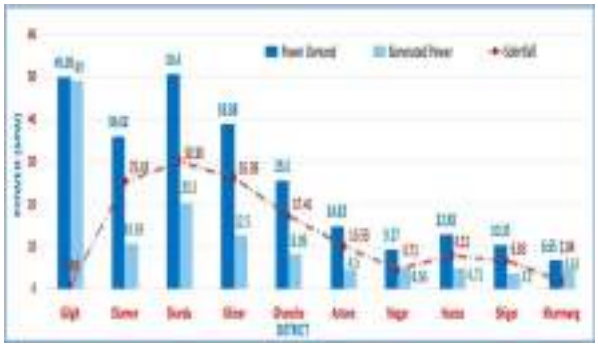

**Figure 2-19 District wise Summer Power Scenario in Gilgit-Baltistan**

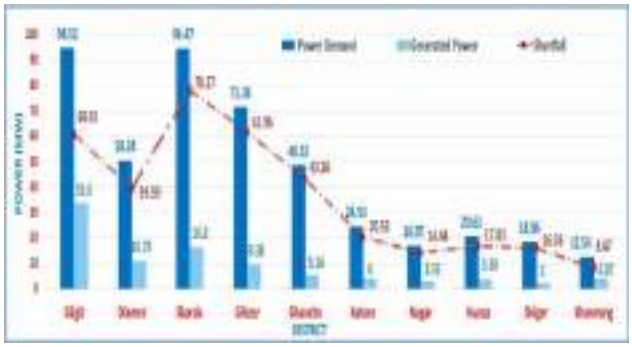

**Figure 2-20 District wise Winter Power Scenario in Gilgit-Baltistan**

In Figure 2-21, comparison could be easily seen for the power demand in Gilgit-Baltistan for the both season of summer and winter.

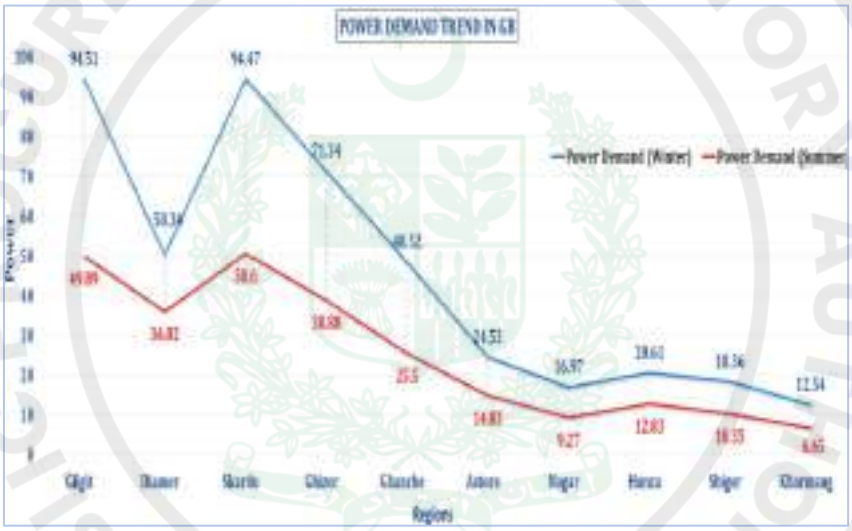


**Figure 2-21 District wise Overall Power Demand in Gilgit-Baltistan**

### 2.4.7 Current Power Market HUNZA District

Energy is a critical input for economic development and correspondingly power sector comprises an indispensable infrastructure in any economy. Providing adequate and affordable electric power is essential for economic development, human welfare and better living standards. The growth of the economy along with its global competitiveness hinges on the availability of reliable and quality power at competitive rates to all consumers throughout the country. Electricity is central to achieving economic, social and environmental objective.

Attabad Lake Hydropower Project is located in the Hunza District, it is worthy to discuss the current Power scenario of Hunza district in detail for understanding the imperial impact of project in the region and forecast the demand for the future. The power supply area of the proposed site covers mainly the Upper, Middle and Lower Hunza District. Currently following hydropower projects are operating in Hunza.



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**Table 2-9 Installed Power in Hunza**

| Sr.No. | Name of Power Station | Year of Completion | Unit Capacity (MW) |
|---|---|---|---|
| **1** | Hassanabad Hunza HPS Phase-I | 1996 | 1.200 |
| **2** | Hassanabad Hunza HPS Phase-II | 1991 | 0.200 |
| **3** | Hassanabad Hunza HPS Phase-III | 2003 | 0.500 |
| **4** | Khyber Gojal Hunza HPS Phase-I | 1987 | 0.400 |
| **5** | Khyber Gojal Hunza HPS Phase-II | 1996 | 0.400 |
| **6** | Misgar Gojal Hunza HPS | 2017 | 3.00 |
| **7** | Ganish Hunza Diesel Generator Set | 2018 | 1.00 |
| **8** | Hassanabad-1 Diesel Generator Set | 2008 | 1.00 |
| **9** | Hassanabad-2 Diesel Generator Set | 2017 | 1.00 |
| **10** | Khizerabad Diesel Generator Set | 2018 | 0.20 |
| **11** | MHP Shimshal | 2017 | 0.20 |
| | | **Total** | **9.1** |

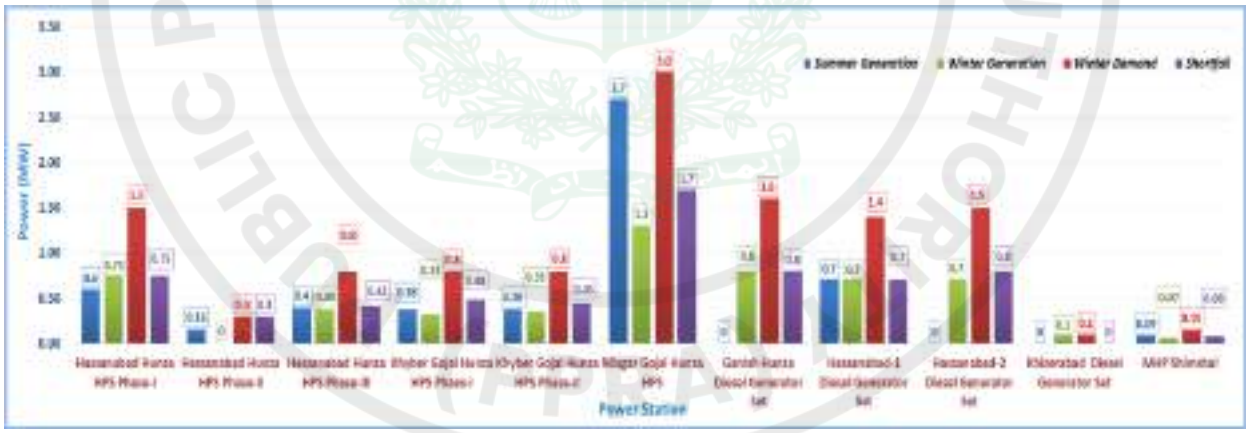


**Figure 2-22 Installed Capacity in Hunza**

### 2.4.8 Load Shedding

The per capita consumption of electrical energy depends on various factors of which the most important are:

- No. of consumers connected to the electrical grid - the more consumers are connected to the grid the higher the per capita consumption will beLoad shedding pattern - the per capita consumption will increase with lower load shedding rates No. of electrical devices per consumer - a growing economy results in a higher prosperity what increases the no. of electrical devices per consumer (fridges, air- conditioning, television etc.).



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- Industrialization - a growing economy also results in a growing no. of commerce and industry. Thus the per capita consumption also includes industrialization.

The scenario of constricted supply-demand is envisaged to undergo a radical improvement with the execution of the new powerhouses. The availability of electricity for production of goods and commodities will result in higher income generation. This increase in income will raise standard of living of the people who will have an impetus to purchase household electric gadgets and appliances.

In the present situation, Gilgit-Baltistan is facing power shortage. Therefore, load shedding is being carried out as load management in entire region. Hunza is also facing worst power shortage which badly impacts its economy. During the survey in Aliabad and Karimabad which are tourist hubs and have sufficient local population it is conceded that the hoteling and local business have been disturbed badly due to long hour load shedding. The load management schedule of Hunza District is listed as under.

**Table 2-10 Load Shedding Hours in Hunza**

| Project | Supply Area | Status | Current Generation (MW) | Load Management / Schedule (Hours) |
|---|---|---|---|---|
| **Hassanabad Hunza HPS Phase-I** | Hassanabad and Aliabad | Operation | 0.60 | **14** |
| **Hassanabad Hunza HPS Phase-II** | - | Un-operational | - | **-** |
| **Hassanabad Hunza HPS Phase-III** | Murtazabad to Khiziriabad | Operational | 0.7 | **14** |
| **Khyber Gojal Hunza HPS Phase-I** | Khyber to Nazimabad | Operational | 0.380 | **22** |
| **Khyber Gojal Hunza HPS Phase-II** | Passu to Shiskhat | Operational | 0.380 | **18** |
| **Misgar Gojal Hunza HPS** | Misgar, Sost, Khudabad, Chipurson, Ganish, Garelth, Karimabad, Hyderabad, Dorkan & Rahimabad | Operational | 2.6 | **22** |
| **Misgar HPS (1.8 kW)** | | Operational in Winter Season | - | |
| **MHP Shimshal** | Shimshal | Operational | 0.060 | **No load shedding** |

### 2.4.9 Electricity Consumers in HUNZA District

Energy is a critical input for economic development and correspondingly power sector comprises an indispensable infrastructure in any economy. Providing adequate and affordable electric power is essential for economic development, human welfare and better livings.

In this chapter, current consumers of Hunza District have been shown in Figure 2-23. As per administrative record, total population of Hunza, Water & Power Dept. (Gilgit-Baltistan) owns 11416 consumers which are categorized into three main consumer groups shown in below table.

| Consumer | Domestic | Commercial | Industrial | Total |
|---|---|---|---|---|
| Connection | 9191 | 2159 | 66 | 11416 |



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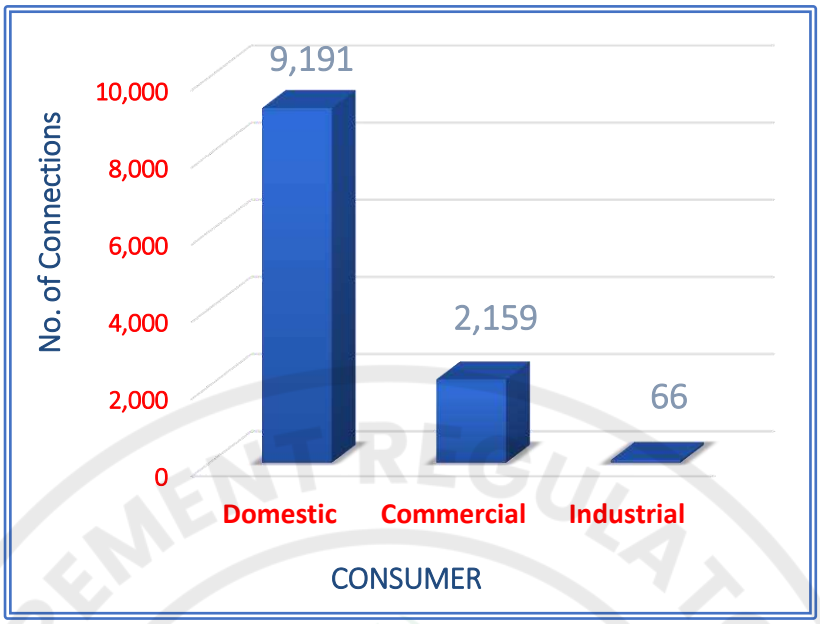


**Figure 2-23 Electricity Consumers in Hunza**

## 2.5 POWER DEMAND FORECASTING

### 2.5.1 Determination and Forecast Power Demand

For a reasonably reliable determination of the power demand, it is foremost mandatory to know the power supply area in which the generated power will be transmitted. Furthermore, the power demand itself and its growth mainly depend on the growth of the population, the increase of the per capita consumption itself and the growth of the economic strength in the area. The per capita consumption usually increases with an increase in the economic strength which highly depends on the available electrical energy.

### 2.5.2 Basis of Load Demand Forecast

Reports of PC-I "Establishment of Regional Grids in Gilgit-Baltistan Phase- I & II" have been used to carry out the Load Forecast as it is recently prepared by the Water and Power (Gilgit-Baltistan). In this report, load demand forecast has been made using WAPDA's methodology (trend analysis) which takes into consideration the annual electricity consumption of domestic, commercial, craft and other users assessed and the historical growth rate for each is calculated on the of available data collected during the survey or the information received from census authorities.

The historical growth rate of each category is further adjusted for forecast keeping in view the prevailing conditions, load factor, increase in standard of living etc. The adjusted growth rates are then adopted for each category and accordingly load demand forecast is worked out.

During survey, the number of consumers, their connected load, their annual energy consumption, population of each area etc. is obtained for the initial years. The demand for the initial year is calculated, and further projected at the adjusted growth rates. Requirement of power energy may be carried out for a period of ten, twenty or thirty years in demand Forecast.



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The period will be covered from 2021 to 2050 (30 years). The reason to extend the plan upto 2050 is to bout with the National Power IGCEP Plan 2047, prepared by the NTDCL. These demand estimates are made for domestic, commercial, crafts, agriculture, industries, public services and lights separately for various load centres identified in ten districts of Gilgit – Baltistan.

As autonomous load is essentially the demand of power of the population in a locality. Thus the rate of population growth is the main determining factor for future load development. It is therefore, essential to give the basis of population growth rate for determining annual power demand as shown In Table 2-11.

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## Table 2-11 Forcosted Population Growth Rate Per Annum (2.74%) in Million (2021-2050)

| S# | Grid Stations | Location | No. of Load Centers | No. of Villages | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 | 2036 | 2037 | 2038 | 2039 | 2040 | 2041 | 2042 | 2043 | 2044 | 2045 | 2046 | 2047 | 2048 | 2049 | 2050 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 132/66/11 KV Humayun Bridge | Skardu | 6 | 14 | 0.72 | 0.74 | 0.76 | 0.781 | 0.802 | 0.824 | 0.847 | 0.87 | 0.894 | 0.918 | 0.943 | 0.969 | 0.996 | 1.023 | 1.051 | 1.08 | 1.11 | 1.14 | 1.171 | 1.203 | 1.236 | 1.27 | 1.305 | 1.341 | 1.377 | 1.415 | 1.454 | 1.494 | 1.535 | 1.577 |
| 2 | 132/66/11 KV Khaplu | Khaplu City | 4 | 12 | 0.232 | 0.238 | 0.245 | 0.252 | 0.258 | 0.266 | 0.273 | 0.28 | 0.288 | 0.296 | 0.304 | 0.312 | 0.321 | 0.33 | 0.339 | 0.348 | 0.358 | 0.367 | 0.377 | 0.388 | 0.398 | 0.409 | 0.42 | 0.432 | 0.444 | 0.456 | 0.469 | 0.481 | 0.495 | 0.508 |
| 3 | 132/66/11 KV Ghowari | Ghanche | 2 | 10 | 0.027 | 0.028 | 0.028 | 0.029 | 0.03 | 0.031 | 0.032 | 0.033 | 0.034 | 0.034 | 0.035 | 0.036 | 0.037 | 0.038 | 0.039 | 0.041 | 0.042 | 0.043 | 0.044 | 0.045 | 0.046 | 0.048 | 0.049 | 0.05 | 0.052 | 0.053 | 0.055 | 0.056 | 0.058 | 0.059 |
| 4 | 132/66/11 KV Gahkuch | Ghizer | 2 | 10 | 0.165 | 0.17 | 0.174 | 0.179 | 0.184 | 0.189 | 0.194 | 0.199 | 0.205 | 0.21 | 0.216 | 0.222 | 0.228 | 0.234 | 0.241 | 0.248 | 0.254 | 0.261 | 0.268 | 0.276 | 0.283 | 0.291 | 0.299 | 0.307 | 0.316 | 0.324 | 0.333 | 0.342 | 0.352 | 0.361 |
| 5 | 132/66/11 KV Gupis | Ghizer | 2 | 8 | 0.118 | 0.121 | 0.125 | 0.128 | 0.131 | 0.135 | 0.139 | 0.143 | 0.146 | 0.151 | 0.155 | 0.159 | 0.163 | 0.168 | 0.172 | 0.177 | 0.182 | 0.187 | 0.192 | 0.197 | 0.203 | 0.208 | 0.214 | 0.22 | 0.226 | 0.232 | 0.238 | 0.245 | 0.252 | 0.258 |
| 6 | 66/11 KV Yasin | Ghizer | 2 | 8 | 0.015 | 0.015 | 0.016 | 0.016 | 0.017 | 0.017 | 0.018 | 0.018 | 0.019 | 0.019 | 0.02 | 0.02 | 0.021 | 0.021 | 0.022 | 0.023 | 0.023 | 0.024 | 0.024 | 0.025 | 0.026 | 0.026 | 0.027 | 0.028 | 0.029 | 0.029 | 0.03 | 0.031 | 0.032 | 0.033 |
| 7 | 66/11 KV Chatorkhand | Ghizer | 2 | 7 | 0.02 | 0.021 | 0.021 | 0.022 | 0.022 | 0.023 | 0.024 | 0.024 | 0.025 | 0.026 | 0.026 | 0.027 | 0.028 | 0.028 | 0.029 | 0.03 | 0.031 | 0.032 | 0.033 | 0.033 | 0.034 | 0.035 | 0.036 | 0.037 | 0.038 | 0.039 | 0.04 | 0.041 | 0.043 | 0.044 |
| 8 | 66/11 KV Ishkoman | Ghizer | 2 | 8 | 0.027 | 0.028 | 0.028 | 0.029 | 0.03 | 0.031 | 0.032 | 0.033 | 0.034 | 0.034 | 0.035 | 0.036 | 0.037 | 0.038 | 0.039 | 0.041 | 0.042 | 0.043 | 0.044 | 0.045 | 0.046 | 0.048 | 0.049 | 0.05 | 0.052 | 0.053 | 0.055 | 0.056 | 0.058 | 0.059 |
| 9 | 66/11 KV Gulmit | Hunza | 2 | 8 | 0.02 | 0.021 | 0.021 | 0.022 | 0.022 | 0.023 | 0.024 | 0.024 | 0.025 | 0.026 | 0.026 | 0.027 | 0.028 | 0.028 | 0.029 | 0.03 | 0.031 | 0.032 | 0.033 | 0.033 | 0.034 | 0.035 | 0.036 | 0.037 | 0.038 | 0.039 | 0.04 | 0.041 | 0.043 | 0.044 |
| 10 | 66/11 KV Sost | Hunza | 2 | 7 | 0.026 | 0.027 | 0.027 | 0.028 | 0.029 | 0.03 | 0.031 | 0.031 | 0.032 | 0.033 | 0.034 | 0.035 | 0.036 | 0.037 | 0.038 | 0.039 | 0.04 | 0.041 | 0.042 | 0.043 | 0.045 | 0.046 | 0.047 | 0.048 | 0.05 | 0.051 | 0.053 | 0.054 | 0.055 | 0.057 |
| 11 | 66/11 KV Gudai | Astore | 2 | 8 | 0.027 | 0.028 | 0.028 | 0.029 | 0.03 | 0.031 | 0.032 | 0.033 | 0.034 | 0.034 | 0.035 | 0.036 | 0.037 | 0.038 | 0.039 | 0.041 | 0.042 | 0.043 | 0.044 | 0.045 | 0.046 | 0.048 | 0.049 | 0.05 | 0.052 | 0.053 | 0.055 | 0.056 | 0.058 | 0.059 |
| 12 | 66/11 KV Rehmanpur | Astore | 2 | 7 | 0.031 | 0.032 | 0.033 | 0.034 | 0.035 | 0.035 | 0.036 | 0.037 | 0.038 | 0.04 | 0.041 | 0.042 | 0.043 | 0.044 | 0.045 | 0.047 | 0.048 | 0.049 | 0.05 | 0.052 | 0.053 | 0.055 | 0.056 | 0.058 | 0.059 | 0.061 | 0.063 | 0.064 | 0.066 | 0.068 |
| 13 | 66/11 KV Shigar | Shigar | 2 | 7 | 0.027 | 0.028 | 0.028 | 0.029 | 0.03 | 0.031 | 0.032 | 0.033 | 0.034 | 0.034 | 0.035 | 0.036 | 0.037 | 0.038 | 0.039 | 0.041 | 0.042 | 0.043 | 0.044 | 0.045 | 0.046 | 0.048 | 0.049 | 0.05 | 0.052 | 0.053 | 0.055 | 0.056 | 0.058 | 0.059 |
| 14 | 66/11 KV Machulu | Ghanche | 2 | 8 | 0.023 | 0.024 | 0.024 | 0.025 | 0.026 | 0.026 | 0.027 | 0.028 | 0.029 | 0.029 | 0.03 | 0.031 | 0.032 | 0.033 | 0.034 | 0.035 | 0.035 | 0.036 | 0.037 | 0.038 | 0.039 | 0.041 | 0.042 | 0.043 | 0.044 | 0.045 | 0.046 | 0.048 | 0.049 | 0.05 |
| 15 | 66/11 KV Dumsum | Ghanche | 2 | 7 | 0.028 | 0.029 | 0.03 | 0.03 | 0.031 | 0.032 | 0.033 | 0.034 | 0.035 | 0.036 | 0.037 | 0.038 | 0.039 | 0.04 | 0.041 | 0.042 | 0.043 | 0.044 | 0.046 | 0.047 | 0.048 | 0.049 | 0.051 | 0.052 | 0.054 | 0.055 | 0.057 | 0.058 | 0.06 | 0.061 |
| 16 | 66/11 KV Pion | Ghanche | 2 | 7 | 0.026 | 0.027 | 0.027 | 0.028 | 0.029 | 0.03 | 0.031 | 0.031 | 0.032 | 0.033 | 0.034 | 0.035 | 0.036 | 0.037 | 0.038 | 0.039 | 0.04 | 0.041 | 0.042 | 0.043 | 0.045 | 0.046 | 0.047 | 0.048 | 0.05 | 0.051 | 0.053 | 0.054 | 0.055 | 0.057 |
| 17 | 66/11 KV Tolti | Skardu | 3 | 8 | 0.031 | 0.032 | 0.033 | 0.034 | 0.035 | 0.035 | 0.036 | 0.037 | 0.038 | 0.04 | 0.041 | 0.042 | 0.043 | 0.044 | 0.045 | 0.047 | 0.048 | 0.049 | 0.05 | 0.052 | 0.053 | 0.055 | 0.056 | 0.058 | 0.059 | 0.061 | 0.063 | 0.064 | 0.066 | 0.068 |
| 18 | 66/11 KV Tangir | Diamer | 3 | 6 | 0.038 | 0.039 | 0.04 | 0.041 | 0.042 | 0.043 | 0.045 | 0.046 | 0.047 | 0.048 | 0.05 | 0.051 | 0.053 | 0.054 | 0.055 | 0.057 | 0.059 | 0.06 | 0.062 | 0.064 | 0.065 | 0.067 | 0.069 | 0.071 | 0.073 | 0.075 | 0.077 | 0.079 | 0.081 | 0.083 |
| 19 | 66/11 KV Darel | Diamer | 3 | 7 | 0.04 | 0.041 | 0.042 | 0.043 | 0.045 | 0.046 | 0.047 | 0.048 | 0.05 | 0.051 | 0.052 | 0.054 | 0.055 | 0.057 | 0.058 | 0.06 | 0.062 | 0.063 | 0.065 | 0.067 | 0.069 | 0.071 | 0.072 | 0.074 | 0.077 | 0.079 | 0.081 | 0.083 | 0.085 | 0.088 |
| | Total | | 47 | 157 | 1.641 | 1.69 | 1.73 | 1.78 | 1.83 | 1.88 | 1.93 | 1.98 | 2.04 | 2.09 | 2.15 | 2.21 | 2.27 | 2.33 | 2.4 | 2.46 | 2.53 | 2.6 | 2.67 | 2.74 | 2.82 | 2.89 | 2.97 | 3.06 | 3.14 | 3.23 | 3.31 | 3.4 | 3.5 | 3.59 |



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### 2.5.3 Parameters of Load Demand Forecast

To develop parameters for prospective power consumption by different types of consumers of different locations/villages of Gilgit-Baltistan, the related results of similar area of other provinces of Pakistan have been studied and used as basic reference for the development of parameters etc. However, the effects of local climate, terrain and financial states of the public have also been considered while designing basic parameters etc.

Based on load demand and energy consumption survey carried out in the sample urban and rural localities, Load demand parameters have been developed for rural and urban localities. Considerable accuracies in proportionate to increase/decrease with the population census have been recorded.

### 2.5.4 Parameters Categorization

The load demand forecast parameters adopted for rural and urban localities of different districts of Gilgit-Baltistan are given in the following table.

**Table 2-12 Load demand parameters Rural Consumers**

| Sr. No | Type of consumers | Load (KW) |
|---|---|---|
| 1 | Domestic | 2 |
| 2 | Commercial | 3 |
| 3 | Community | 5 |
| 4 | Small industry | 12 |
| 5 | Pump water supply | 15 |
| 6 | Pump irrigation | 7.50 |
| 7 | Street lights | 3 |

**Table 2-13 Load Demand parameters Urban Consumers**

| Sr. No | Type of Consumers | Load (KW) | | | |
|---|---|---|---|---|---|
| | | 3-5 Marla | 7-10 Marla | 1-Kanal | 2-Kanal |
| 1 | Domestic | 3 | 8 | 12 | 20 |
| 2 | Commercial | 10 | 15 | 20 | 25 |
| 3 | Community | 10 | 15 | 26 | 30 |
| 4 | Small Industry | 10 | 15 | 30 | 60 |
| 5 | Pump water supply | - | - | - | 40 |
| 6 | Pump irrigation | - | - | - | 25 |
| 7 | Street lights | - | - | - | 0.2 |

### 2.5.5 Load Forecasting Results

Based on above various power demand/ load forecast has been estimated in terms of maximum power which generally occurs in January, required for the present connected consumers and the deprived villages. According to the assessment of the existing load position



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in the area optimistic scenario is not far from realistic demand assessment and could be considered as the likely power demand/ load forecast of the regions in Gilgit-Baltistan. The load forecast up to 2050 is tabulated as under:

**Table 2-14 Load Demand Forecast (MW) Gilgit-Baltistan upto 2050**

| YEAR | DISTRICTS | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gilgit | Ghizer | Nagar | Hunza | Diamer | Astore | Skardu | Ghance | Shiger | Khar mang | Total |
| **2021** | 115.97 | 71.22 | 28.1 | 28.2 | 106.48 | 45.26 | 94 | 47.27 | 27.5 | 25.5 | **589.5** |
| **2022** | 117.96 | 72.44 | 28.58 | 28.69 | 108.31 | 46.04 | 95.62 | 48.08 | 27.97 | 25.94 | **599.63** |
| **2023** | 119.99 | 73.69 | 29.07 | 29.18 | 110.17 | 46.83 | 97.26 | 48.91 | 28.45 | 26.38 | **609.93** |
| **2024** | 122.06 | 74.96 | 29.58 | 29.68 | 112.07 | 47.64 | 98.93 | 49.75 | 28.94 | 26.84 | **620.45** |
| **2025** | 124.16 | 76.25 | 30.08 | 30.19 | 114 | 48.46 | 100.64 | 50.61 | 29.44 | 27.3 | **631.13** |
| **2026** | 126.29 | 77.56 | 30.6 | 30.71 | 115.96 | 49.29 | 102.37 | 51.48 | 29.95 | 27.77 | **641.98** |
| **2027** | 128.46 | 78.89 | 31.13 | 31.24 | 117.95 | 50.14 | 104.13 | 52.36 | 30.46 | 28.25 | **653.01** |
| **2028** | 130.67 | 80.25 | 31.66 | 31.78 | 119.98 | 51 | 105.92 | 53.26 | 30.99 | 28.73 | **664.24** |
| **2029** | 132.92 | 81.63 | 32.21 | 32.32 | 122.04 | 51.88 | 107.74 | 54.18 | 31.52 | 29.23 | **675.67** |
| **2030** | 135.21 | 83.03 | 32.76 | 32.88 | 124.14 | 52.77 | 109.59 | 55.11 | 32.06 | 29.73 | **687.28** |
| **2031** | 137.53 | 84.46 | 33.32 | 33.44 | 126.28 | 53.68 | 111.48 | 56.06 | 32.61 | 30.24 | **699.1** |
| **2032** | 139.9 | 85.92 | 33.9 | 34.02 | 128.45 | 54.6 | 113.4 | 57.02 | 33.17 | 30.76 | **711.14** |
| **2033** | 142.31 | 87.39 | 34.48 | 34.6 | 130.66 | 55.54 | 115.35 | 58 | 33.74 | 31.29 | **723.36** |
| **2034** | 144.75 | 88.9 | 35.07 | 35.2 | 132.91 | 56.49 | 117.33 | 59 | 34.33 | 31.83 | **735.81** |
| **2035** | 147.24 | 90.43 | 35.68 | 35.8 | 135.19 | 57.47 | 119.35 | 60.02 | 34.92 | 32.38 | **748.48** |
| **2036** | 149.78 | 91.98 | 36.29 | 36.42 | 137.52 | 58.45 | 121.4 | 61.05 | 35.52 | 32.93 | **761.34** |
| **2037** | 152.35 | 93.56 | 36.92 | 37.05 | 139.88 | 59.46 | 123.49 | 62.1 | 36.13 | 33.5 | **774.44** |
| **2038** | 154.97 | 95.17 | 37.55 | 37.68 | 142.29 | 60.48 | 125.61 | 63.17 | 36.75 | 34.08 | **787.75** |
| **2039** | 157.64 | 96.81 | 38.2 | 38.33 | 144.74 | 61.52 | 127.77 | 64.25 | 37.38 | 34.66 | **801.3** |
| **2040** | 160.35 | 98.47 | 38.85 | 38.99 | 147.23 | 62.58 | 129.97 | 65.36 | 38.02 | 35.26 | **815.08** |
| **2041** | 163.11 | 100.17 | 39.52 | 39.66 | 149.76 | 63.66 | 132.21 | 66.48 | 38.68 | 35.86 | **829.11** |
| **2042** | 165.91 | 101.89 | 40.2 | 40.34 | 152.34 | 64.75 | 134.48 | 67.63 | 39.34 | 36.48 | **843.36** |
| **2043** | 168.77 | 103.64 | 40.89 | 41.04 | 154.96 | 65.86 | 136.79 | 68.79 | 40.02 | 37.11 | **857.87** |
| **2044** | 171.67 | 105.43 | 41.6 | 41.74 | 157.62 | 67 | 139.15 | 69.97 | 40.71 | 37.75 | **872.64** |
| **2045** | 174.62 | 107.24 | 42.31 | 42.46 | 160.33 | 68.15 | 141.54 | 71.18 | 41.41 | 38.4 | **887.64** |
| **2046** | 177.63 | 109.08 | 43.04 | 43.19 | 163.09 | 69.32 | 143.97 | 72.4 | 42.12 | 39.06 | **902.9** |
| **2047** | 180.68 | 110.96 | 43.78 | 43.94 | 165.89 | 70.51 | 146.45 | 73.65 | 42.84 | 39.73 | **918.43** |
| **2048** | 183.79 | 112.87 | 44.53 | 44.69 | 168.75 | 71.73 | 148.97 | 74.91 | 43.58 | 40.41 | **934.23** |
| **2049** | 186.95 | 114.81 | 45.3 | 45.46 | 171.65 | 72.96 | 151.53 | 76.2 | 44.33 | 41.11 | **950.3** |
| **2050** | 190.16 | 116.78 | 46.08 | 46.24 | 174.6 | 74.22 | 154.14 | 77.51 | 45.09 | 41.81 | **966.63** |



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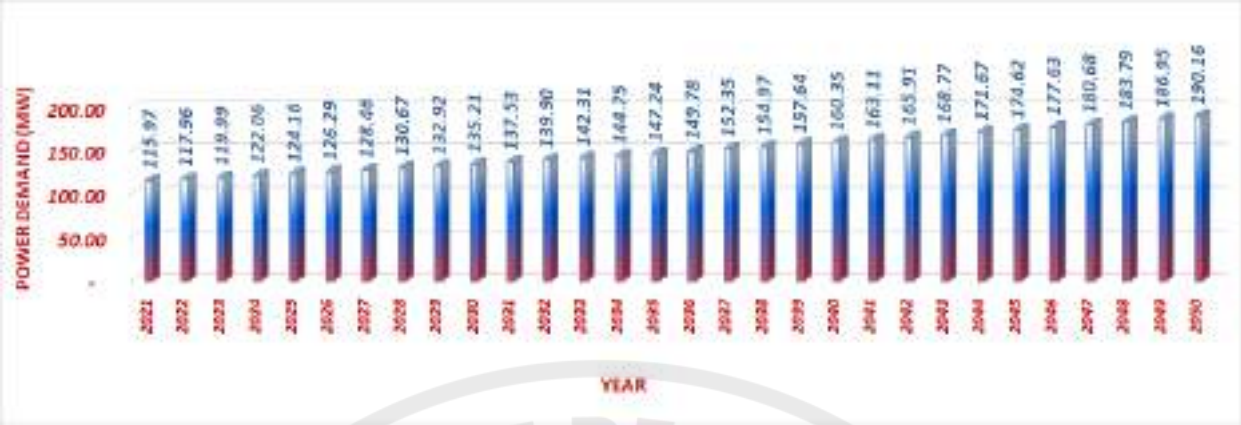


**Figure 2-24 Power Demand Forecast Gilgit (2021-50)**

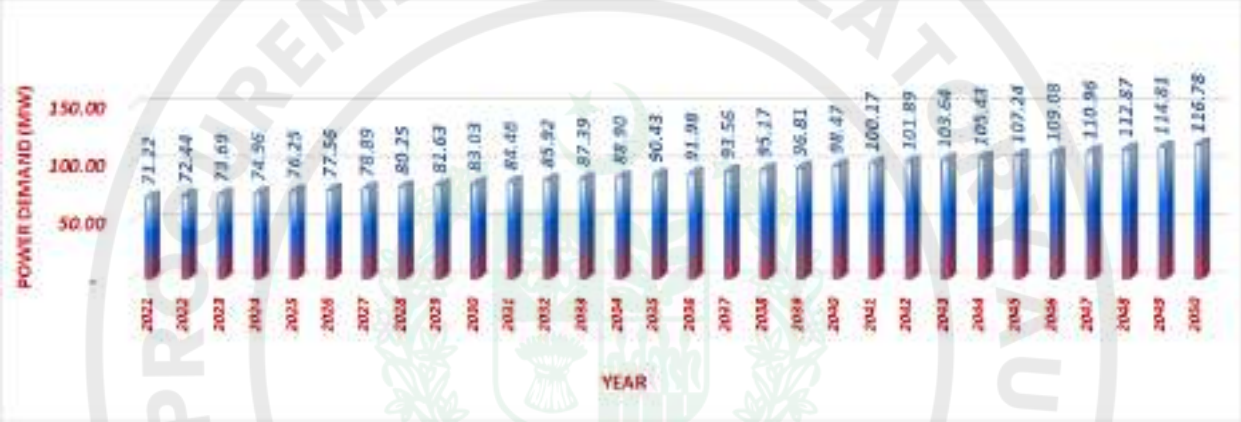


**Figure 2-25 Power Demand Forecast Ghizer (2021-50)**

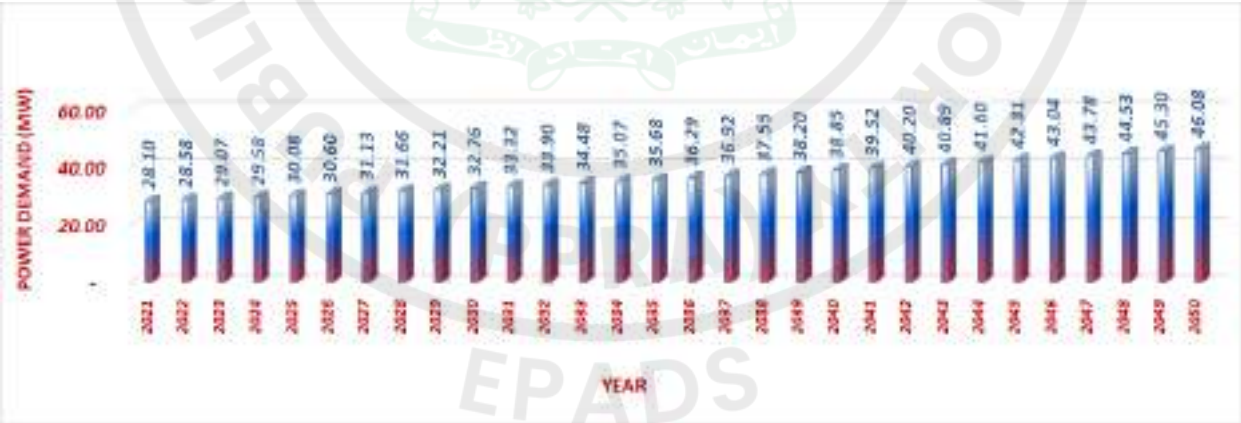


**Figure 2-26 Power Demand Forecast Nagar (2021-50)**



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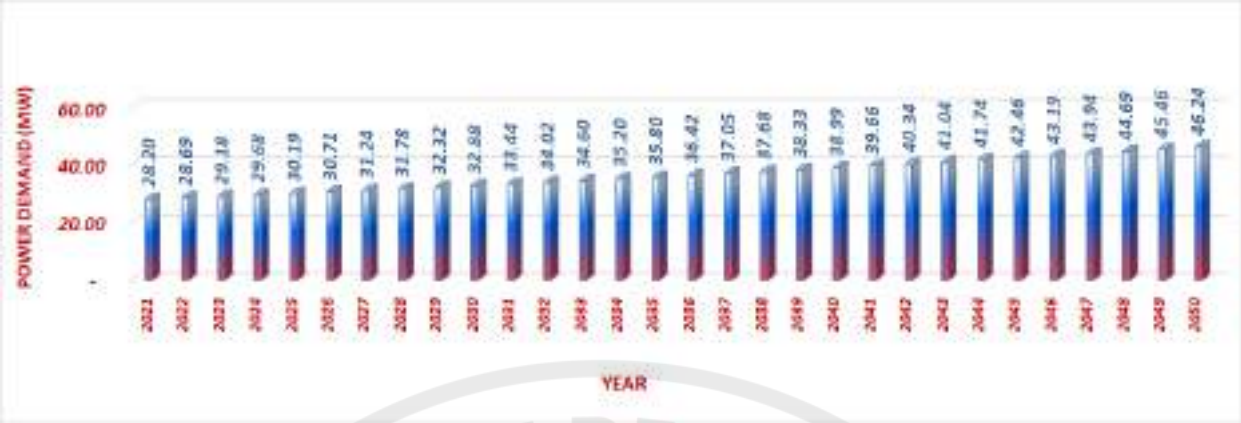


**Figure 2-27 Power Demand Forecast Hunza (2021-50)**

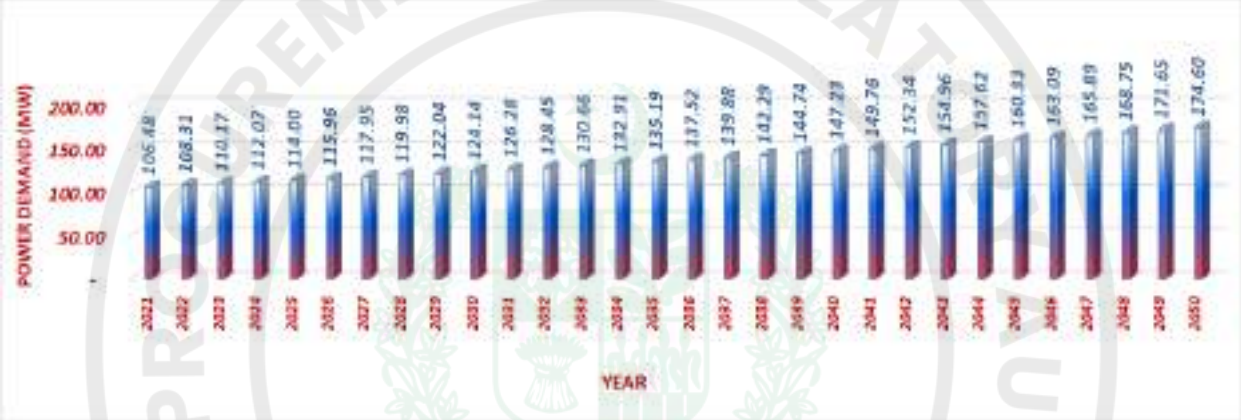


**Figure 2-28 Power Demand Forecast Diamer (2021-50)**

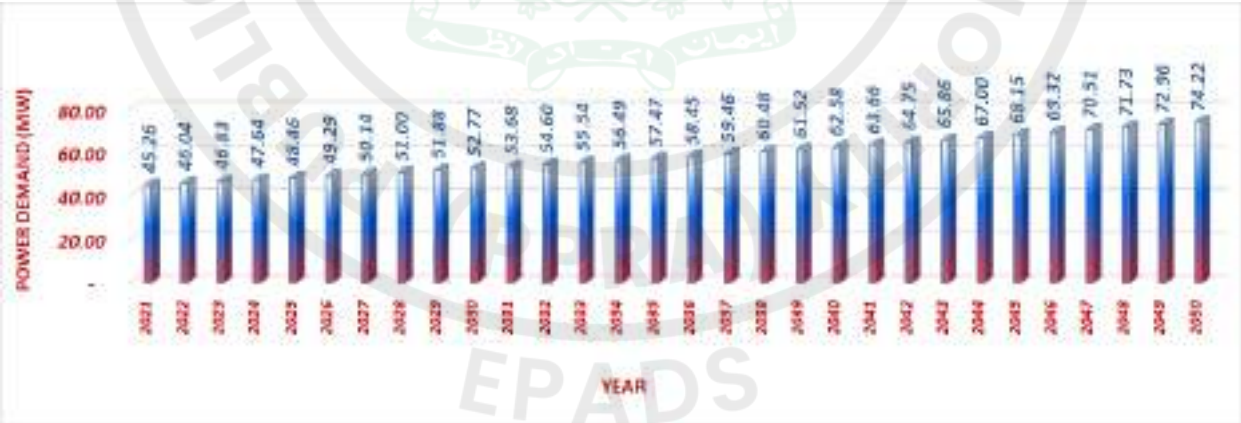


**Figure 2-29 Power Demand Forecast Astore (2021-50)**



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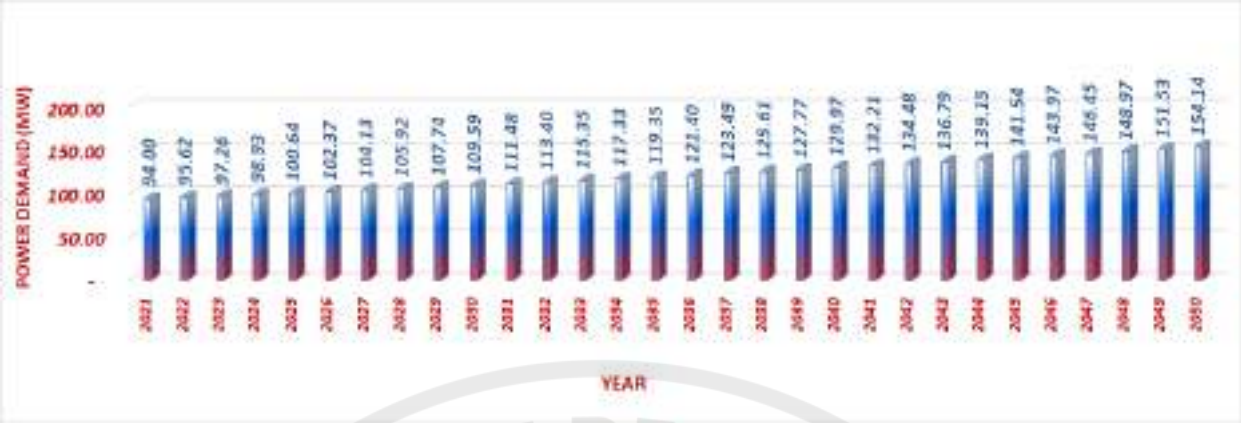


**Figure 2-30 Power Demand Forecast Skardu(2021-50)**

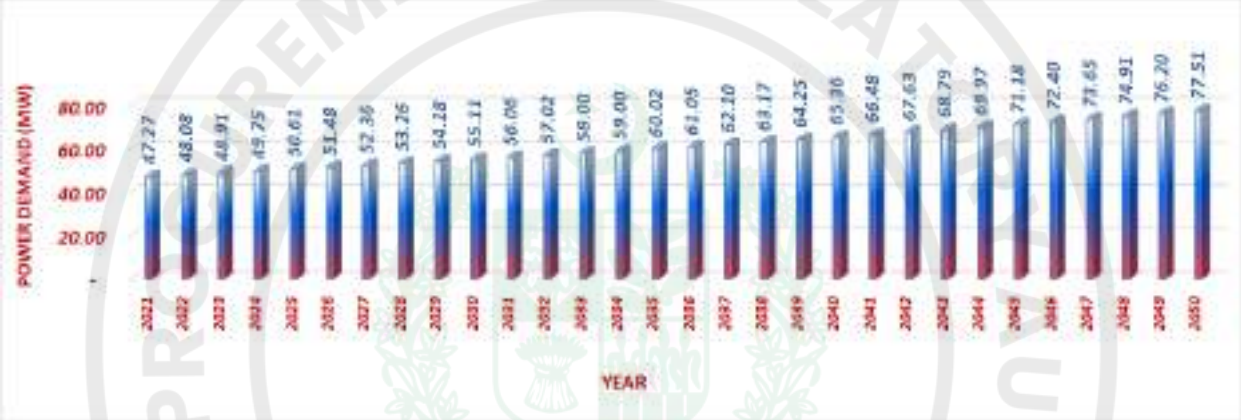


**Figure 2-31 Power Demand Forecast Ghance (2021-50)**

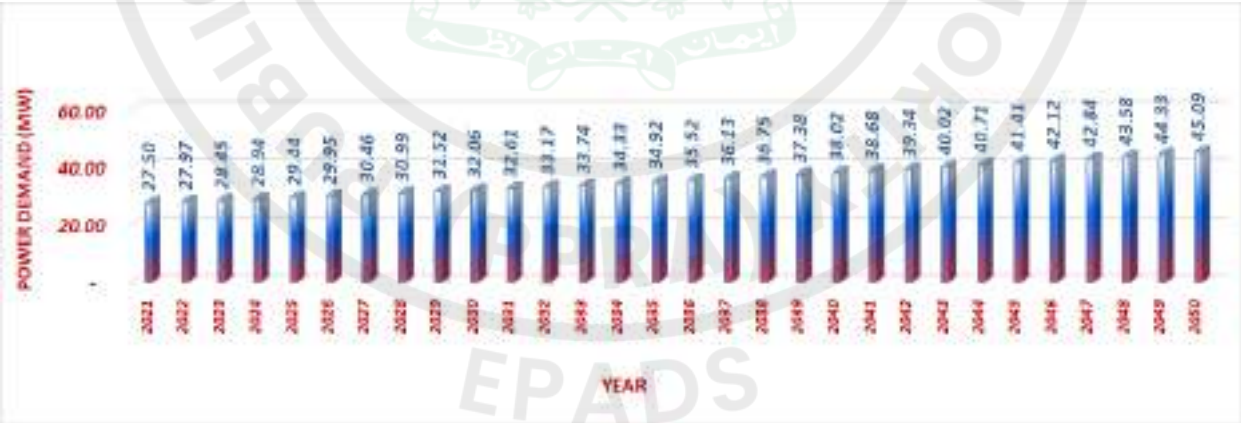


**Figure 2-32 Power Demand Forecast Shiger (2021-50)**



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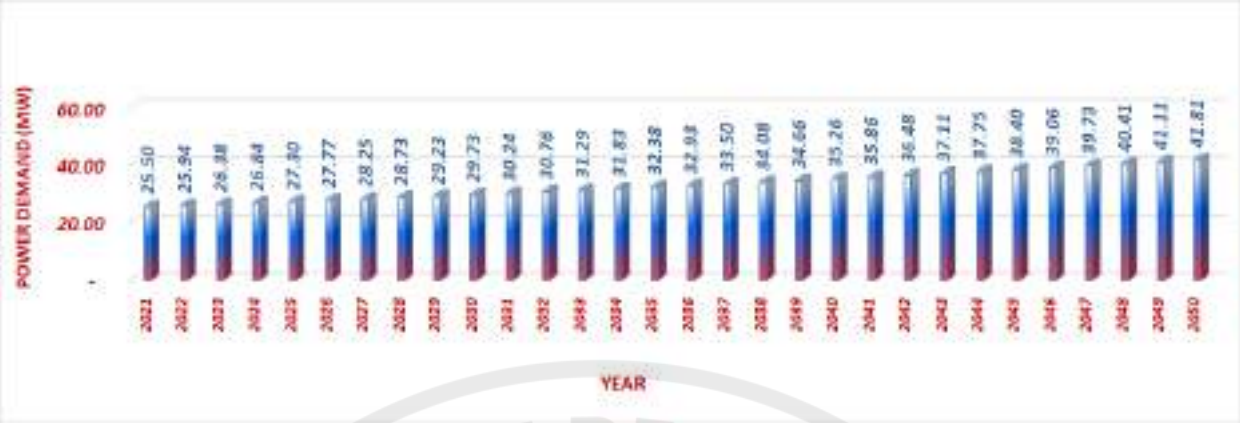


**Figure 2-33 Power Demand Forecast Kharmang (2021-50)**



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### 2.5.6 Estimated Power and Energy of Attabad Lake Hydropower Project

Attabad Hydropower Project will be constructed on Hunza River and KKH is the only way to approach the project. This route has prominence due to China-Pak Economic Corridor (CPEC), which started in Pakistan from the Khunjerab Pass. The main focus in Market survey/ load forecast is being kept on the Hunza region as power will be transmitted to Sost (Upper Hunza) and Aliabad (Central Hunza), further interconnected to the regional grid of Gilgit-Baltistan from the proposed switchyard of Aliabad and also available to supply the power to Lower Hunza and Nagar Valley as 132/66/11 Grid proposed in Sikandarabad Headquarter of Tehsil Nagar-2, Nomal and Gilgit city.

The power and energy have been estimated based on 10-day flows for all years from 1966 to 2015. For 10-Daily Power Curves, the optimum installed capacity would be 54 MW with environmental flow of 3 $m^3/s$ having mean annual energy of 373.69 GWh. The plant factor will be taken as 79 %.

The calculated annual energy, for years 1998 (average year), 2011 (wet year) and 1996 (dry year), is 375.75, 449.49 and 333.87 GWh respectively. The energy calculated based on 10 daily flows for 50 year ranges between 333.87 GWh to 449.49 GWh. A mean value of 373.69 GWh has been taken as mean annual energy. The 10 daily power and energy for average, wet and dry years are presented below.

As in average year, the installed power of 54 MW would be available for 24 hours from May to October. Peaking power (4 hours) will be available throughout the year, however, off-peak power (20 hours) will vary from 14 MW to 54 MW and will remain full from May to October. When flow reduces due to winter in November, the power generation would also reduce, however, enough flows remain available to run one turbine unit during lowest flow period as indicated in Figure 2-34.

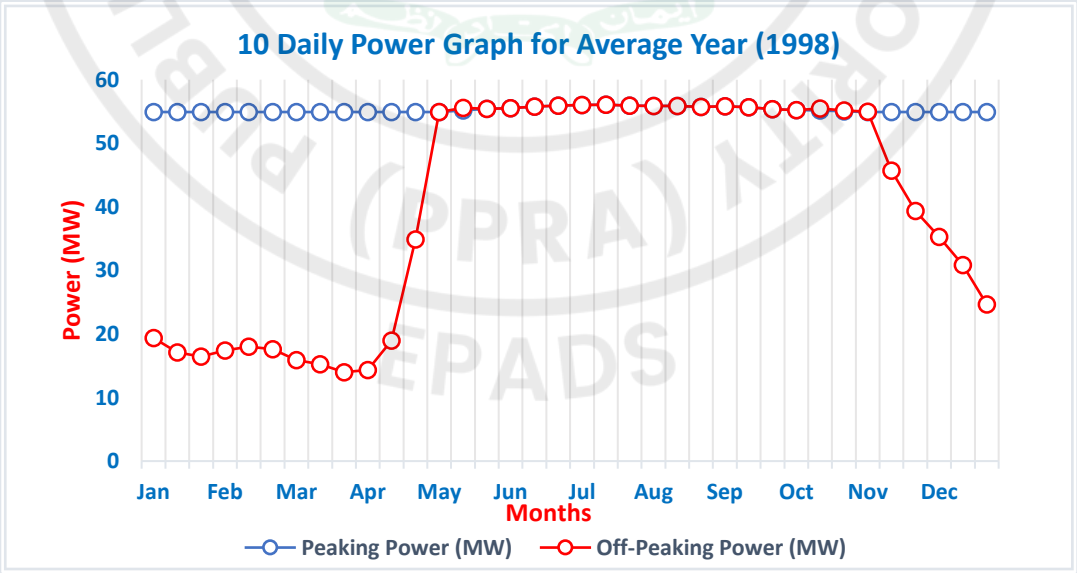


**Figure 2-34 10-Daily Power Graph for Average Year (1998)**

In wet year, installed power of 54 MW would be available from May to mid-December. Power may reach to full capacity during high flows of wet year even in February and March. In low flow period, the minimum power is estimated to remain at 20 MW as indicated in Figure 2-35.



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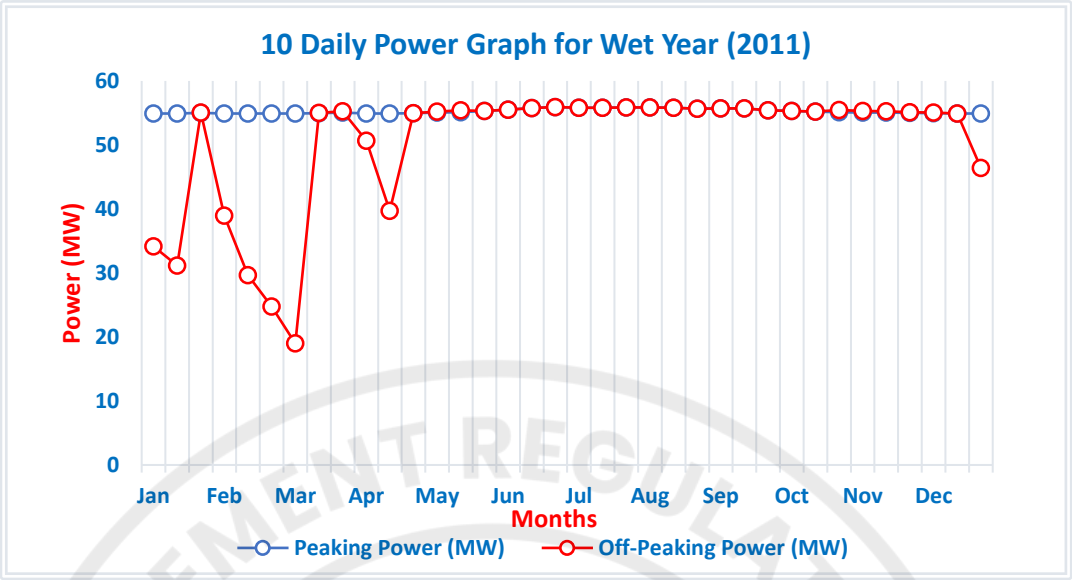


**Figure 2-35 10-Daily Power Graph for Wet Year (2011)**

In dry year, installed power of 54 MW will be available from June to mid-October and reduces as low as 9 MW when minimum flows are available. For dry year 1996, the power variation over the year is indicated in Figure 2-36.

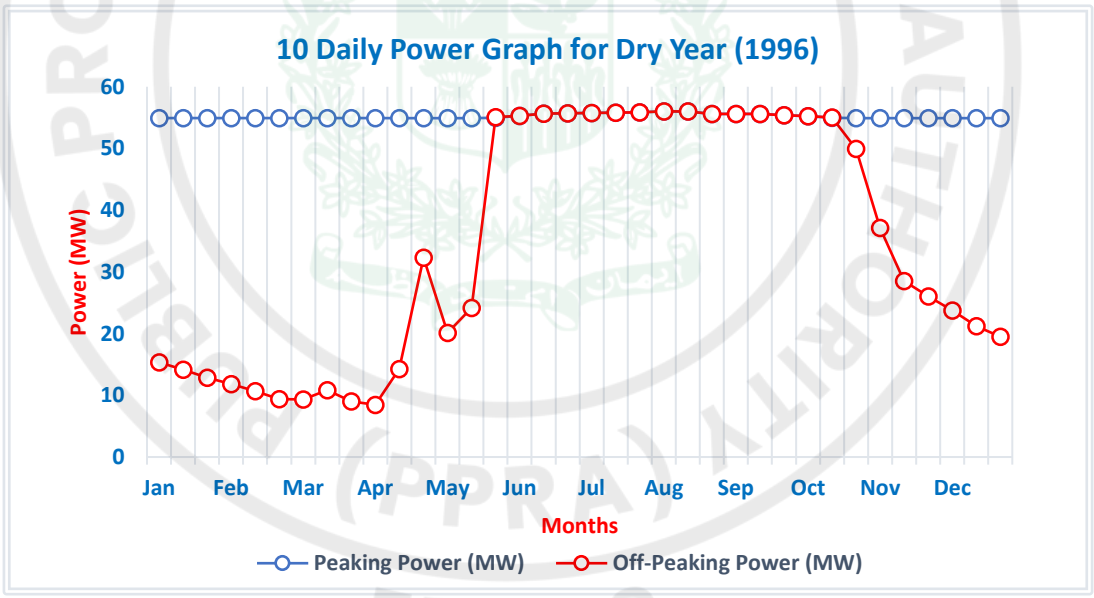


**Figure 2-36 10-Daily Power Graph for Dry Year (1996)**

The mean annual energy for the recorded period from 1966 to 2015 has been estimated and it is graphically presented in Figure 2.37. The graph indicates that the estimated annual energy over a period of 50 years does not vary much and remain quite consistent with little variation. It varies from 333.87 GWh to 449.49 GWh with mean value as 373.69 GWh. The plant factor for 54 MW power plant would be 79%. The low variation in mean annual energy and high plant factor indicate the reliability of hydropower from the lake.



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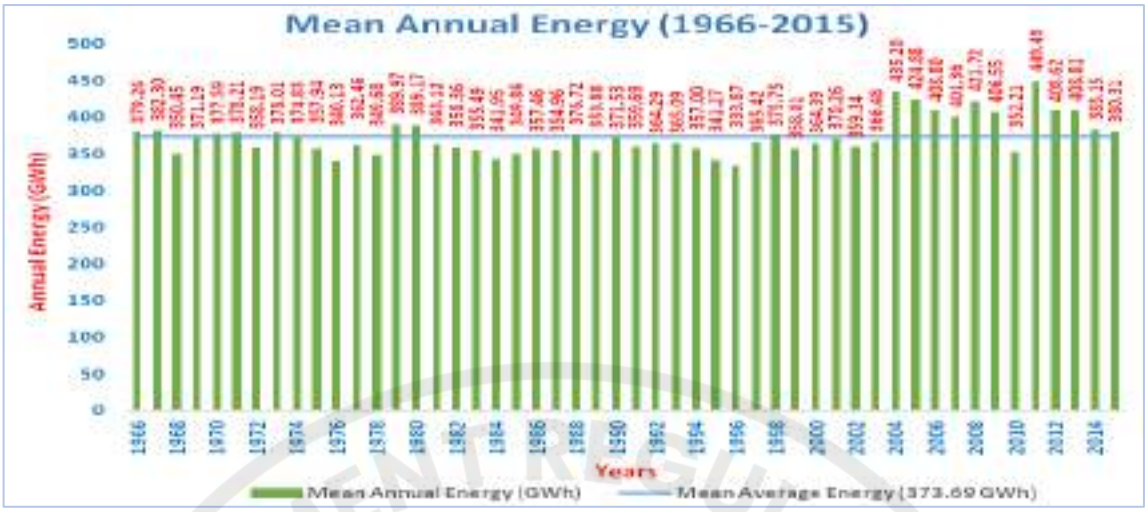


**Figure 2-37 Mean Annual Energy from (1996 to 2015)**

A comparison has also been plotted between monthly energy generations for Wet, Average and Dry years. Mean Annual Energy Curves indicate the trend of variations of monthly energies in GWh. The graph is shown at Figure 2.38.

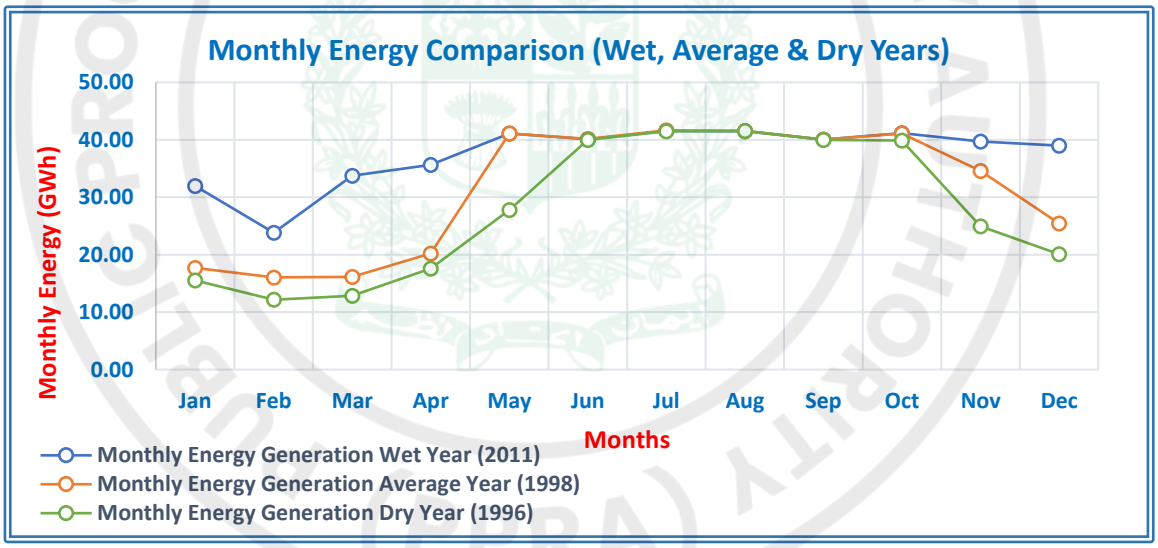


**Figure 2-38 Monthly Energy Comparison (Wet, Average & Dry Years)**



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# 3 TOPOGRAPHIC AND HYDROGRAPHIC SURVEY

## 3.1 GENERAL

Topographic survey is imperative for planning and design of engineering projects. In order to prepare the Feasibility Design of a project, the site topography obtained through survey and mapping should not only accurate but also readily available in an acceptable format for use in the next stages of the project. For this Project, initially Survey of Pakistan Maps / GT sheets on 1:250,000 & 1:50,000 scale for the Project Area have been utilized for obtaining topographic information for preliminary studies and Project Layout. This information has been used to carry out field surveys. Moreover, these GT sheets have been used to assess the catchment area of the Project for hydrological assessment.

## 3.2 TOPOGRAPHY OF THE HUNZA RIVER

Hunza River, a left bank and major tributary of Gilgit River in Gilgit Baltistan (GB), originates from the confluence of the two rivers i.e. Khunjerab River and Ghujerab River, near a tunnel about 7 km upstream of an area named Shachkatr. The Khunjerab River begins in the snow-clad mountains and glaciers in the north and south of Khunjerab Pass. The river flows to the west then turns southward. It ends when it flows into the Hunza River. The Ghujerab River starts from small glaciers and snow-topped mountains of the Ghujerab Range, and flows to the west and later joins Hunza River.

Passing through the whole Gojal Valley, Hunza River falls into Attabad Lake near Shishkat Village and again emerges from it near Attabad Village. From there, Hunza River flows through main Hunza Valley and later on discharges into the Gilgit River at Danyore Village near Karakuram International University (KIU).

The catchment area of Hunza River upstream of the Project Site is about 8,900 km² which mostly consists of glaciers and snow deposits accumulated in the mountainous region usually during winter. Hunza River cuts through the Karakoram Range and flows approx. 250 km with an average slope of 0.90% from north to south before it merges into the Gilgit River. Many large size glaciers like Batura, Passu, Ghulkin, Gulmit, Bliglong, Minapin, Hasanabad and Muchlobel Glaciers drain in Hunza River. The water from main streams including Chaprot, Hasanabad and Molma Nullahs from large as well as small valleys also drains into the Hunza River. The discharge of Hunza River has its peak in months from May to September due to melting of snow/glaciers due to rise in temperature.

The main tributaries of Hunza River include Kilik, Chapurson, Shimshal, Hispar, Bar Budalas and Naltar River. Kilik River begins in the slopes of the mountains between Mintaka and the Kilik pass and flows to the south east and ends when it empties into the Hunza River. Chapursan River begins in the area of the Chilanji Pass and the slopes of Kampiri Diwar peak. It flows to the east and joins Hunza River near Khudabad. Shimshal River begins in the Shimshal Pass from Virjirab, Yezghil and Khurdopen Glaciers. It flows to the west and after reaching near Passu it joins the Hunza River. The Hispar River forms from the melt water of the Hispar Glacier flows northwest, passing through Hispar, Hopar and Nagar villages until the confluence with the Hunza River in the Hunza Valley. Naltar River begins from the Shani Glaciers and flows along Naltar Valley in south east direction to join Hunza River.



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Hunza River is the main river of the Hunza Valley, which is a very scattered settlement with meager population, bordering with Khyber Pakhtunkhwa to the west and the Xinjiang Region of China to the north-east. It is surrounded by high peaks namely Rakhaposhi, Hunza, Darmyani peak, Ghenta Sar, Ultar Sar, Bojahagur Duanasir and Lady Finger peak. Karakoram Highway (KKH) (N-35) runs along the Hunza Valley, switching to the Khunjerab Pass at the border with China Xinjiang. The valley consists of three regions i.e. Upper Hunza, Central Hunza and Lower Hunza. The Upper Hunza (Gojal) is beautiful valley starts from Attabad Lake and extends to Misgar, Shimshal and Chapurson (border areas). Gulmit Village is capital city of upper Hunza and Sost is important village for commercial purposes. KKH runs from this region of Hunza and exit to neighboring country China, at Khunjareb Pass and from Chapurson Wakhan Corridor. Central Hunza is most populous Region of Hunza starts from village Murtazabad and ends at Attabad. Lower Hunza starts from a village Khizirabad and ends at Nasirabad. The Nasirabad's location on KKH makes it as a centre village of Lower Hunza. KKH enter into this Region on the first bridge of Hunza, at Nasirabad from Nagar Valley.

## 3.3 ATTABAD LAKE

In January, 2010, Attabad Lake was formed due to massive landslide near Attabad Village. The landslide disaster resulted in blockage of flow of Hunza River, complete submergence of Ainabad & Lower Shishkat Villages and partial flooding of Gulmit Village, displacement of population and submergence of about 19 km section of Karakoram Highway (KKH) along left bank of Hunza River. As the Hunza River backed up, the lake extended 22 km upstream and rose to a depth of 120 m. An open cut spillway 415 m long, 60 m wide and 54 m deep was constructed on the landslide mass by Frontier Works Organization (FWO) to pass flow of Hunza River over the spillway and to avoid further backing up of Hunza River in upstream Valley.

The Lake is surrounded with towering mountains on both sides and is now one of the main attractions in Hunza valley that leads to the tourism. KKH passes through 05 road tunnels (07 km long) on its left bank. The length of Attabad Lake varies from 9 km to 12 km depending upon the variation of summer and winter flows of Hunza River.

**Figure 3-1: A view of Attabad Lake**



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## 3.4 PROJECT AREA

ALHPP is proposed on Attabad Lake along N-35 (KKH) in Hunza Valley. The Project Area generally comprises of loose material and fragmented terrain along the right bank of Hunza River whereas left bank is stable. The weir site has been proposed at existing spillway of Attabad Lake. The powerhouse site is about 2.5 km downstream of the Weir site, along the left bank of Hunza River.

## 3.5 ACCESSIBILITY

### 3.5.1 Roads Network

The Project is accessible from main cities of Pakistan, primarily Islamabad and Gilgit along the existing N-35 (KKH). KKH starts at Hassanabdal and passes through KPK and the GB and terminates at Khunjerab Pass in the Karakoram Range on the Pakistan – China border:

The route through KKH can also be alternatively accessed via Motorways from Islamabad to Burhan Interchange near Hassanabdal (M-1 Islamabad-Peshawar Motorway – 44 km) and from Burhan Interchange to Thakot (M-15 Hazara Motorway – 180 km). From there, the access onward to Gilgit and Hunza continues as a part of Karakuram Highway (Thakot to Gilgit – 390 km; Gilgit to Attabad Lake/Hunza along Hunza River – 120 km).

There is another route from Islamabad to Gilgit and Hunza via Babusar Pass, through National Highway (N-15). This route is although shortest than KKH through Besham, to reach upto Chilas but it usually remains closed for six months in a year due to heavy snowfall during the winter season. The road distances from various places within Project Area and other parts of country are tabulated in **Table 3-1:**

**Distances of Important Places from Project Area**

| Sr. No. | Project Vicinity | | Outside Project Area | |
|---|---|---|---|---|
| | Place | Distance (km) | Place | Distance (km) |
| 1 | Passu | 36 | Khunjerab | 150 |
| 2 | Hussaini | 25 | Gilgit | 120 |
| 3 | Gulmit | 18 | Chilas | 240 |
| 4 | Shishkat | 15 | Babusar Pass | 275 |
| 5 | Sarat | 03 | Besham | 450 |
| 6 | Salmanabad | 3.5 | Islamabad | 735 |
| 7 | Karimabad | 15 | Lahore | 1,100 |
| 8 | Aliabad | 20 | Karachi | 2,300 |

### 3.5.2 Airport and Air Link

Gilgit Airport is the nearest facility to the Project Area. The Gilgit Airport is about 120 km from the Project Site. Domestic flights from Islamabad airport are schedule for Gilgit on daily basis but viability of the flight depends upon the weather conditions persisting there. Recently, flights from Lahore and Karachi are also operational to Gilgit Airport.

### 3.5.3 Project Layout

The weir site has been proposed at existing spillway of Attabad Lake alongwith sediment flushing structure. Water will be diverted to powerhouse through power intake, low pressure



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headrace tunnel, surge tank and penstock on the left bank. The coordinates of weir & powerhouse sites are listed below:

| Site | Easting (m) | Northing (m) |
|---|---|---|
| Weir | 484036.834 | 4018143.837 |
| Powerhouse | 481645.920 | 4017963.719 |

The proposed overflow weir / ungated spillway is 60 m wide overflow and a sediment flushing channel / undersluice 19 m wide on its left site. The powerhouse site is about 2.5 km downstream of the proposed overflow weir / ungated spillway along the left bank of Hunza River.

A design discharge of 60 $m^3/s$ will be diverted towards the powerhouse through intake left bank waterway located upstream of overflow weir / ungated spillway. A 2.32 km long low pressure headrace tunnel having a diameter of 5.5 m would run along the left bank leading to a 10 m wide and 45 m high surge tank. From there, a 470 m long embedded steel penstock with 3.6 m diameter would be laid over the left bank slopes leading down to the surface powerhouse to generate 54 MW with 03 Francis turbines. From powerhouse, a 20 m long tailrace channel leading from each generation unit will discharge water back into the Hunza River.

The **Photographs 3.2, 3.3 & 3.4** presents a view of existing spillway of Attabad Lake, proposed intake, surge tank & powerhouse areas.

**Figure 3.2: Spillway Area (Looking Upstream)**



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**Figure 3.3: A view of Intake Area**

**Figure 3.4: A view of Surge Tank and Powerhouse Area**

## 3.6 TOPOGRAPHIC SURVEY

### 3.6.1 Available Topographic Information

Topographic information of the Project Area available at the beginning of the Study for the ALHPP comprised the following Survey of Pakistan (SoP) Maps:



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GT Sheet 42-L with scale 1:250,000.

GT Sheets 42-L/11 and 42-L/15 with scale 1:50,000 (**Photo 3.5**).

These maps have been used in the preliminary project assessments e.g. to develop the general project layout to estimate the catchment area, study of topographical and geological features etc.

In addition to the study of Survey of Pakistan Maps, the Satellite based survey data has also been utilized to get first-hand information regarding the topography and contours of the Project Area. Additionally, a comprehensive terrestrial survey program was setup and executed by Survey Division Peshawar, HPO WAPDA equipped with state of the art equipment and experienced staff. The corresponding activities have been carried out in accordance with the requirements of the scope of work.

This section describes the topography of the Project Area, applied methodology, description of control points & benchmarks carried out during the Feasibility Study and the results of the topographic survey.

### 3.6.2 Scope of Work

For the development of an adequate Topographical Maps for ALHPP, depicting the existing features both natural and man-made and specific land areas with ground levels, the following major activities have been carried out:

- Setup a Project trigonometric network with a system of Benchmarks.
- Terrestrial survey of the area of Project components about 400 hectares at scale 1:1000 with contour interval of 2 m, covering 4 km downstream of weir site along Hunza River.
- Longitudinal profile of Hunza River, 4 km downstream from weir site.
- Terrestrial survey of valley cross sections along Hunza River, 4 km downstream of weir site at an interval of 200 m, covering the main river course and valley slopes upto 200 m on either side.
- Terrestrial survey of borehole locations.
- Satellite based survey of the Project Area



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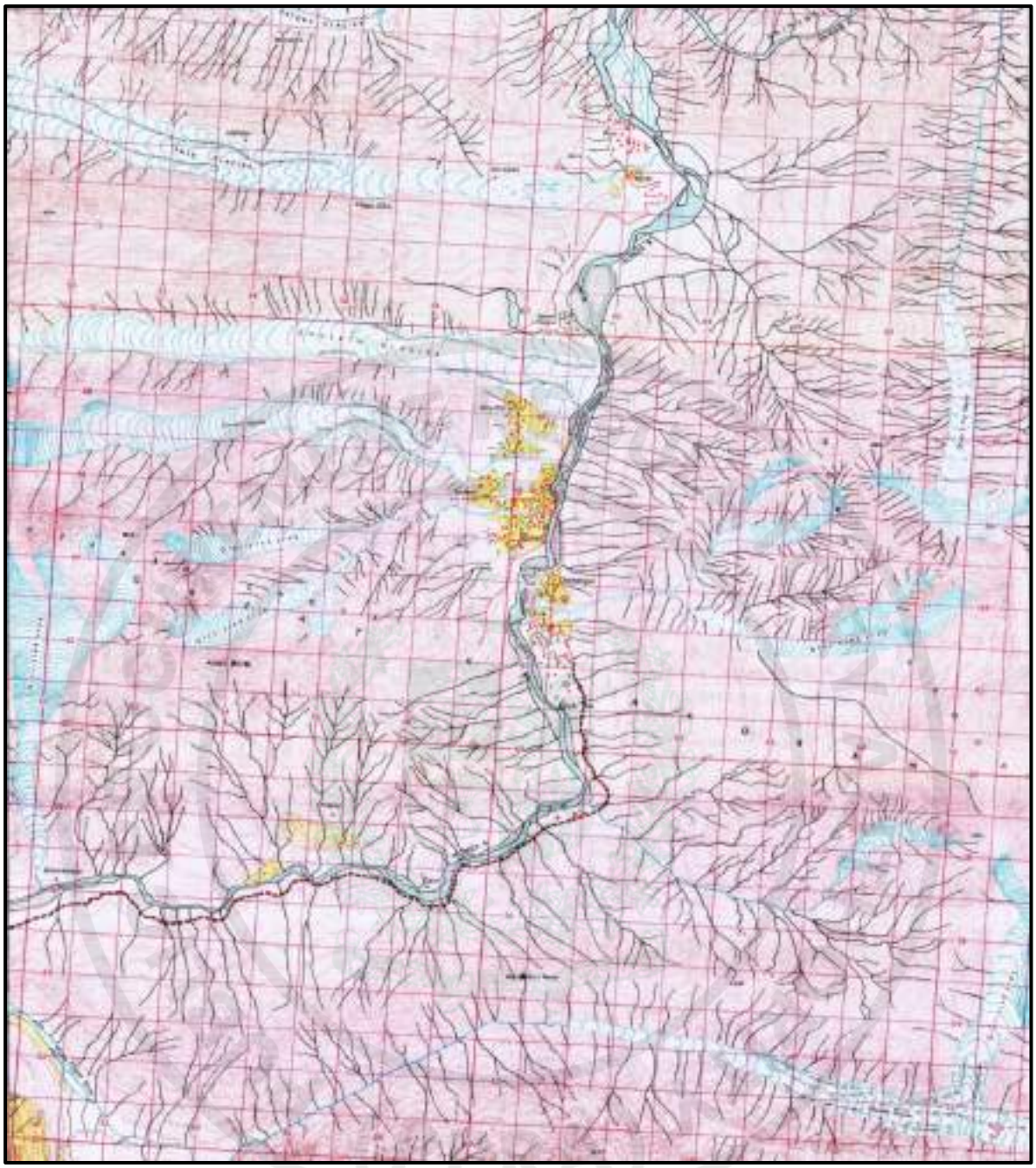

**Figure 3-5 Map Section of Survey of Pakistan Sheet 42-L/15**

### 3.6.3 Survey Standards and Requirements

All the survey work for the Feasibility Study of ALHPP has been conducted in accordance with the minimum Performance Standards and in line with the Survey Standards of Survey of Pakistan (SoP) in terms of “Accuracy and Precision”. The Survey Standards and Pre-requisites to be observed during the survey work are as under:

#### 3.6.3.1 General

The horizontal and vertical geodetic system to be introduced for the ALHPP based on Survey of Pakistan. Installed permanent stations, control points; traverse points etc. referred to those co-ordinates and elevations. To avoid unnecessary, long traverse lines control points have been established and determined as close as possible to the individual survey sites. Control points



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referred directly to control points of the Survey of Pakistan and determined by traverses or triangulation or any combination of them.

Traverse lines started and close at the nearest control points of the Survey of Pakistan at pre-installed and surveyed control stations. Permanently marked traverse points at interval of about 1 km. However, as many as possible fixed points shall be permanently marked out in the Project Area for later reference. All fixed points-control stations, permanent traverse points, benchmarks be marked by cast in bolt or steel pin for centering and elevation reference. The station with their designation be made clearly visible in the filed by enamel paint for easy identification.

#### 3.6.3.2 Triangulation

In the chosen system all horizontal and vertical angles and all inclined distances have to be observed directly. The horizontal and vertical angles must be observed in three complete rounds. The mean of the rounds not exceed 2". Inclined distances must be measured directly, in both fore-sighting and back sighting directions.

Total stations with a standard deviation for angle measurement of +1" and for distance measurement of +2mm+2ppm has been employed. For each point, station compensation has been carried out. The closing error of triangles with station compensated angles has not exceeded 5". The inclined measured distances shall be reduced to the horizontal by the reciprocal-calculation method taking into consideration refraction and earth curvature. The same has to be employed for trigonometrically calculated differences of height.

#### 3.6.3.3 Control Points Determination

For the determination of control points by traverses total station with a standards deviation for angle measurement for +1" and for distance measurement of +2mm+2ppm shall be employed. The horizontal angles shall be observed in two complete rounds with a mean of not exceeding 8". Distance shall be measured in fore-and back-sight directions.

All traverses shall be connected and closed to co-ordinate points of the Survey of Pakistan (SOP). To minimize set-up errors, the forced centering method has been applied. The closing errors shall be distributed according to common survey standards. For closed-traverse lines the allowable error shall be:

- Horizontal-angle closing $\pm 2" \sqrt{N}$
- Where "N" is the number of traverse stations distance closing $\pm 0.05\ m \sqrt{Dkmt}$
- Where "D" is the total distance of traverse line (in km).

#### 3.6.3.4 Technimetrics Traverses

Technimetrics traverses necessary for the connection of the topographic area and section surveys at the powerhouse site has been carried out by total stations. All tachometric traverses have been closed to prior coordinated stations and their closing errors distributed.



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The closing errors shall not be larger than:

| | |
|---|---|
| Horizontal-angle closing | $\pm$1" $\sqrt{N}$ |
| Where "N" is the number of traverse stations. | |
| Distance | $\pm$ 1.0 m $\sqrt{Dkm}$ |
| Where "D" is the total distance of the line (in km) | |
| Height | $\pm$ 0.2 m $\sqrt{Dkm}$ |
| Where "D" is the total distance of the line (in km) | |

### 3.6.3.5 Precise Leveling

For precise leveling, SOP level with plan-parallel plate, with at least a count of 0.1 mm, or equivalent digital leveling instruments has been employed, using invar-leveling staffs. All leveling loops have been leveled in fore and back directions. Special care has to be taken that the distances of back and fore-sights are equal and not longer than 30 m. All back and fore-sight distances have to be recorded. No intermediate readings have been taken.

| | |
|---|---|
| Pf error has to be allowable error | $\pm$1.0 mm $\sqrt{Dkm}$ |
| Where "D" is the total length of the line | |

The distribution made proportional to the length of the sights.

### 3.6.3.6 Ordinary Leveling – 3rd Order

All the lines have been surveyed in fore and back sight directions. It have been aimed that distance for back and fore sights do not differ very much. Intermediate observations to bench marks have been avoided. All level loops have been started, connected and compensated to prior determined benchmarks. The accuracy for survey have been shall be:

| | |
|---|---|
| Between fore and back-leveling | (6 $\sqrt{Dkm}$) mm |
| Loop between two bench marks | (2+6 $\sqrt{Dkm}$) mm |

Where "D" is the total length of the line (in km)

The error distribution is to be made either proportional to the length of the sight or to the number of instrument settings.

## 3.7 METHODOLOGY APPLIED TO THE TOPOGRAPHIC SURVEY

For the topographic survey of ALHPP, the following two approaches have applied comprising:

- Conventional terrestrial survey used for detailed topographic maps with high accuracy.
- Satellite based survey used for overview project maps:
- Google Earth Method.
- Geographic Information System (GIS) Method.



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The following surveying works have been carried out during the Feasibility Study:

Establishment of ground control points;

- Terrestrial survey works of weir and powerhouse site covering Project components including weir & sediment flushing channel, power intake, power tunnel, surge tank, penstock, powerhouse and tailrace area;
- Longitudinal profile of Hunza River;
- Terrestrial survey works of valley cross sections along Hunza River;
- Survey of locations of bore holes;
- Development of Topographic Maps at the required scales.
- Development of Digital Elevation Model (DEM) based on high resolution satellite images.

### 3.7.1 Reference System

In order to start the topographic field survey work, the reference grid of Survey of Pakistan (SOP) is required to be connected. However, there was no standard Benchmark (BM) established by SOP in the vicinity of Project Area and its surroundings. Due to the non-availability of the SoP BM, the reference BM has been established in the Project Area by using Differential Global Positioning System (DGPS).

The benchmarks established through DGPS have been verified with the Total Station. The terrestrial survey of the Project Area has been carried out with reference to these benchmarks to prepare topographic features of ALHPP.

### 3.7.2 Instruments Used

The terrestrial topographic survey has been conducted using Electronic Total Stations. The conditions of the survey instruments have been checked prior survey to ensure high accuracy of the record data. The following instruments have been used for the terrestrial survey works:

- Topcon Total Station W 0303.
- Trimble R8s GNSS.

### 3.7.3 DGPS Survey of Project's Reference Points

The surveying campaign commenced in the early stage of the Feasibility Study in August, 2020. Due to non-availability of the SOP BM as a reference point, it has been decided to use the DGPS-Receiver called Trimble R8s to establish reference points at Project Site. 03 locations have been identified, making triangulations.

The starting point established over a pre-constructed BM along old Karakoram highway, 190 m upstream of SCOM office located near Tunnel-1 inlet. This BM has been named as BM-1 and the receiver has set as "Base Station" at BM-1 for longer duration in static mode of observation, to collect its coordinate data.



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For the static surveying, Trimble R8s receiver is capable of giving the following accuracy:

- Horizontal 3 mm + 0.1 ppm RMS
- Vertical 3.5 mm + 0.4 ppm RMS

Keeping the “Base Station” in observation mode, another receiver “Rover” has moved to other two points i.e. BM-2 & H-35, one by one for 60 minutes to collect coordinate data. To receive the signals from satellite, it has been ensured that both the receivers have minimum obstructions like building, trees, power lines etc. The signals have received at minimum cut of angle of 15° or more. The Base Station receiver measured the errors in the GPS signals and transmitted the corrections to the Rover receiver.

The data from both the Base Station and Rover receiver then downloaded for processing and conversion from grid to ground parameters. The accuracy achieved in the DGPS survey of reference points was 50 cm. The values of these established reference points verified by the survey team using Total Station through triangulation. The coordinates and elevation of reference points BM-1 & BM-2 have further been used as Project’s Permanent Reference BM to start the survey activities in the Project Area.

**Figure 3-2 Survey of Project’s Permanent Reference Benchmark BM-1**

## 3.8 TERRESTRIAL TOPOGRAPHIC SURVEY OF PROJECT AREA

During the survey campaign, the survey of Project Area covering all the Project components, Valley Cross-Sections and Longitudinal Profile along Hunza River has been conducted as specified in the scope of work, to provide reliable data for the study of Project Layout.

The terrestrial survey work has been carried out by two experienced survey teams of Survey Division Peshawar, WAPDA. In the course of Feasibility Study, a comprehensive terrestrial survey has been conducted to achieve topographic information to the required level. One of the



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major objectives is the elaboration of detailed topographic maps at scale 1: 1,000 with contour interval of 2 m of the area of the project structures as specified in the scope of work.

The terrestrial survey works carried out comprise weir and powerhouse site, covering the project components:

- Overflow Weir & Sediment Flushing Channel.
- Power Intake.
- Low Pressure Headrace Tunnel.
- Surge Tank.
- Penstock.
- Powerhouse.
- Tailrace Channel.

The terrestrial survey of Project Area has been completed in September, 2020. The 02 number concrete monuments BM-1 & BM-2 form the basis for a new triangulation system. All the terrestrial surveyed areas tied into the Project's Permanent Reference Benchmarks i.e. BM-1 & BM-2 near weir and powerhouse site.

**Figure 3-3 Terrestrial Topographic Survey in progress**

### 3.8.1 Horizontal Control

The horizontal control has been done through a combination of triangulation and traversing method supported by the use of reference points established through DGPS. All the survey



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work conducted with digital display infrared beam Total Station. The triangulation network consists of well balance quadrilaterals or center point polygons and also well balance triangles.

The traversing has been in the closed loop form. All traversing lines measured in two directions (forward and backward) and mean value has been used. The linear measurement units used in the survey work and mapping work are metric and the angular measurement in degree, minutes and seconds of arc.

### 3.8.2 Vertical Control

The Reference Datum i.e. the mean sea level established by SOP was not available in the vicinity of Project Area; therefore, the vertical control datum of Project's Permanent Reference Benchmark BM-1 has been used as the reference datum and utilized in survey of the Project Area.

### 3.8.3 Traverse Survey

Before carrying out the topographic survey, a traversing network for the project was prepared. It included a plan of the temporary benchmarks / control points network across the project. The traverse survey started from reference points established through DGPS i.e. BM-1 & BM-2. The accuracy of horizontal control has been achieved with traversing using total station. With traversing, sixty eight (68) traverse stations / control points have been established by the survey team in the entire area of interest to acquire the field survey data in digital format.

The traverse stations / control points have been established on the available rocks and existing drainage structures such as culverts in the project area by marking with engraved circle or triangle and a nail driven or engraved dot at the center of either mark. All the traverse stations / control points were properly labeled with red paint.

Survey Division Peshawar, WAPDA also conducted closed loop survey which connects the traverse between the control points with the permanent benchmarks used for the survey works for the ALHPP.

Control network diagram is presented in **Figure 3.8** and the list of traverse stations / control points is given in **Table 3-1**.

**Table 3-1 Traverse Station / Control Points Coordinates**

| Sr. No. | Point ID | Easting (m) | Northing (m) | Elevation (m.a.s.l) |
|---|---|---|---|---|
| 1 | H1 | 481219.010 | 4017664.199 | 2395.493 |
| 2 | H2 | 481316.503 | 4017685.054 | 2401.955 |
| 3 | H3 | 481234.627 | 4017720.891 | 2404.297 |
| 4 | H4 | 481208.544 | 4017700.529 | 2396.713 |
| 5 | H5 | 481207.521 | 4017649.336 | 2394.247 |
| 6 | H6 | 481155.351 | 4017596.546 | 2390.609 |
| 7 | H7 | 481067.386 | 4017555.005 | 2387.171 |
| 8 | H8 | 481366.571 | 4017758.322 | 2392.405 |
| 9 | H9 | 481507.726 | 4017724.318 | 2381.848 |
| 10 | H10 | 481641.130 | 4017625.234 | 2400.877 |
| 11 | H11 | 481723.047 | 4017643.665 | 2398.740 |



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| Sr. No. | Point ID | Easting (m) | Northing (m) | Elevation (m.a.s.l) |
|---|---|---|---|---|
| 12 | H12 | 481754.223 | 4017702.743 | 2362.396 |
| 13 | H13 | 481937.494 | 4017821.742 | 2361.025 |
| 14 | H14 | 482112.760 | 4017983.292 | 2360.351 |
| 15 | H15 | 481877.785 | 4018005.462 | 2326.289 |
| 16 | H16 | 482026.702 | 4018092.896 | 2322.609 |
| 17 | H17 | 481936.766 | 4018078.820 | 2326.115 |
| 18 | H18 | 481733.176 | 4017959.549 | 2319.386 |
| 19 | H19 | 481459.525 | 4017895.827 | 2314.159 |
| 20 | H20 | 481393.770 | 4017994.438 | 2309.371 |
| 21 | H21 | 481513.855 | 4018067.421 | 2326.376 |
| 22 | H22 | 481678.359 | 4017799.827 | 2334.528 |
| 23 | H23 | 481874.743 | 4017894.523 | 2335.437 |
| 24 | H24 | 482338.056 | 4018023.919 | 2358.811 |
| 25 | H25 | 482115.210 | 4017956.484 | 2373.939 |
| 26 | H26 | 481546.606 | 4018136.405 | 2330.802 |
| 27 | H27 | 481511.528 | 4018209.542 | 2337.769 |
| 28 | H28 | 482583.422 | 4017872.307 | 2354.598 |
| 29 | H29 | 482762.508 | 4017925.426 | 2364.108 |
| 30 | H30 | 482962.406 | 4018027.410 | 2372.087 |
| 31 | H31 | 483285.338 | 4018027.670 | 2407.801 |
| 32 | H32 | 483292.996 | 4018113.798 | 2410.373 |
| 33 | H33 | 483362.495 | 4018089.701 | 2415.424 |
| 34 | H34 | 483404.048 | 4018082.722 | 2424.795 |
| 35 | H35 | 483614.843 | 4018068.728 | 2488.864 |
| 36 | H36 | 483693.079 | 4018030.816 | 2516.953 |
| 37 | H37 | 483326.100 | 4018033.572 | 2410.711 |
| 38 | H38 | 483560.133 | 4018147.964 | 2410.505 |
| 39 | H39 | 483686.987 | 4018185.536 | 2424.069 |
| 40 | H40 | 483761.281 | 4018168.847 | 2429.451 |
| 41 | H41 | 483870.869 | 4018145.434 | 2432.829 |
| 42 | H42 | 483906.838 | 4018135.625 | 2432.418 |
| 43 | H43 | 483737.347 | 4018080.162 | 2501.220 |
| 44 | H44 | 483734.333 | 4018090.725 | 2495.450 |
| 45 | H45 | 483830.176 | 4017982.229 | 2512.200 |
| 46 | H46 | 483944.550 | 4017876.574 | 2506.413 |
| 47 | H47 | 483981.604 | 4017859.367 | 2495.696 |
| 48 | H48 | 484015.395 | 4017905.324 | 2489.082 |
| 49 | H49 | 484041.794 | 4017964.620 | 2478.943 |
| 50 | H50 | 484004.629 | 4017954.352 | 2486.987 |
| 51 | H51 | 482167.582 | 4017890.217 | 2408.422 |
| 52 | H52 | 482249.332 | 4017903.423 | 2411.156 |
| 53 | H53 | 481724.009 | 4017598.961 | 2399.555 |
| 54 | H54 | 481544.398 | 4018247.745 | 2353.586 |



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| Sr. No. | Point ID | Easting (m) | Northing (m) | Elevation (m.a.s.l) |
|---|---|---|---|---|
| 55 | H55 | 481352.229 | 4018204.355 | 2367.864 |
| 56 | H56 | 481165.994 | 4018143.351 | 2376.892 |
| 57 | H57 | 482121.169 | 4018482.184 | 2359.034 |
| 58 | H58 | 482316.677 | 4018427.092 | 2364.145 |
| 59 | H59 | 482577.583 | 4018307.879 | 2378.900 |
| 60 | H60 | 481182.345 | 4018060.014 | 2362.644 |
| 61 | H61 | 484078.421 | 4017922.132 | 2473.744 |
| 62 | H62 | 484080.523 | 4017847.832 | 2471.363 |
| 63 | H63 | 484108.774 | 4017936.913 | 2459.167 |
| 64 | H64 | 484158.301 | 4017963.964 | 2439.110 |
| 65 | H65 | 484149.613 | 4017961.179 | 2441.517 |
| 66 | H66 | 484161.563 | 4018032.721 | 2418.575 |
| 67 | H67 | 484029.993 | 4018100.567 | 2428.459 |
| 68 | H68 | 483963.947 | 4018121.981 | 2432.581 |



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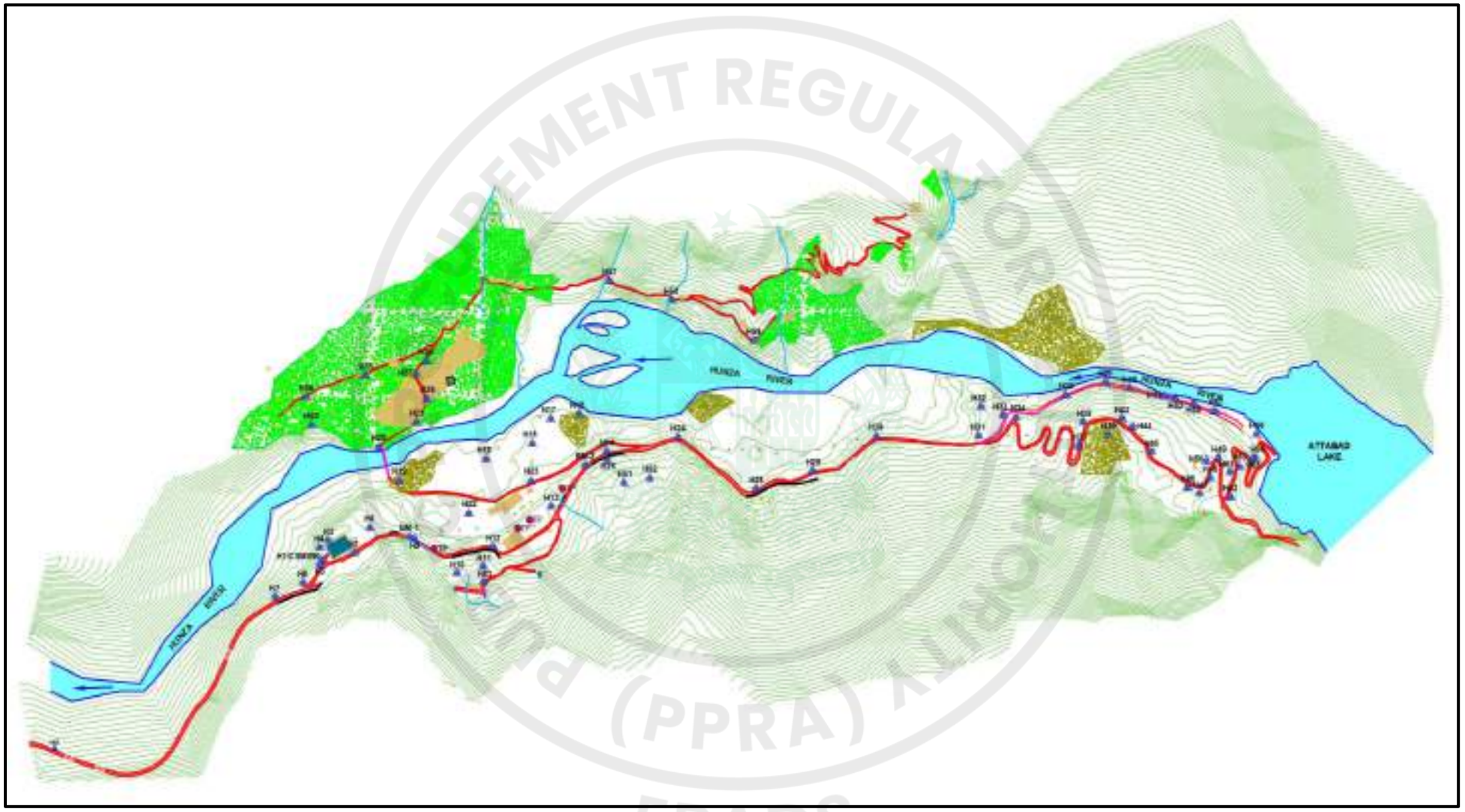


**Figure 3-4 Control Network Diagram**



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### 3.8.4 Survey of Weir and Powerhouse Site

The terrestrial survey at the Weir and Powerhouse site was performed based on a temporary benchmarks / control points network which were tied to the two reference points i.e. Project's Permanent Reference Benchmarks BM-1 & BM-2, located about 2.8 km & 2.1 km downstream of the Weir site respectively along the old Karakoram highway.

The survey works performed at Weir site covers an area of overflow weir and sediment flushing section, power intake and headrace tunnel area. The survey works performed at Powerhouse site covers an area of powerhouse itself, surge tank, penstock and tailrace channel. The survey of Weir and Powerhouse site covers part of valley slopes on left and right bank of the Hunza River.

### 3.8.5 Survey of Valley Cross Sections and Longitudinal Profiles

During the survey campaign, the Survey Division Peshawar, HPO, WAPDA conducted a detailed terrestrial topographic survey of valley cross sections and longitudinal profile along Hunza River. The valley cross sections covers upto 4 km downstream Hunza River reach from the weir axis. The valley cross-sections taken at an interval of 200 m. The surveyed data of each cross-section includes left and right valley slopes down to the water level of the Hunza River. The topographic survey of these cross-sections have been conducted based on temporary benchmarks / control points network which have been tied to the two Project's Permanent Benchmarks i.e. BM-1 & BM-2.

The longitudinal water profile of Hunza River, 4 km downstream of weir axis has been surveyed to establish the river drop. The water levels are taken on the left bank of the river.

### 3.8.6 Survey of Locations of Geotechnical Investigations

As part of the geotechnical field investigation program of 06 boreholes core drilling and 08 test pits have been carried out for geological investigation. The location of the boreholes and test pits has been based on temporary benchmarks / control points network tied to the two Project's Permanent Benchmarks i.e. BM-1 & BM-2. The borehole and test pits locations have been marked at major project components prior to start of drilling work.

In some cases, platforms have erected for safe installation of the drilling rig in sloped terrain. Therefore, the recorded ground level of the borehole may deviate from the elevation of natural ground upto 5m.



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## 3.9 RESULTS OF TERRESTRIAL TOPOGRAPHIC SURVEY

### 3.9.1 The Attabad Lake Hydropower Project's Reference System

The reference system of the ALHPP is based on Differential Global Positioning System (DGPS). The results of all terrestrial topographic surveys are tied to the reference points i.e. Project's Permanent Benchmarks established in the Project Area through DGPS.

### 3.9.2 Benchmarks of Attabad Lake Hydropower Project

Due to non-availability of SOP BM in the vicinity of Project Area, the DGPS based Project's Permanent Benchmarks are established in the Project Area, comprising of 02 concrete monuments (BM-1 & BM-2) covering the Project Area. The two monuments were newly constructed at carefully selected sites to meet the demands of the project.

The new constructed concrete monuments are of rectangular shape and painted in white colour with their nominations indicated in red colour at two sides**.** On top of the monument a steel bolt is incorporated into the massive concrete. This steel bolt is the reference point of the monument. For protection of the steel bolt from mechanical damage the bolt is placed in a hole of the monument some 5 cm below the top.

**Table 3.2** provides detailed information alongwith the corresponding photographic images about the individual monuments of ALHPP.

**Table 3-2 Permanent Benchmarks in the Project Area**

| Name | Easting (m) | Northing (m) | Elevation (m.a.s.l) | Description |
|---|---|---|---|---|
| BM-1 | 481492.694 | 4017731.980 | 2384.000 | Along old Karakoram highway, 190 m upstream of SCOM office building located near Tunnel-1 inlet. |
| BM-2 | 482045.533 | 4017941.757 | 2360.841 | 697 m upstream of BM-1 along old Karakoram highway. |



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### 3.9.3 Detailed Topographic Maps

The results of the survey campaigns have been processed to elaborate corresponding topographic maps of the Project Area. The contour lines have been interpolated using the survey software “Eagle Point”. Further the observed data has been digitized in the AutoCAD software. The digitization of the features has been done by creating the feature layers in the software. The different layer features have the unique colour and symbols so that they can be easily well distinguished from the other feature.

In the detailed terrestrial survey, natural and man-made structures were recorded. The main features that have been recorded in the topographic survey of the Project area are:

- Slided area at the right bank of Hunza River near weir site
- Rock outcrop at the power intake area.
- Section of Old KKH downstream of Attabad Lake.
- Access road to Sarat & Attabad village.
- Bridge over Hunza River for access to Sarat & Attabad village located some 200 m downstream of proposed powerhouse.
- Flat and boulders area at powerhouse site.
- Old Chinese Camp.
- Helipads near powerhouse area.
- Tracks, paths, road culverts, protection walls and electric poles.
- Inlet & Outlet of transportation tunnel 1.



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- Inlet & Outlet of transportation tunnel 2.
- SCOM Office Building near inlet of Tunnel 1.
- Alignment of nullahs on left and right bank of Hunza River.

Changes in slope such as roads along the hillside and at the edges of waterways have been surveyed in detail and defined as break lines for the interpolation of contour lines. The scale of the topographic maps is 1: 2,000 with 2 m contour intervals. Based on maps at that scale, all relevant design drawings of the project structure are prepared.

The survey output at scale 1: 2,000 topographic maps of the Project Area produced based on the terrestrial survey are presented in **Volume-2** (Drawings) in 20 sheets (A3 format). All features important for the Feasibility Design of the permanent Project components are included in the survey works.

### 3.9.4 Survey of Valley Cross Sections and Longitudinal Profiles

21 valley cross sections surveyed along the Hunza River at an interval of 200 m d/s of weir axis. The surveyed data of each cross-section includes left and right valley slopes (ranges from 175 m to 250 m on either side) down to the water level of the Hunza River. The **Figure 3.9** gives an overview of cross sections surveyed. The left and right end points of the cross-section are given in **Table 3.3.** The drawings of each cross section at scale 1: 2,000 are presented in **Volume-2 (Drawings)** in 10 sheets (A3 format).

The longitudinal water profile has been observed along Hunza River and is placed in **Volume-2 (Drawings)**. The longitudinal profile along Hunza River is presented in 11 sheets (A3 format) at scale 1: 1,000. The total length of longitudinal profile along Hunza River is 4.05 km and there is a drop of 142 m.

### 3.9.5 Survey of Locations for Geotechnical Investigations

The coordinates, elevations and locations of each borehole drilled at main weir, sediment flushing channel, headrace tunnel and powerhouse are given in Section-5 (Geological and Geotechnical Studies). The survey of locations of boreholes recorded in the early phase of the Project based on temporary benchmarks / control points which have been tied to the two Project's Permanent BM i.e. BM-1 & BM-2. The different spreads of control points have been established to locate the position of boreholes in the entire Project Area.



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## Table 3-3 Coordinates of Left and Right End Points of Valley Cross Sections

| | Easting (m) | Northing (m) | Elevation (m.a.s.l) | Remarks |
|---|---|---|---|---|
| 0+000 | 484077.365 | 4017941.320 | 2470 | Left |
| | 484205.810 | 4018320.698 | 2490 | Right |
| 0+200 | 483885.506 | 4017976.367 | 2502 | Left |
| | 484006.588 | 4018355.031 | 2490 | Right |
| 0+400 | 483719.739 | 4018047.813 | 2510 | Left |
| | 483785.170 | 4018391.765 | 2490 | Right |
| 0+600 | 483577.857 | 4018017.414 | 2470 | Left |
| | 483515.202 | 4018416.293 | 2470 | Right |
| 0+800 | 483299.359 | 4018076.046 | 2406 | Left |
| | 483463.127 | 4018438.753 | 2470 | Right |
| 1+000 | 483146.204 | 4018016.188 | 2380 | Left |
| | 483188.056 | 4018437.080 | 2430 | Right |
| 1+200 | 483004.758 | 4018007.143 | 2380 | Left |
| | 482954.053 | 4018407.700 | 2450 | Right |
| 1+400 | 482934.019 | 4017977.650 | 2380 | Left |
| | 482708.504 | 4018312.614 | 2364 | Right |
| 1+600 | 482479.398 | 4017897.855 | 2370 | Left |
| | 482619.378 | 4018339.828 | 2378 | Right |
| 1+800 | 482348.418 | 4018010.660 | 2360 | Left |
| | 482403.348 | 4018436.239 | 2370 | Right |
| 2+000 | 482207.685 | 4017980.708 | 2360 | Left |
| | 482155.249 | 4018462.863 | 2353 | Right |
| 2+200 | 482085.488 | 4018002.977 | 2340 | Left |
| | 481855.273 | 4018441.588 | 2343 | Right |
| 2+400 | 481984.360 | 4017916.143 | 2340 | Left |
| | 481699.521 | 4018218.715 | 2340 | Right |
| 2+600 | 481676.984 | 4017805.103 | 2334 | Left |
| | 481602.212 | 4018158.829 | 2330 | Right |
| 2+800 | 481527.774 | 4017818.831 | 2330 | Left |
| | 481351.268 | 4018134.832 | 2356 | Right |
| 3+000 | 481351.380 | 4017750.629 | 2392 | Left |
| | 481176.516 | 4018084.672 | 2364 | Right |
| 3+200 | 481190.382 | 4017674.022 | 2380 | Left |
| | 481009.968 | 4017943.860 | 2340 | Right |
| 3+400 | 481134.673 | 4017603.367 | 2370 | Left |
| | 480793.191 | 4017768.011 | 2360 | Right |
| 3+600 | 480952.946 | 4017433.204 | 2390 | Left |
| | 480733.056 | 4017620.875 | 2360 | Right |
| 3+800 | 480855.228 | 4017276.855 | 2360 | Left |
| | 480606.025 | 4017454.702 | 2360 | Right |
| 4+000 | 480561.414 | 4017119.775 | 2360 | Left |
| | 480551.091 | 4017454.839 | 2360 | Right |



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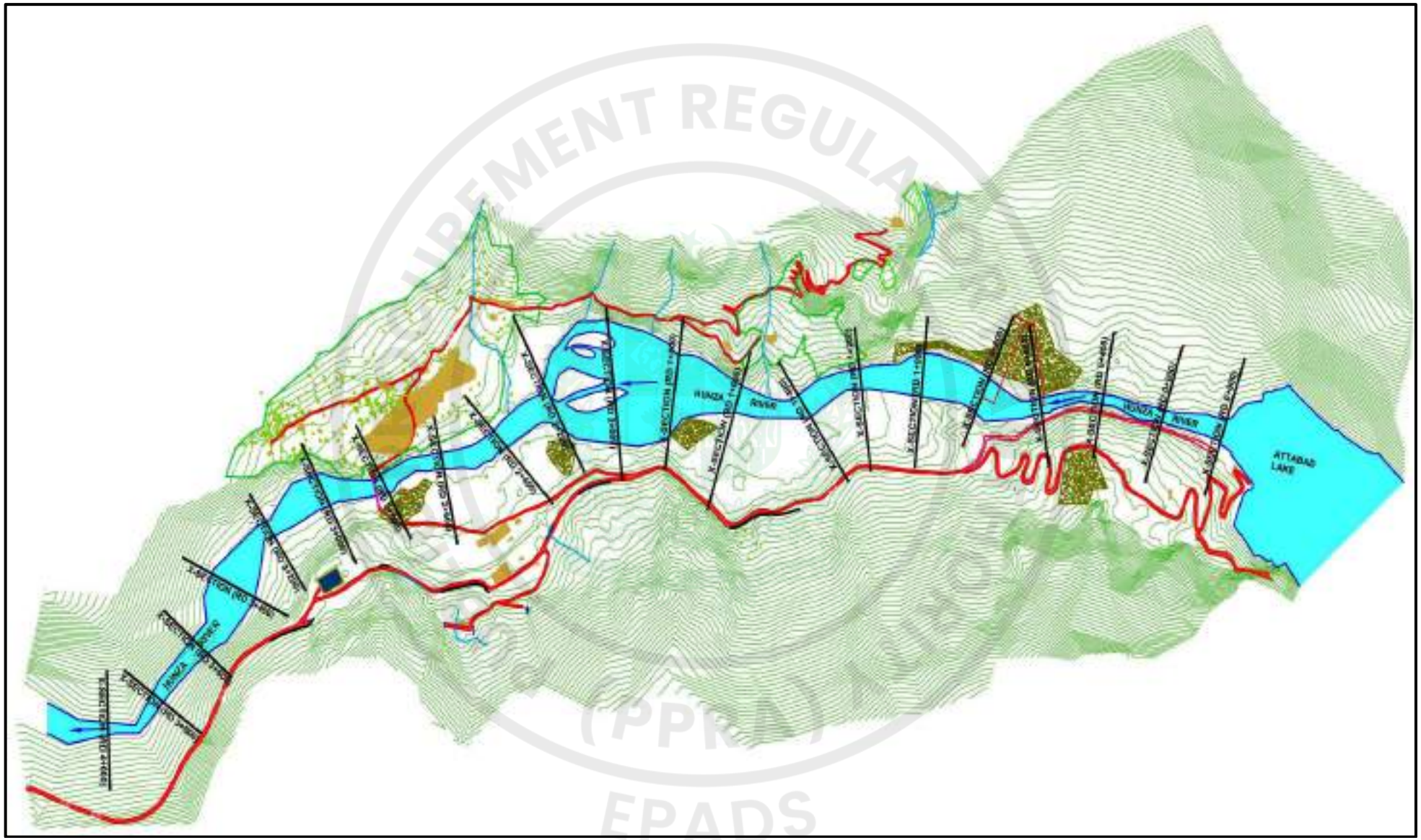


**Figure 3-5 Valley Cross Sections along Hunza River**



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## 3.10 SATELLITE BASED SURVEY OF PROJECT AREA

The Satellite based survey is a most advanced system for such purposes where several types of Geographical and Geo-physical information about the earth are observed through Satellites. Several types and forms of data from the satellite imageries are processed, analyzed and used for the specific purposes.

### 3.10.1 Google Earth Method

Google Earth is a geo-browser that accesses satellite and aerial imagery and other geographic data over the internet to represent the Earth as a three-dimensional globe. It renders a 3D representation of Earth based on satellite imagery. The program maps the Earth by the superimposition of images obtained from satellite imagery, aerial photography and GIS data onto a 3D globe, allowing users to see cities and landscapes from various angles.

### 3.10.2 Methodology

For the preliminary working, topographic data has been collected through Google Earth Pro and relevant elevations were computed through web based applications for this purpose.

### 3.10.3 Geographic Data

Google Earth Pro has built in tools which gives the 3-dimensional value of any location. Using this tool numerous points have been taken in the Area of Interest (AOI). All the features e.g. river boundaries, roads, inhabitation/dwellings etc. have been demarcated on Google and saved as Keyhole Markup Language (KML) files for exporting to other software for further analysis. The google earth model of the AOI is presented in **Figure 3.10**.

### 3.10.4 Geographic Information System (GIS) Method

Geographic Information System (GIS) refers to Satellite based Geospatial Technology which is a tool use to acquire, store, analyze, manage, and present all types of geographical information in a variety of contexts, operations and applications. The use of Geospatial Information is becoming widely used in everyday life through Satellite Navigation and Geographical Information Systems (GIS). It is used to determine precise locations all over the globe, in any weather conditions and at any time of the day.

GIS geodetic surveying equipment for land surveyors has become smaller and easier to use being faster to use than other surveying methods. GIS technology combines database, mapping and statistical methods to integrate georeferenced data into visual displays where the relationships, patterns and trends in the data can be more easily identified.

### 3.10.5 Fundamental Components of GIS

Geospatial technology combines key data and visual information from multiple sources and integrates everything into databases to create intelligent maps. GIS is based on two fundamental components:

- Data (Satellite Imagery / DEM); and
- Computer software to perform calculations and analysis.



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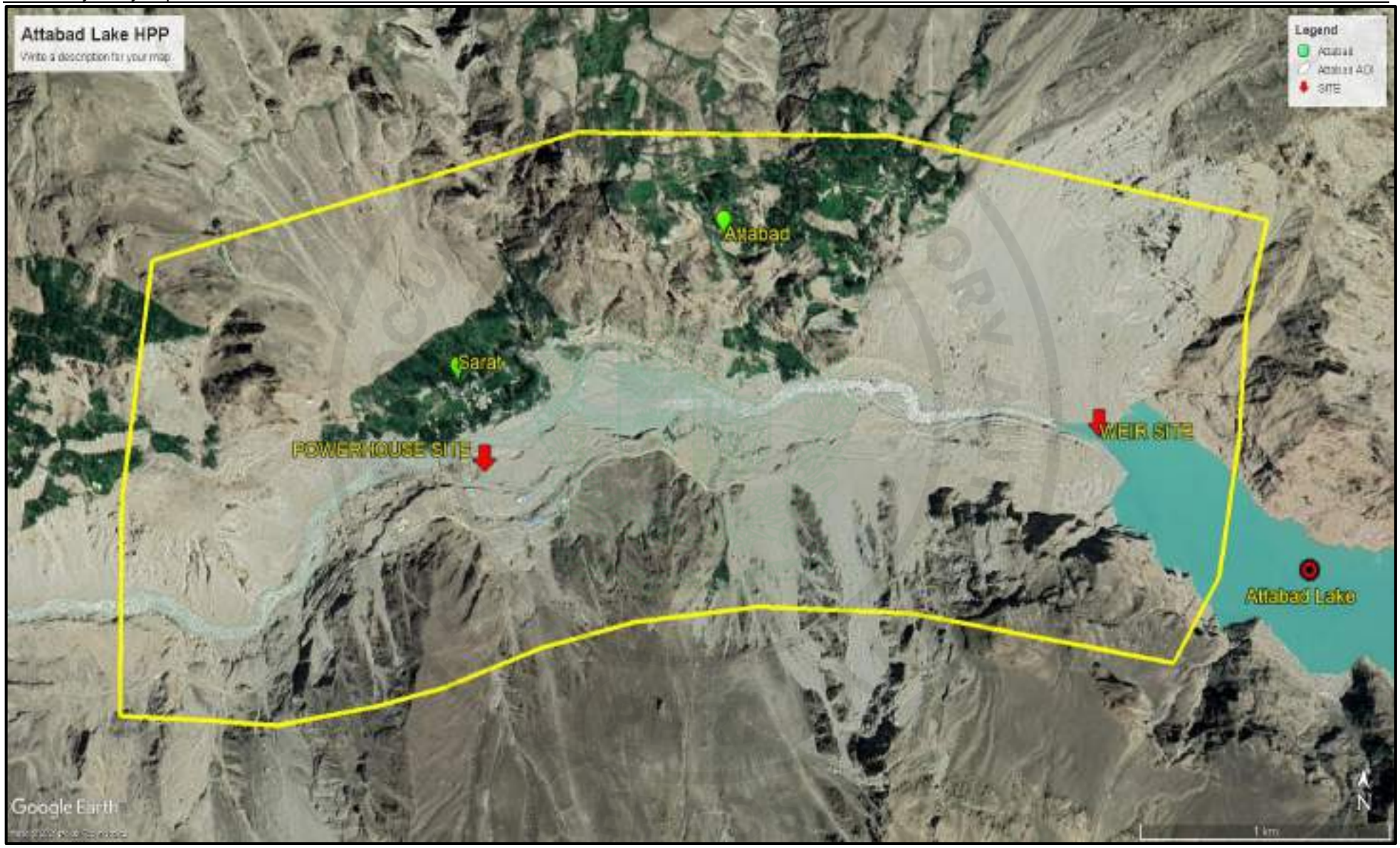


**Figure 3-6 Google Earth Model**



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### 3.10.6 Satellite Imageries

A Satellite Imagery contains data hidden in each pixel, which when unlocked, can tell a lot about what is looking at. There are many analysis techniques that can be applied to multispectral imagery to extract specific features of interest. These algorithms rely on the same principles of reflectivity and absorption at various wavelengths that allow seeing certain features when visualizing them with different band combinations. The various satellite imageries are: -

- Landsat 8 Satellite Images
- Shuttle Radar Topography Mission (SRTM)
- ASTER instrument

### 3.10.7 Data Acquisition and Assembly

In the initial stages, it was apparent that there would be a need for a number of different data sources. This process was simplified by making a list of the data that would be required. Thereon, for the pertinent Area of Interest, various necessary High Resolution Satellite Imageries / Digital Elevation Models (DEMs) acquired through United States Geological Survey (USGS) and ESRI Portals. These were processed and analyzed using ArcGIS, AutoCAD Civil 3D and Erdas Imagine etc. The following satellite imageries were acquired and processed for geospatial analysis and processing: -

- Landsat 8 OLI TIRC C1 Level-1
- Landsat Look Images with Geographic Reference
- Landsat Look Natural Color Image
- Landsat Look Quality Image
- Landsat Look Thermal Image
- Level-1 GeoTIFF Data Product
- SRTM / SRTM 1 Arc-Second
- Google High Resolution Imageries

### 3.10.8 Procedure and Methodology

ArcGIS and ERDAS Imagine, top of the line software for GIS working has been used for analysis and processing of Satellite Images. ArcGIS Explorer is a GIS viewer which can work as a client for ArcGIS Server, ArcIMS, ArcWeb Services and Web Map Service (WMS). ArcGIS Online is a web application allowing sharing and search of geographic information, as well as content published by Esri, ArcGIS users, and other authoritative data providers. For introduction the steps involved are very briefly mentioned as under:

### 3.10.9 Coordinate Transformation

Coordinate Transformation has been carried out to transform the coordinates of the satellite image from WGS84 to projected Coordinates System of WGS 1984 UTM Zone 43N.



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### 3.10.10 Geo Referencing

The term, Geo Referencing, is commonly used in the GIS field to describe the process of associating a physical map or raster image of a map with spatial locations. It is the process of scaling, rotating, translating and deskewing the image to match a particular size and position.

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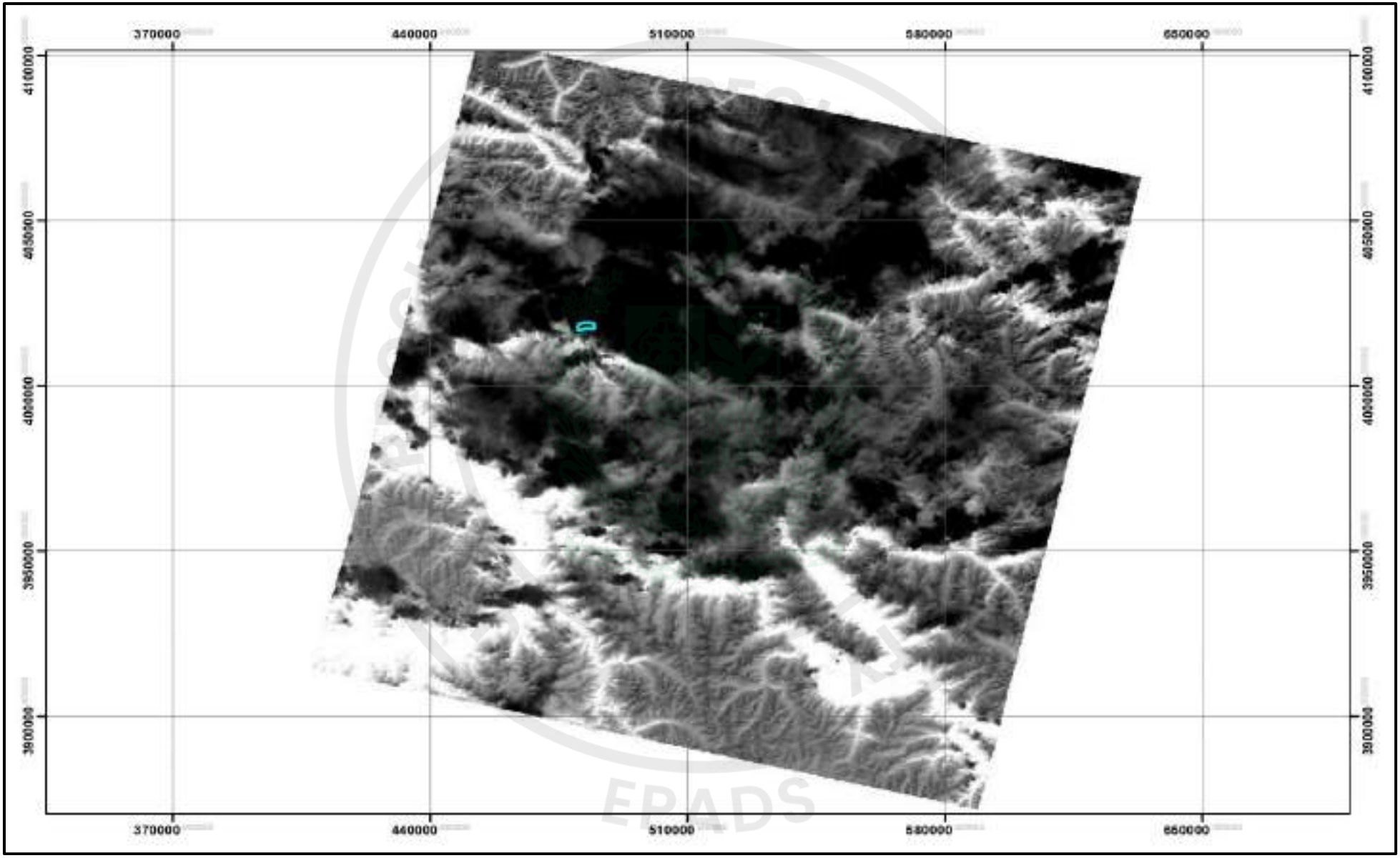


**Figure 3-7 Landsat 8 Panchromatic Image**



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Geo Referencing of the existing features, observed through Google Earth and with physical Site measurement, on the satellite imageries has been carried out. Proper geo-referencing done with the help of SOP Maps and exact coordinate values from the field survey.

### 3.10.11 Raster Mosaic

An overall Raster Mosaic from Raster Datasets covering the entire Project Area has been created. Mosaic clipping of the Raster conducted to extract the AOI.

### 3.10.12 Image Corrections

The applicable image corrections applied for image enhancement including the correction for Atmospheric Scattering and distortions.

### 3.10.13 Band Combination

As defined earlier to visualize different features, e.g. water bodies, vegetation, roads, inhabitation etc. the prescribed combinations of band were created and image classification carried out to identify features on ground.

### 3.10.14 Image Classification

Image classification refers to the task of extracting information classes from a multiband raster image. The resulting raster from image classification can be used to create thematic maps. Depending on the interaction between the analyst and the computer during classification, there are two types of classification: supervised and unsupervised. As a matter of fact, Object-Based (or Object-Oriented) Image Analysis Classification which is a hybrid form of classification has been used. Various features including roads, rivers and villages etc. have been digitized from panchromatic satellite images and Google Earth Pro and have been superimposed over the base map in respective layers.

### 3.10.15 Digital Elevation Model (DEM)

Earth observation data comes in form of 2D flat imagery. For realistic appearance, elevations are required to rectify and make those images three-dimensional. The most common digital data of the shape of the earth's surface is cell-based called Digital Elevation Model (DEM). This data is used as input to quantify the characteristics of the land surface.

A DEM is a raster representation of a continuous surface, usually referencing the surface of the earth. The accuracy of this data is determined primarily by the resolution (the distance between sample points). Other factors affecting accuracy are data type (integer or floating point) and the actual sampling of the surface when creating the original DEM. The DEM of AOI is presented in **Figure 3.12**.



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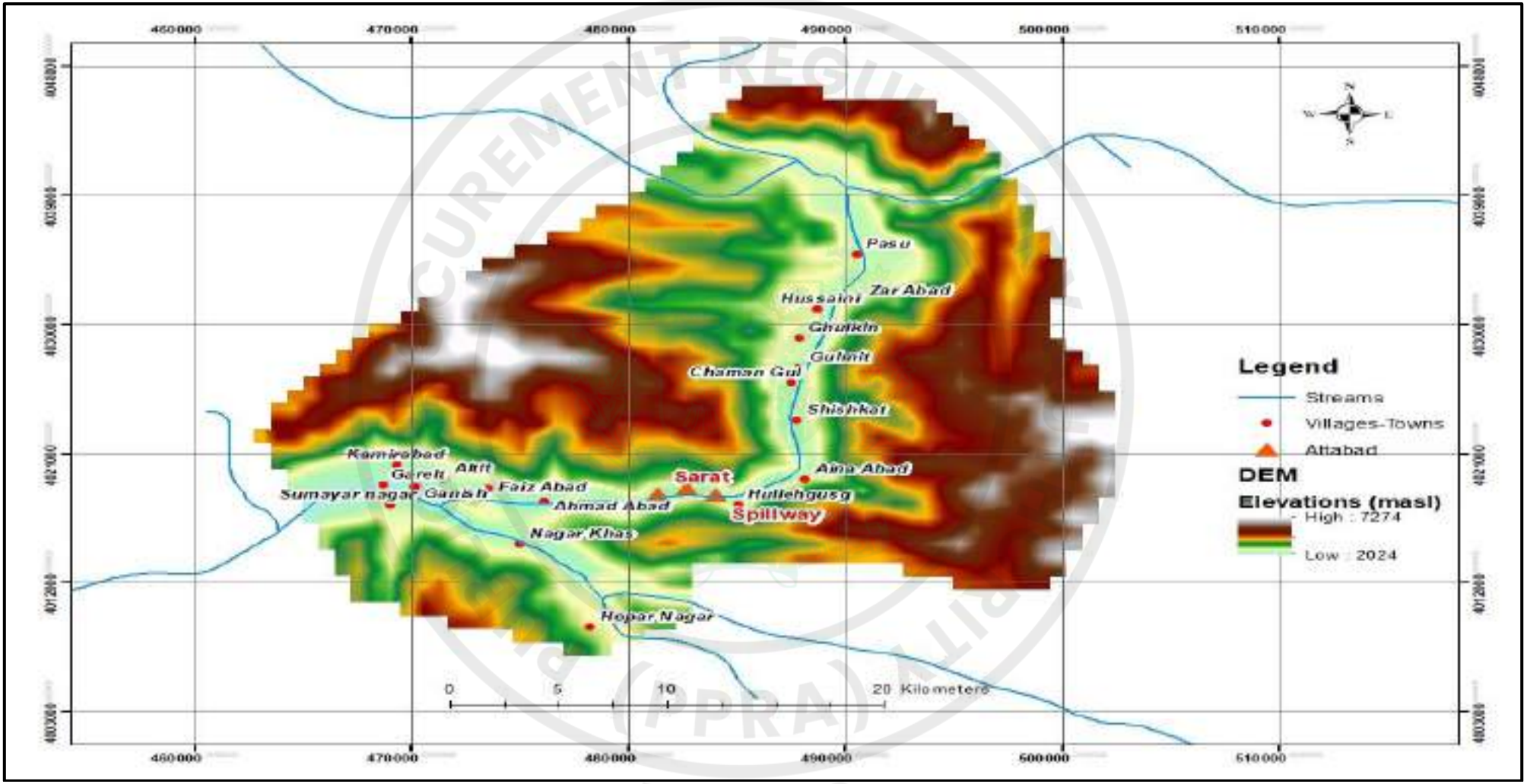


**Figure 3-8 Digital Elevation Model**



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## 3.11 HYDROGRAPHIC SURVEY

Hydrographic Survey refers to the under-water survey involving water depth measurements. In order to determine the capacity of the Attabad Lake, the hydrographic survey of the Lake has been carried out by International Sedimentation Research Institute, Pakistan (ISRIP), WAPDA during September and October, 2020.

### 3.11.1 Scope of Work

III. The Hydrographic Survey of Attabad Lake includes the following major activities:

IV. Cross-sections of the lake along range lines from left to right bank, at 250 m interval for first 3 km & 500 m interval for rest of the lake.

V. Computation of existing storage capacity of the lake.

VI. Development of area-capacity curve.

VII. Development of contour maps of the Lake.

VIII. Discharge Measurement at Ganish Bridge.

## 3.12 METHODOLOGY APPLIED TO THE HYDROGRAPHIC SURVEY

### 3.12.1 Instrument Used

For surveying the submerged part of the lake, an inflatable Rubber Boat and Echo Sounding equipment including a recorder, a transmitting & receiving transducer and power supply has been used. For surveying the exposed bed of the lake, Total Station and Global Positioning System (GPS) have been utilized.

### 3.12.2 Horizontal and Vertical Control of Cross Sections

To carry out the hydrographic survey of the lake, the horizontal and vertical control points near water edge at left bank has been established by ISRIP survey team. All the cross-sections are connected to the geodetic network used in the topographic survey.

### 3.12.3 Hydrographic Survey

The hydrographic survey consists of depth sounding by manual or electronic sonar equipment and position determination relative to measured depth. The reservoir depth along range lines has been determined by the sonic sounder. The accuracy of sonic sounder used in the survey is 0.5% ± 1 inch of indicated depth.

First of all the boat positioned at left bank of the lake, such that it is in line of already established range line, then sounding instrument turned on and mark has been placed on the sonic chart in order to show the starting position and depth with reference to water edge. Thereafter, the depths plotted on sonic chart with reference to left bank distance and simultaneously observed and noted the corresponding coordinate from the GPS. GPS has been used to keep the position of the boat straight as it move continuously across the range line. This process has continued until the boat touched the opposite bank and finally marked the right bank water edge.



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**Figure 3-9 Observation of under-water Cross-Sections**

**Figure 3-10 Equipment showing continuous Trace of Bed Profile**



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### 3.12.4 Capacity Computations by TIN Method using ArcGIS

For the capacity computation of Attabad Lake, Triangular Irregular Network (TIN) method using ArcGIS have been utilized, which provides most accurate and reliable results.

Triangular Irregular Network (TIN) is preferred to represent the reservoir bed surface using the available data in more accurate manner. ArcGIS has the ability to do volumetric calculations from these surface models. TIN model is a surface representation derived from points with an X, Y co-ordinate and a Z value or surface value. TINs are a form of vector-based digital geographic data and are constructed by triangulating a set of vertices (points). The vertices are connected with a series of edges to form a network of triangles. There are different methods of interpolation to form these triangles, such as Delaunay triangulation or distance ordering. ArcGIS supports the Delaunay triangulation method. A TIN expects units to be in feet or meters, not decimal degrees. Delaunay triangulations are not valid when constructed using angular coordinates from geographic coordinate systems.

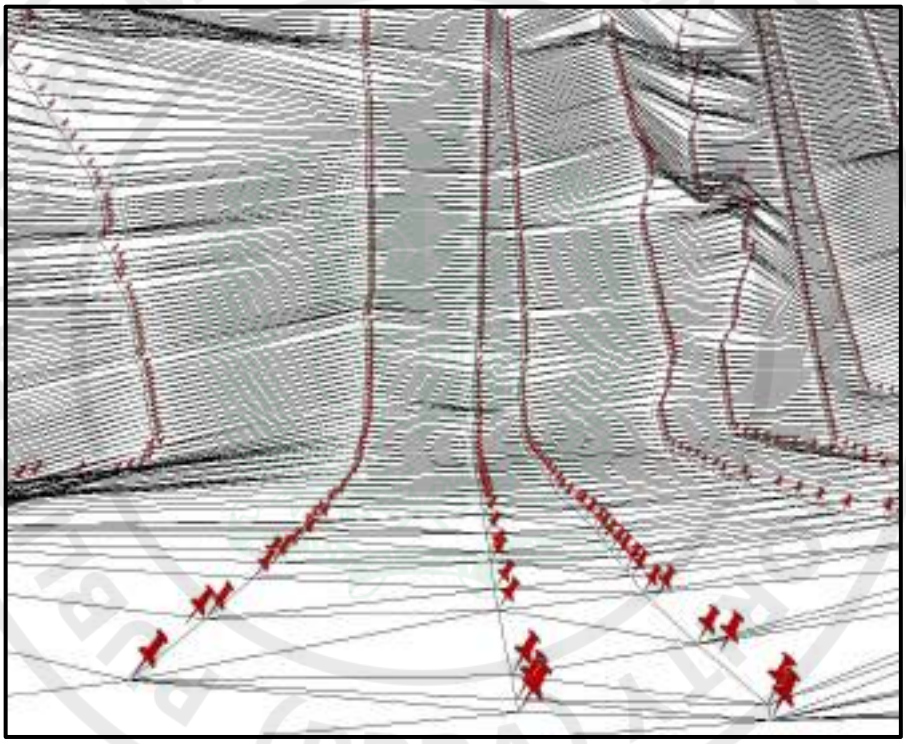

**Figure 3-11 Cross-sectional Points and Triangles formed from Hydrographic Data**

#### 3.12.4.1 Displaying TIN Surfaces

Triangulated Irregular Networks (TINs) represent continuous surfaces such as terrain elevation or temperature gradient. The surface is represented as a set of facets formed by connecting data points at nodes to create adjacent triangles. Typically, a TIN can be displayed using color-shaded relief to depict elevation. Shaded relief simulates the sun's illumination of the earth's surface. By adding color to this, the ridges, valleys, hillsides and their respective heights can easily be seen. The Elevation map is presented in **Figure-3.16**.



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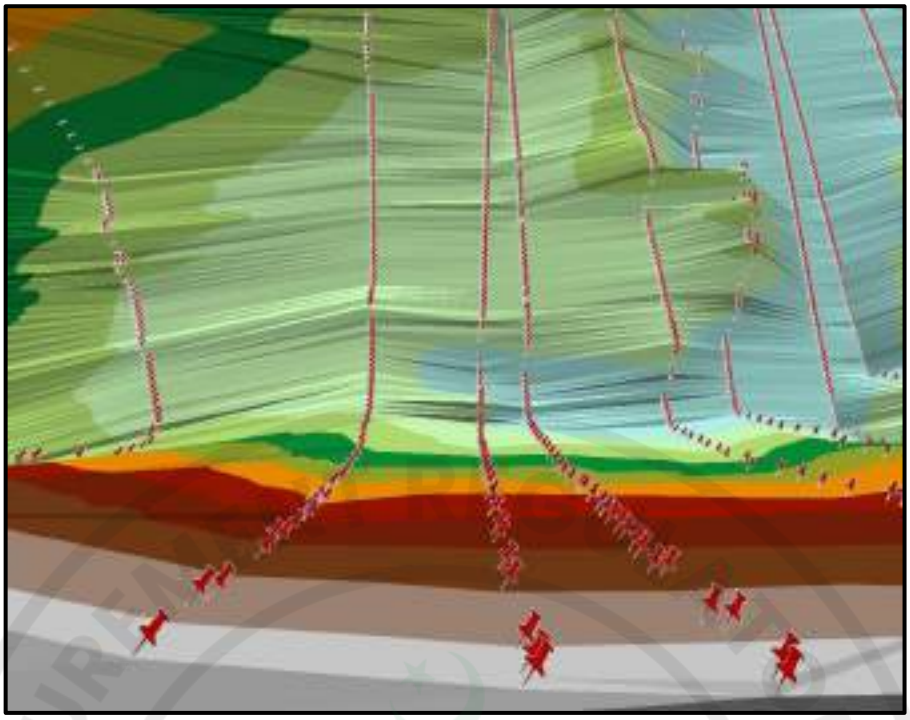
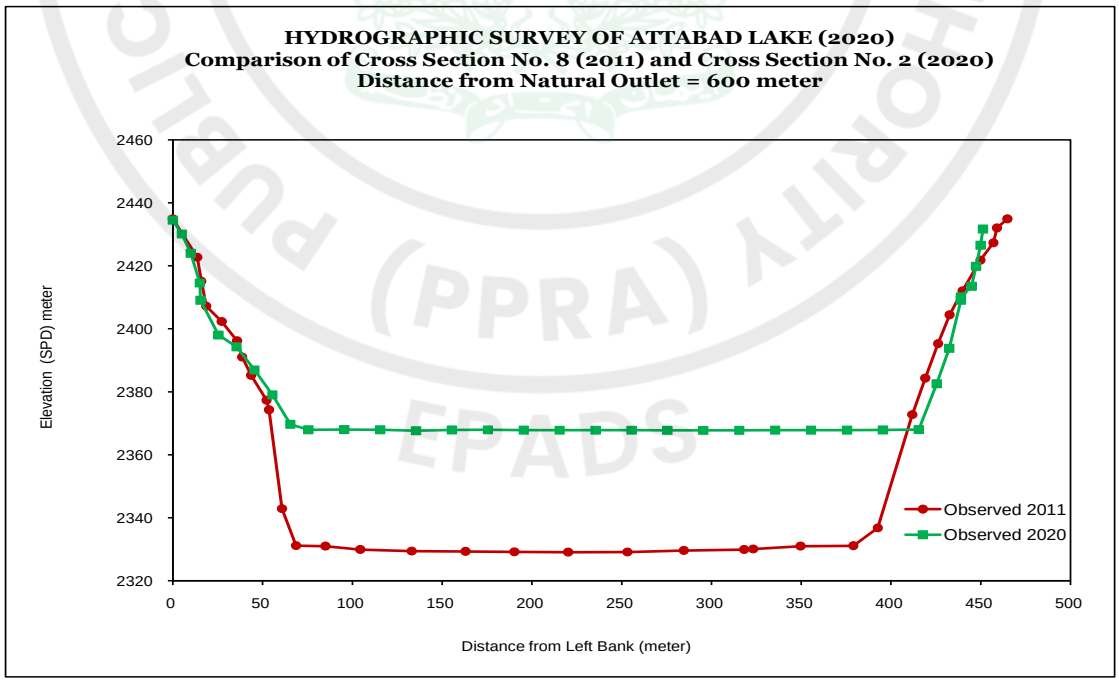


**Figure 3-12 Elevation Map**

## 3.13 RESULTS OF HYDROGRAPHIC SURVEY

The storage capacity at Maximum Conservation Level (El. 2409 masl) comes to be 99,249 Acre Feet (122.42 $Mm^3$). The present water surface area of lake at El. 2409 masl is 1088.7 Acres (4.41 $km^2$). Comparison of current data with previous survey report of year 2011 showed that on an average there is 30 to 40 m deposition in 9 years.




### 3.13.1 Cross Sections & Surveyed Plan of Lake

The X-Sections along 40 range lines covering a total lake length of 12,450 m have been taken. The spacing of the range lines varies between 75 m to 500 m. The width of cross-sections ranges from 245 m to 1289 m upto El. 2430 masl. The surveyed data of the observed cross-sections is



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presented in Volume-7 Appendix-I (A). The drawings of each cross-section are presented in **Volume-2 (Drawings)** in 40 sheets (A3 format). To give an idea about the geometry of the lake area, the contour plan and elevation bands have also been developed and presented in **Volume-2 (Drawings)**.

### 3.13.2 Comparison of Selected Cross Sections

For comparison of depth, the 04 X-Sections at a distance of 600 m, 1,400 m, 9,720 m and 11,920 m from natural outlet (spillway) selected and superimposed with previous observed survey data of 2011. The comparison of these cross-sections is presented in **Volume-2 (Drawings)** in 04 sheets.

### 3.13.3 Longitudinal Bed Profile

Longitudinal bed profile have been observed, using sonic sounder. At the time of longitudinal profile observation, water surface level has also been observed to facilitate the computation of bed levels from echo sounding data. Digitized sonic profile data and mean bed levels of the cross-sections were used to prepare longitudinal profile, presented in **Volume-7 Appendix-I (C)**.

### 3.13.4 Thalweg Profile

The minimum bed elevation at each cross section along the length of the lake has been used to plot the Thalweg profile of lake and is presented in **Volume-7 Appendix-I (D)**.

### 3.13.5 Capacity and Surface Area

The capacities and surface areas have been computed from ArcGIS using Trianguled Irregular Network (TIN) Method. The capacity and surface area of the lake at different elevations has been calculated. The area-capacity data is presented in **Volume-7 Appendix-I (B)**.

### 3.13.6 Discharge Measurement at Ganish Bridge

The discharge observations have been taken at Ganish Bridge in the month of September and October 2020. The cross-sectional data and discharge sheets are presented in **Volume-7 Appendix-I (E)**.

## 3.14 QUALITY CONTROL

The topographic and hydrographic survey has been conducted by qualified and experienced team of Survey Division, Peshawar, HPO WAPDA and ISRIP respectively in accordance with the scope of work. Before the start of survey activities, the survey equipment has been calibrated to avoid any error. Apart from this, certain check measurements has also taken during the survey campaign for assuring the quality work.



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# 4 HYDROLOGY AND SEDIMENTATION

## 4.1 GENERAL

Northern Areas of Pakistan is unique in its geographical configuration and layout which houses confluence of three major mountain ranges i.e. Hindukush, Karakorum and Himalayans and 5 out of 14 peaks above 8000 m.a.s.l. The Hindukush-Karakoram-Himalaya (HKKH) Region, often called “Water Towers of Asia,” provides natural reserves of fresh water in the form of snow and glaciers that sustain water availability in mountainous or Himalayan Areas, as well as in adjacent areas.

These mountain ranges are characterized for their slope instability due to the inherent topographic, geological, geomorphological, seismological, hydrological and anthropogenic reasons. Consequently, hazards like earthquakes, landslides, mud slides, debris slides, rock avalanches, erosions, glaciated drifts and glaciated lake outburst floods (GLOF) are common phenomena. Water channels like rivers, nullahs and streams, lines of communication like highways, roads and tracks and built up areas like towns, villages, hutments and isolated houses, agriculture farms and orchard remains exposed to these hazards with variable level of vulnerability. The interaction between hazard and vulnerability leads to disaster in the form of blocking water channels like rivers, disrupting line of communications and washing away farms and orchards causing physical, social, psychological, political, economic and environmental impacts on those communities and people along with their infrastructure who suffer from these events.

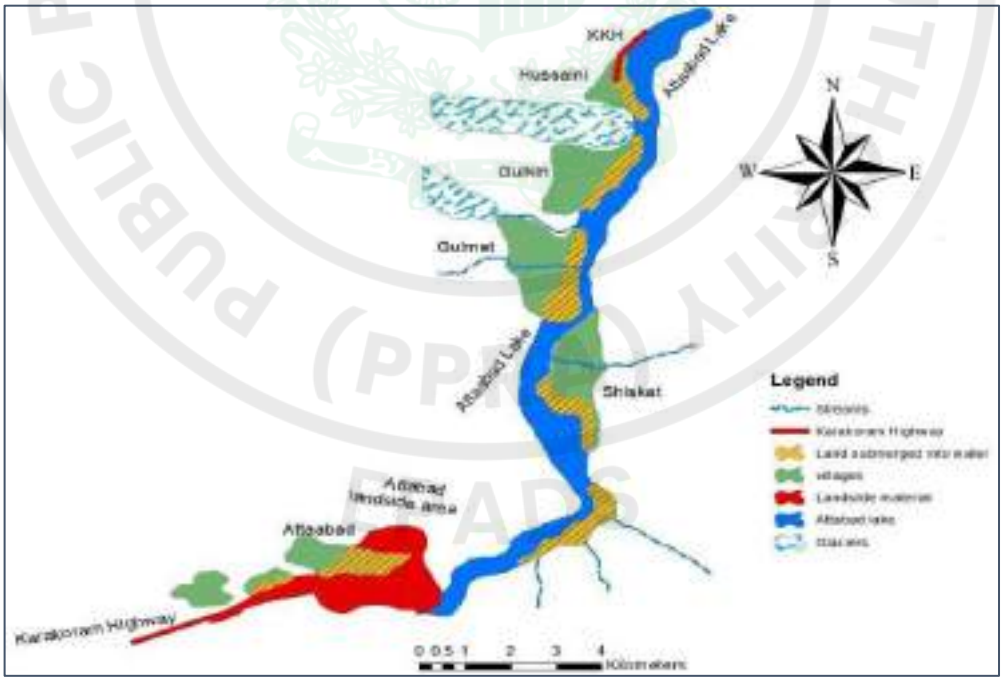


**Figure 4-1 Attabad Landslide Area & Extent of Lake**

January 4, 2010 is a day which witnessed a landslide hazard meeting with the vulnerabilities of Attabad and Sarat Villages, 109 km north-east of Gilgit and 20 km upstream from Karimabad in



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Hunza Valley, their farms and orchards, the River and Karakorum Highways (KKH) resulting into a historical event of creation of huge lake subsequently engulfing most parts of the villages like Ainabad, Shishkat, Gulmit, Gulkin and Hussaini into its fold.

## 4.2 HUNZA VALLEY

Karimabad, the capital of the Hunza Valley offers a panoramic view of high peaks like Rakaposhi. Nagar is the large kingdom across the river from Hunza. Passu is a village of farmers and mountain guides about 15 km away from Gulmit. This is the setting-off point for climbing expeditions up the Batura, Passu, Kurk and Lupgar groups of peaks, and for trekking trips up the Shimshal Valley and Batura Glacier.

### 4.2.1 Gojal Valley

Gojal with an area of about 8,500 km² is the largest tehsil of the Northern Areas of Pakistan. Lying in Upper Hunza, it shares border with China in the northeast and with Afghanistan in the northwest. Gulmit is the largest settlement of Gojal, commonly referred to as the capital of the tehsil. The main villages are Gulmit, Borit, Ghulkin, Hussaini and Passu which are well connected with other parts of the Region through KKH. Gojal has a population of about 20,000 with different ethnic groups of Wakhi and Burushaski. The dwellers of the area have mostly moved from Pamir areas of China, Afghanistan and Tajikistan and central part of Hunza.

There are parallel glaciers extend down to the main river valley from the upper catchments of mountain range between Gulmit and Passu. The Region is home to lofty ice capped peaks, roaring rivers, lush green pastures and long glaciers.

## 4.3 HUNZA RIVER

Hunza River is one of the main tributary basins of the Indus Basin River that contributes about 12% of the upper Indus flow, upstream of Tarbela Dam. About 80% of the total inflow into this dam originates from less than 20% of its contributing area, essentially from areas of heavy snowfall and glacierized basins above 3500 m a s l. About 50% of the basin area has elevations higher than 4700 m a s l.

The tributaries joining the Hunza River are Chapursan, Khunjerab, Ghujerab, Shimshal and Hispar Rivers.



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**Figure 4-2 Hunza River**

## 4.4 HUNZA RIVER CATCHMENT

The Hunza River Basin lies in the high Karakoram Range within longitudinal range from 74º02' to73º03’ and latitudinal range 35º54' to 37º05' in the Northern Area of Pakistan. It is bordered in the west by Gilgit River Basin, in the north by Afghanistan and China, and in the south by Shigar and Indus River Basins. The small portion in the north east of this basin drains in the Chinese territory. Most of the terrain of the basin falls in the elevation range of about 1,500m.a.s.l to more than 7,500 m a s l. The basin occupies an area of 16,389.4sq.km. The glacier cover of the basin is about 4,677.3 sq.km. The basin comprises of major valleys like Naltar, Nagar, Shimshal and Chapursan and hanging glaciers in the high Karakoram Range. A part of KKH passes across this basin linking Pakistan with China through Khunjerab Pass.



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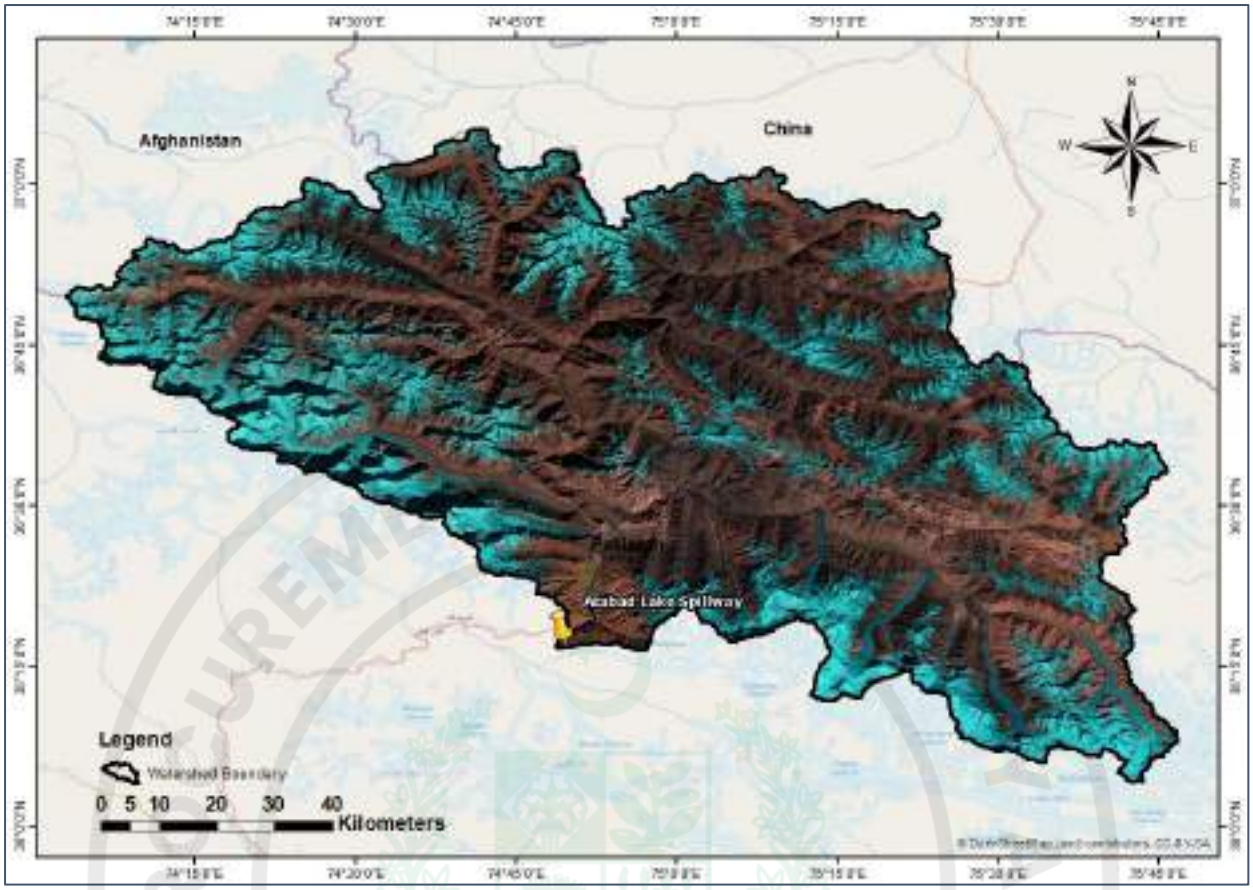


**Figure 4-3 Attabad Lake Catchment Area with Landsat Imagery**

## 4.5 CLIMATE

The Karakoram-Himalayan Region is glaciologically complex with high altitude source are as (above 4,500 m a s l) having perma frost and annual precipitation in excess of 2,000 mm while some of the large glaciers nouts extending down to semi-arid valley floors (2,700 m a s l) receive annual precipitation of less than 200 mm. The Karakoram area is influenced mainly by abroad scale weather system originating primarily from the Mediterranean or from the area of the Caspian Sea during the winter and spring seasons.

The Gilgit Meteorological Station is the nearest station to Hunza Valley that has a sound historical record covering more than five decades. Monthly temperature variations (maximum, minimum and mean) at Gilgit indicate parabolic trend with peak in the month of July. Summer prevails in months from June to August. In July and August, mean maximum and minimum temperatures are normally above 35˚C and 15˚C respectively. The winter is cold and chilly that starts from November and remain still end of March. The lowest temperatures are in the month of January when mean maximum and minimum temperatures reaches below10˚C and (-) 2˚C respectively.

The mean monthly rainfall data of Gilgit Climatological Station is available for the period 1951 to 2014. The available data has been processed to achieve annual, monthly and % monthly distribution of rainfall at Gilgit. The results so achieved are presented in Table 4 1. The mean annual precipitation for the period 1951 to 2004 is 186 mm. March and May are the months of maximum rainfall while the lowest rainfall occurs in the month of November. The graphical representation of average monthly and Min, Max and Average precipitation is given in **Figure**



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**4-4**. The maximum daily precipitation recorded during the historic period is 48.3 mm in October 1987. The Project Area receives precipitation in the form of rain in summer and snow in winter.

**Table 4-1 Annual & Monthly Distribution of Precipitation (mm) At Gilgit (1951 to 2014)**

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1951 | 3.7 | - | - | - | 21.4 | - | 27.8 | - | - | - | - | - | 17.63 |
| 1952 | 3.7 | 6.1 | 10.2 | 18.1 | 20.2 | 26.2 | 26.3 | 27.6 | 22.8 | - | - | - | 17.91 |
| 1953 | - | - | - | - | - | - | 31.3 | - | 19.6 | 13.2 | 8.3 | 4.9 | 15.46 |
| 1954 | - | - | - | - | 20.7 | 23.8 | 26.4 | 25.5 | 23.2 | 15.8 | 9.4 | 4.4 | 18.65 |
| 1955 | 3.2 | 8.3 | 12.7 | 15.1 | 19.6 | 23.7 | 25.9 | 28.3 | 23.2 | 16.3 | 10.8 | 7 | 16.18 |
| 1956 | 3.6 | 7.4 | 12.5 | 17.6 | 23.6 | 24.2 | 29.5 | 25.1 | 24.4 | 17.0 | 10.7 | 5.3 | 16.74 |
| 1957 | 4.1 | 5.6 | 11.8 | 14.3 | 18.2 | 22.6 | 27.9 | 25.8 | 21.8 | 15.6 | 9.7 | 5.8 | 15.27 |
| 1958 | 6.1 | 7.9 | 13.3 | 18.4 | 18.8 | 23.2 | 27.1 | 24.8 | 24.4 | 17.9 | 10.6 | 7.4 | 16.66 |
| 1959 | 4.6 | 5.9 | 12.6 | 18.9 | 18.6 | 24.5 | 26.2 | 27.6 | 26.5 | 19.4 | 10.4 | 5.1 | 16.69 |
| 1960 | 3.3 | 9.9 | 11.1 | 14.8 | 19.4 | 23.2 | 27.9 | 29.2 | 23.8 | 17.7 | 10.5 | 5.3 | 16.34 |
| 1961 | 4.7 | 5.9 | 13.4 | 16.8 | 21.9 | 25.7 | 29.6 | 27.7 | 24.3 | 16.6 | 8.0 | 1.8 | 16.37 |
| 1962 | 2.7 | 6.9 | 12.6 | 16.4 | 19.9 | 24.1 | 25.2 | 26.4 | 20.4 | 15.4 | 8.9 | 4.2 | 15.26 |
| 1963 | 2.2 | 8.2 | 11 | 16.1 | 20.8 | 26.7 | 27.9 | 27.7 | 22.4 | 17.0 | 9.8 | 4.7 | 16.21 |
| 1964 | 2.3 | 5.7 | 12.7 | 15.6 | 18.8 | 22.6 | 26.3 | 27.9 | 23.1 | 17.2 | 8.8 | 4.1 | 15.43 |
| 1965 | 5.2 | 6.1 | 11.8 | 15 | 19.8 | 23.6 | 27.3 | 24.3 | 21.9 | 16.8 | 10.9 | 2.8 | 15.46 |
| 1966 | 3.1 | 8.7 | 10.8 | 15.2 | 18.9 | 25.5 | 26.2 | 26.4 | 20.8 | 14.7 | 7.6 | 3.2 | 15.09 |
| 1967 | 2 | 6.5 | 10.9 | 16.2 | 17.5 | 24.5 | 28.8 | 28.2 | 22.8 | 14.2 | 8.6 | 5.1 | 15.44 |
| 1968 | 3.5 | 6.2 | 12.9 | 16.3 | 18.7 | 25.5 | 29.2 | 30.5 | 22.7 | 14.9 | 7.9 | 4.5 | 16.07 |
| 1969 | 2.4 | 6.3 | 13.9 | 15.6 | 20.5 | 24.2 | 28.2 | 27.6 | 22.2 | 16.4 | 9.9 | 3.9 | 15.93 |
| 1970 | 3.9 | 6.5 | 10.9 | 17.5 | 19.8 | 24.6 | 26.5 | 27.4 | 23.2 | 16.7 | 8.4 | 3.6 | 15.75 |
| 1971 | 2.1 | 5.4 | 12.6 | 18.1 | 21.2 | 28.6 | 27.6 | 27.1 | 21.3 | 16.1 | 9.4 | 4.3 | 16.15 |
| 1972 | 3.8 | 4.3 | 12.0 | 15.7 | 18.4 | 23.9 | 25.4 | 24.9 | 21.1 | 14.6 | 9.9 | 4.9 | 14.91 |
| 1973 | 2.1 | 6.4 | 10.1 | 16.6 | 20.5 | 27.2 | 28.4 | 27.9 | 23.8 | 15.4 | 9.2 | 3.6 | 15.93 |
| 1974 | 2.3 | 5.1 | 13.1 | 18.3 | 19.8 | 23.3 | 26.3 | 26.1 | 20.9 | 15.5 | 8.6 | 3.2 | 15.21 |
| 1975 | 2.3 | 5.1 | 10.1 | 16.4 | 19.2 | 24.3 | 25.9 | 26.3 | 22.4 | 16.8 | 7.5 | 3.9 | 15.02 |
| 1976 | 5.5 | 5.5 | 10.7 | 17.2 | 21.5 | 24.9 | 30.1 | 25.1 | 21.9 | 15.5 | 9.5 | 3.7 | 15.93 |
| 1977 | 3.1 | 5.9 | 13.5 | 18.2 | 15.5 | 27.7 | 30.7 | 27.7 | 22.9 | 17.5 | 11.1 | 5.0 | 16.57 |
| 1978 | 2.7 | 6.3 | 10.3 | 17.5 | 21.8 | 26.9 | 27.3 | 27.5 | 22.3 | 17.1 | 8.7 | 5.1 | 16.13 |
| 1979 | 3.9 | 7.2 | 10.5 | 17.3 | 17.1 | 24.1 | 28.2 | 24.9 | 21.1 | 16.9 | 10.4 | 5.4 | 15.58 |
| 1980 | 3.7 | 6.3 | 11.3 | 18.6 | 20.9 | 25.1 | 27.3 | 26.1 | 21.4 | 16.6 | 9.6 | 5.7 | 16.05 |
| 1981 | 3.9 | 7.4 | 11.9 | 16 | 21.9 | 23.1 | 27.5 | 25.7 | 20.5 | 15.4 | 8.9 | 6.4 | 15.72 |
| 1982 | 3.8 | 4.9 | 11.0 | 17.7 | 21.1 | 23.6 | 27 | 28.5 | 21.1 | 16 | 9.0 | 3.9 | 15.63 |
| 1983 | 2.9 | 4.7 | 9.3 | 16.9 | 21.7 | 23.3 | 26.7 | 27.5 | 24.3 | 16.2 | 9.7 | 4.6 | 15.65 |
| 1984 | 2.7 | 4.8 | 13.1 | 16.5 | 19.5 | 26.3 | 27.3 | 29.4 | 20.3 | 15.5 | 8.7 | 3.7 | 15.65 |
| 1985 | 3.5 | 6.6 | 13.5 | 17.9 | 19.8 | 24.0 | 29.2 | 26.9 | 22.3 | 15.9 | 9.6 | 5.1 | 16.19 |
| 1986 | 2.9 | 6.5 | 10.1 | 15.7 | 19.4 | 23.7 | 27.3 | 24.7 | 21.7 | 16.1 | 9.7 | 4.1 | 15.16 |
| 1987 | 2.5 | 7.1 | 12.5 | 16.3 | 18.2 | 22.5 | 25.1 | 26.1 | 23.1 | 14.3 | 9.0 | 4.8 | 15.13 |
| 1988 | 5.5 | 6.8 | 10.9 | 17.3 | 22 | 24.0 | 28.4 | 25.6 | 23.0 | 15.3 | 10 | 5.5 | 16.19 |
| 1989 | 2.7 | 4.8 | 11.8 | 15 | 17.5 | 23.2 | 24.2 | 22.9 | 21.6 | 15.7 | 9.2 | 6.3 | 14.58 |
| 1990 | 5.2 | 6.3 | 10.7 | 15.4 | 23.1 | 25.3 | 28.5 | 26.9 | 23.2 | 15.2 | 9.5 | 5.1 | 16.20 |
| 1991 | 5.1 | 6.9 | 11.7 | 15.7 | 18.3 | 23.8 | 25.3 | 25.4 | 22.2 | 14.7 | 9.1 | 7.2 | 15.45 |
| 1992 | 4.4 | 6.3 | 9.7 | 16.1 | 20 | 24.1 | 26.7 | 26.1 | 21.1 | 15.3 | 11.5 | 7.5 | 15.73 |
| 1993 | 3.4 | 8.1 | 10.4 | 17.9 | 21.2 | 23.6 | 25.1 | 25.3 | 22.9 | 15.5 | 9.5 | 5.8 | 15.73 |



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| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1994 | 4.3 | 5.9 | 13.1 | 14.8 | 21.1 | 24.2 | 28.7 | 28.9 | 21.5 | 15.5 | 10.1 | 4.5 | 16.05 |
| 1995 | 1.1 | 5.9 | 11.7 | 16 | 20.8 | 24.1 | 27.3 | 27.1 | 22.5 | 16.1 | 9.5 | 3.7 | 15.48 |
| 1996 | 2.7 | 7.5 | 12 | 16.3 | 19 | 22.8 | 24.7 | 27.3 | 23.9 | 15.1 | 8.7 | 3.1 | 15.26 |
| 1997 | 3.9 | 6.1 | 11.1 | 17.8 | 20 | 24.9 | 28.9 | 25.5 | 22.9 | 16.3 | 9.7 | 5.7 | 16.07 |
| 1998 | 3.7 | 7.4 | 11.9 | 17.1 | 20.9 | 23.1 | 28.1 | 26.4 | 22.7 | 18.1 | 11.3 | 5.2 | 16.33 |
| 1999 | 5.1 | 7.7 | 12.5 | 16.6 | 21.4 | 24.2 | 27.5 | 25.5 | 23.5 | 15.5 | 9.4 | 3.9 | 16.07 |
| 2000 | 3.3 | 5.5 | 11 | 17.1 | 23.4 | 24.9 | 25.7 | 24.7 | 21.1 | 16.2 | 9.9 | 5.8 | 15.72 |
| 2001 | 3.5 | 8.2 | 12.6 | 18.1 | 23.8 | 25.5 | 27.9 | 25.1 | 20.2 | 16.1 | 8.7 | 5.9 | 16.30 |
| 2002 | 3.3 | 7.2 | 13.2 | 16.5 | 20.9 | 24 | 25.3 | 26.0 | 19.5 | 17.3 | 11.0 | 5.9 | 15.84 |
| 2003 | 5.1 | 6.9 | 11.5 | 17.1 | 17.9 | 24.5 | 27.7 | 26.3 | 22 | 15.3 | 9.5 | 5.2 | 15.75 |
| 2004 | 5.7 | 8.3 | 15.1 | 17.3 | 20.7 | 24 | 25.5 | 25.1 | 22.1 | 15.4 | 10.9 | 6.7 | 16.40 |
| 2005 | 11.2 | 14.1 | 12.4 | 58.9 | 32.6 | 2.7 | 9.3 | 2.1 | 2.1 | 0 | 4.0 | 0.4 | 12.48 |
| 2006 | 15.4 | 6 | 2.1 | 23 | 1.5 | 11.1 | 8.1 | 39 | 11.9 | 5.7 | 4.0 | 5.8 | 11.13 |
| 2007 | 0 | 1.3 | 11.9 | 15.2 | 12 | 18.8 | 12.5 | 6.4 | 6.3 | 0 | 0 | 0 | 7.03 |
| 2008 | 2.9 | 0 | 0 | 8.3 | 75.8 | 15.6 | 3.5 | 10.9 | 8.3 | 12.9 | 0.6 | 31.5 | 14.19 |
| 2009 | 33 | 10.1 | 7 | 43.6 | 2 | 14.6 | 2 | 1 | 16 | 1 | 0 | 9 | 11.61 |
| 2010 | 0 | 14 | 22 | 24.6 | 60.7 | 23.2 | 52.9 | 71.8 | 10.4 | 1 | 0 | 0 | 23.38 |
| 2011 | 2.7 | 60.3 | 12.7 | 6.2 | 18.8 | 20.8 | 14.8 | 13.8 | 37.2 | 4.9 | 0.2 | 2.3 | 16.23 |
| 2012 | 0 | 9 | 36.9 | 11.3 | 18.6 | 2.6 | 0.5 | 8.2 | 25.1 | 0.2 | 1.2 | 5.1 | 9.89 |
| 2013 | 3.1 | 3.6 | 3.2 | 0.9 | 52.2 | 15.6 | 0.3 | 61.1 | 13.8 | 0 | 11.7 | 0 | 13.79 |
| 2014 | 0.5 | 0.4 | 7.7 | 0.5 | 11.1 | 4 | 21.2 | 22.4 | 2.1 | 35.4 | 3.8 | 0 | 9.09 |
| **Avg** | 4.11 | 7.41 | 11.76 | 17.10 | 21.46 | 22.58 | 24.99 | 26.08 | 20.87 | 14.42 | 8.40 | 4.96 | 15.45 |

As regarding the temperature data, it is also available for the period of 1951 to 2014. The same has been processed to compute, mean, maximum and minimum temperature. The results are presented in the Table 4-2.

**Table 4-2 Average Max & Min Monthly Temperature at Gilgit**

| Month | Mean Min Temp ($^{o}$C) | Mean Max Temp ($^{o}$C) |
|---|---|---|
| Jan | 2.4 | 9.4 |
| Feb | 0.7 | 12.6 |
| Mar | 5.7 | 18.2 |
| Apr | 9.5 | 24.1 |
| May | 12.1 | 28.6 |
| Jun | 15.1 | 34 |
| Jul | 18.4 | 36.1 |
| Aug | 17.8 | 35.3 |
| Sep | 12.7 | 31.7 |
| Oct | 6.8 | 25.5 |
| Nov | 0.9 | 18.2 |
| Dec | -1.9 | 11.5 |
| Annual Mean | 7.9 | 23.8 |



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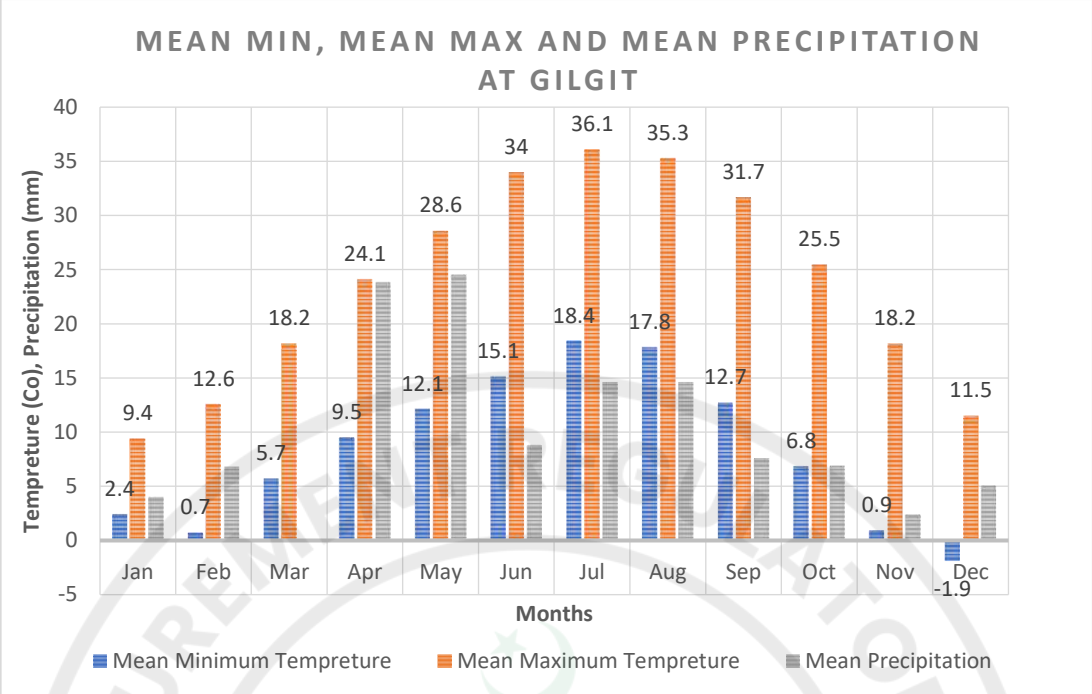


**Figure 4-4 Mean Max, Mean Min and Mean Precipitation at Gilgit**

## 4.6 ISOHYETAL MAP OF ATTABAD LAKE CATCHMENT

Although no data has been available to depict the precipitation pattern of the Hunza Basin, therefore, gridded precipitation data is used for the preparation of the isohyetal map to have a picture of precipitation distribution in the basin. Climate Hazards Group Infra-Red Precipitation with Station (CHIRPS) data for the last 20 years (2000 - 2019) is used for this purpose. CHIRPS was formed in collaboration of USGS Earth Resources Observation and Science (EROS) Center for reliable and up-to-date data sets.

The isohyetal map shows the mean annual rainfall of the basin for the last 20 years (2000 – 2019). Mean Annual Precipitation values vary from 88 to 485 mm. It is assessed that. precipitation is maximum near the Khunjerab Area and lower in the entire middle portion of the basin being the minimum near Misgar Village. Volume



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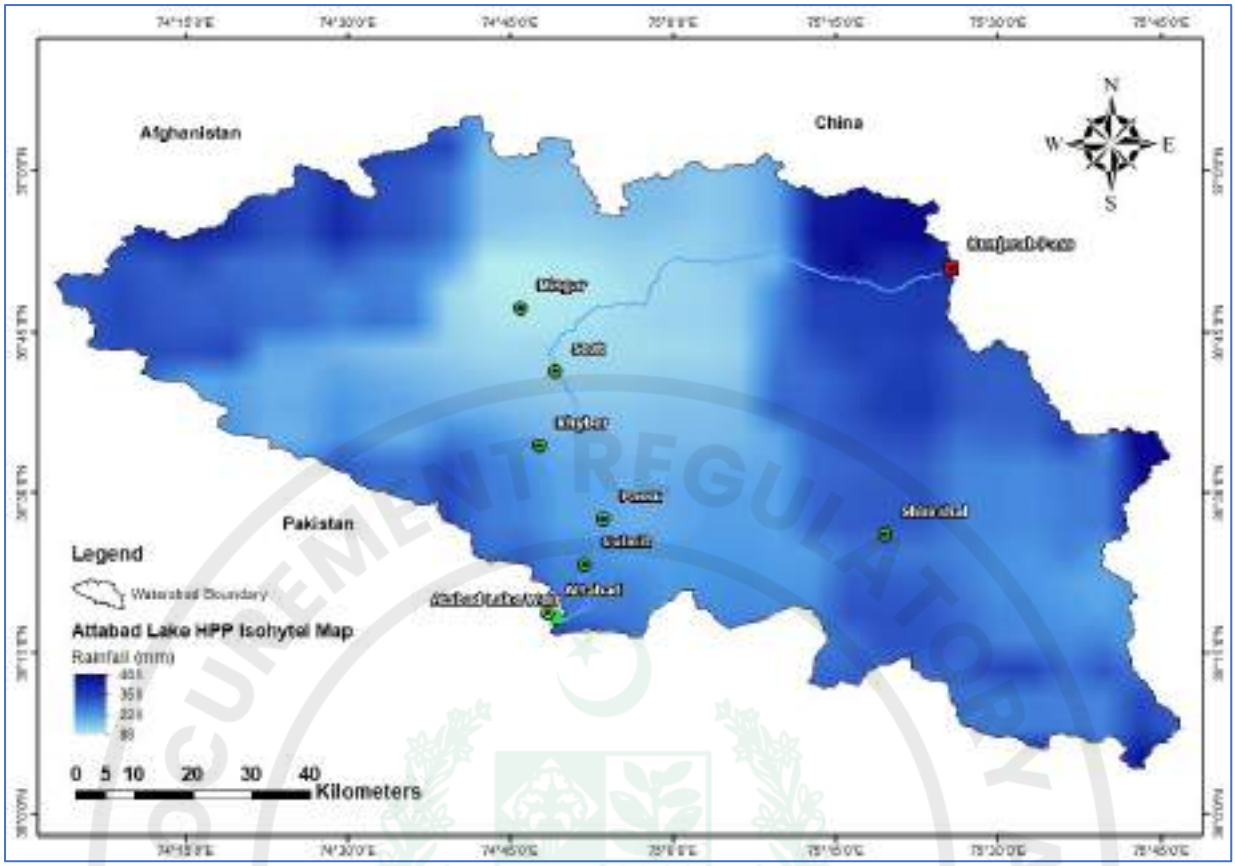


**Figure 4-5 Isohyetal Map of Hunza Catchment**

## 4.7 HYDROLOGY

The Karakoram and Himalayan mountains form the main source of snow and ice melt runoff to the Indus River System. The precipitation enhancing and shadowing effects of the main mountain ranges provide dramatic contrasts that greatly complicate the hydrological picture. The main tributaries of Hunza River are; Chapursan, Kilik, Bola, Das joining the Hunza River from the west and Khunjerab along with Ghujerab, Shimshal and Hispar Rivers joining river from the east of the valley. The river flows of Hunza are usually maximum in the month of July when snow and glacier melt is at its peak while these are minimum in the month of March when snow and ice melting is in significant.

### 4.7.1 Hydrologic Measurement Station

The hydrological data has been collected from Danyor station from the Surface Water Hydrology Project (SWHP), WAPDA located on Hunza River at Danyor Bridge.

**Table 4-3 hydrologic Measurement Station at Hunza River**

| No | Name | River | Basin | Sub-basin | Latitude | Longitude | Elevation (m.a.s.l) | Catchment Area ($km^2$) |
|---|---|---|---|---|---|---|---|---|
| 1 | Danyor Br. | Hunza | Indus | Hunza | 35°55’40’’ | 74 °22’35” | 1,494 | 13,157 |



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## 4.8 FLOW MEASUREMENT

There is no hydrological gauging station on Hunza River except one at Danyor Bridge being operated by SWHP-WAPDA. This station is located at about 107 km downstream of Attabad Land Slide Dam. The catchment area of Hunza River upto Danyor gauging station is 13,157 $km^2$, whereas it is14,083 $km^2$ upto its confluence with Gilgit River. Hunza River catchment area is 8,901 $km^2$ upto Attabad Landslide Dam. Therefore, river flows are transposed and estimated from documented discharge data from hydrological station at Danyor. Daily discharge data from 1966 to 2015 is available and processed for the calculations. Data for year 2016 was incomplete, therefore, it was not used in the calculations.

Mean annual flows are calculated and drawn in the figure below for the period 1966-2015. Average value for mean annual flow has been calculated as 208.36 $m^3/s$. Year 1973 witnessed the highest average flow of 310 $m^3/s$ whereas, year 1997 witnessed the lowest average flows of 127 $m^3/s$.

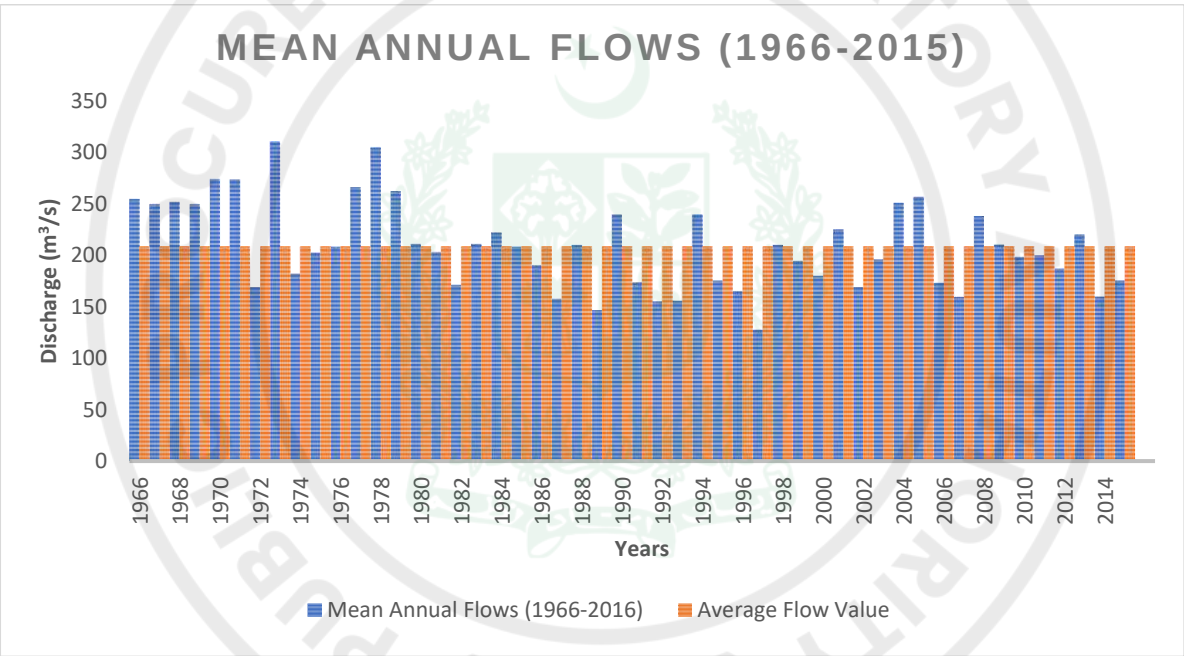


**Figure 4-6 Mean Annual Flows**

Mean monthly flows are estimated and plotted in the graph below. Flows are generally maximum in July and August reaching 700 $m^3/s$. Whereas, flows are low from December to April each year when snow falls in the catchment. The graph shows that design discharge of 60 $m^3/s$ is available for about half year (almost 6 months). Graph shows that flows are exceeding the design discharge from June to October which shows the potential of hydropower generation.



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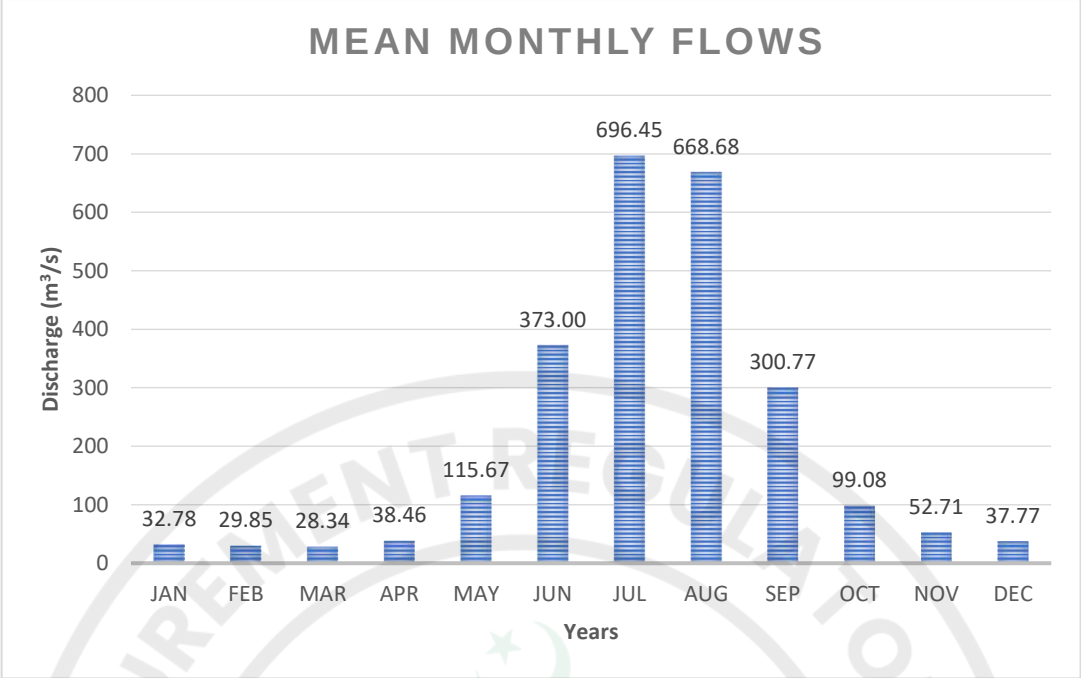


**Figure 4-7 Mean Monthly Flows**

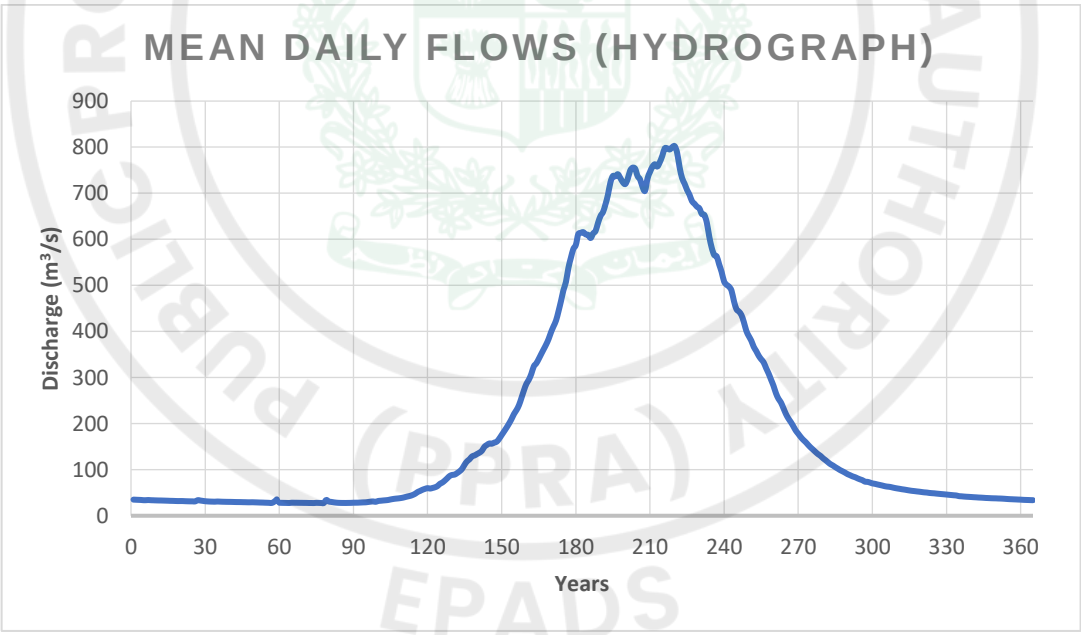


**Figure 4-8 Mean Daily Flows**

Mean daily flows are plotted in **Figure 4-8** which shows the sudden increase in flows after the fifth month and reaches to peak in July and August. Maximum, Mean and Minimum daily flows for the period 1966-2015 are also plotted in the **Figure 4-9**.



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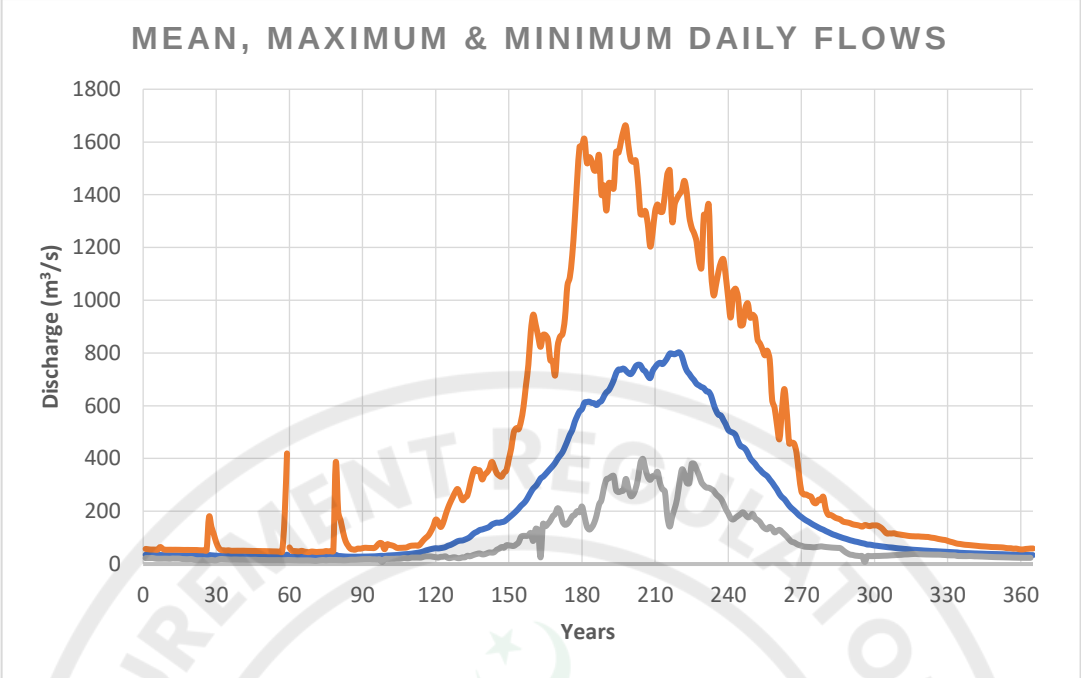


**Figure 4-9 Mean, Maximum & Minimum Daily Flows**

### 4.8.1 Flow Duration Curve (FDC)

FDC for ALHPP is plotted on the basis of almost 51 years (1966-2016). From FDC it us evident that design discharge of 60 $m^3/s$ is available for almost 50% of the time. Therefore, design discharge of 60 $m^3/s$ is justified for the generation of 54 MW power.

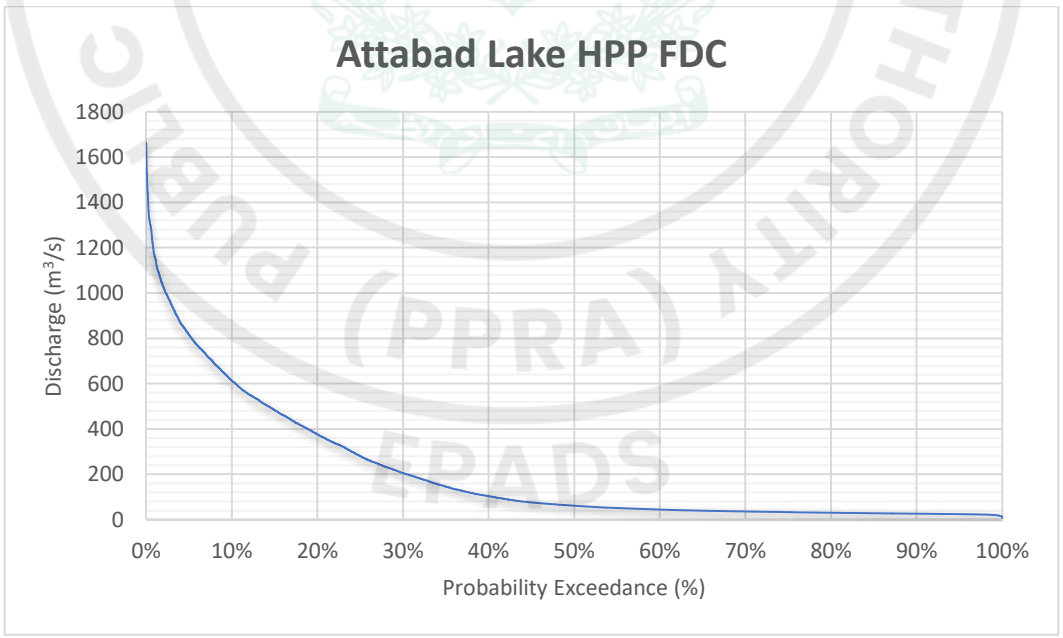


**Figure 4-10 Attabad Lake Flow Duration Curve (FDC)**

**Table 4-4 Flow Duration Curve Results**



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| Probability Exceedance (%) | Flow ($m^3/s$) | Probability Exceedance (%) | Flow ($m^3/s$) |
|---|---|---|---|
| 10 | 613.4 | 60 | 44.3 |
| 20 | 376.6 | 70 | 36.0 |
| 30 | 205 | 80 | 30.3 |
| 40 | 103.3 | 90 | 26.2 |
| 50 | 61.3 | 99 | 20.5 |

## 4.9 WATER LEVELS

The available head for power generation has been determined from normal operative level and the water level where tailrace channel joins Hunza River.

### 4.9.1 Upstream Water Levels

Upstream water levels have been determined keeping in view the operation of the Attabad Lake. For power and energy estimates, the normal operative level varies from 2,408 m.a.s.l to 2,412 m.a.s.l.

### 4.9.2 Downstream Water Levels (Tail-water Rating Curve)

The tail-water rating curve for downstream of the powerhouse at Hunza River is obtained using the water levels, historic discharges and cross section of Hunza River. Calculations are tabulated at **Table 4 5** and the tailwater rating curve is plotted at **Figure 4 11**. The downstream tail water rating has been adopted for stage estimation downstream of power house. The head losses expected to occur in the power scheme have been calculated to determine the net head available for power generation.

**Table 4-5 Tailwater Curve Analysis**

| Water Surface Elevation (m.a.s.l) | Discharge ($m^3/s$) | Velocity (m/s) | Flow Area ($m^2$) | Wetted Perimeter (m) | Top Width (m) |
|---|---|---|---|---|---|
| 2300.10 | 29.50 | 1.29 | 22.80 | 51.31 | 51.18 |
| 2300.35 | 98.27 | 1.87 | 52.53 | 68.02 | 67.77 |
| 2300.75 | 215.19 | 2.38 | 90.39 | 81.51 | 81.11 |
| 2301.35 | 394.73 | 3.00 | 131.40 | 83.59 | 82.93 |
| 2301.95 | 616.04 | 3.55 | 173.32 | 85.68 | 84.76 |
| 2302.55 | 876.00 | 4.05 | 216.15 | 87.76 | 86.58 |
| 2303.12 | 1172.50 | 4.51 | 259.90 | 89.85 | 88.40 |
| 2303.62 | 1503.99 | 4.94 | 304.55 | 91.93 | 90.23 |
| 2304.06 | 1869.31 | 5.34 | 350.12 | 94.02 | 92.05 |
| 2304.47 | 2267.56 | 5.72 | 396.61 | 96.10 | 93.88 |
| 2304.92 | 2698.06 | 6.08 | 444.00 | 98.19 | 95.70 |
| 2305.40 | 3049.87 | 6.17 | 494.07 | 106.72 | 104.05 |
| 2305.95 | 3525.16 | 6.44 | 547.06 | 110.79 | 107.93 |



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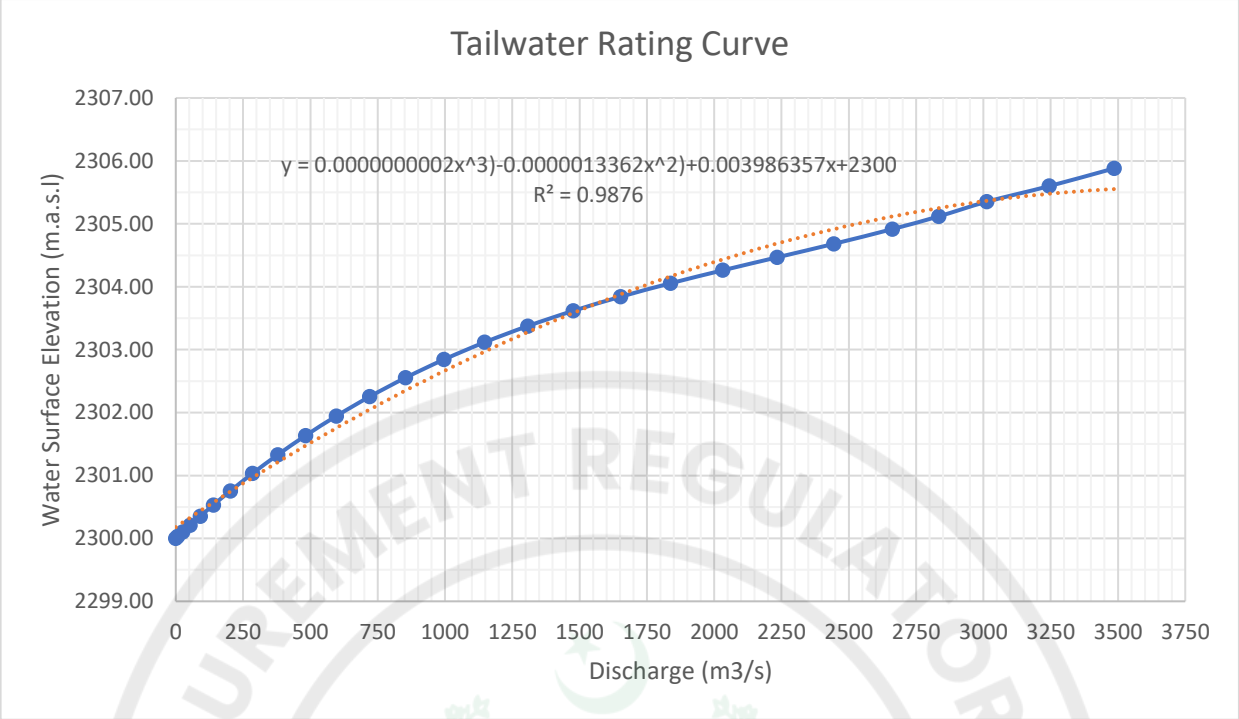


**Figure 4-11 Tailwater Rating Curve**

## 4.10 FLOOD ESTIMATION

Flood has been estimated from the available record. The maximum peak discharges of mean daily for every year recorded. The instantaneous peaks will definitely be higher than the measured daily flows and can be enhanced while execution accordingly. Instantaneous peak flows for the period 1966 to 2015 has been calculated and plotted as well.

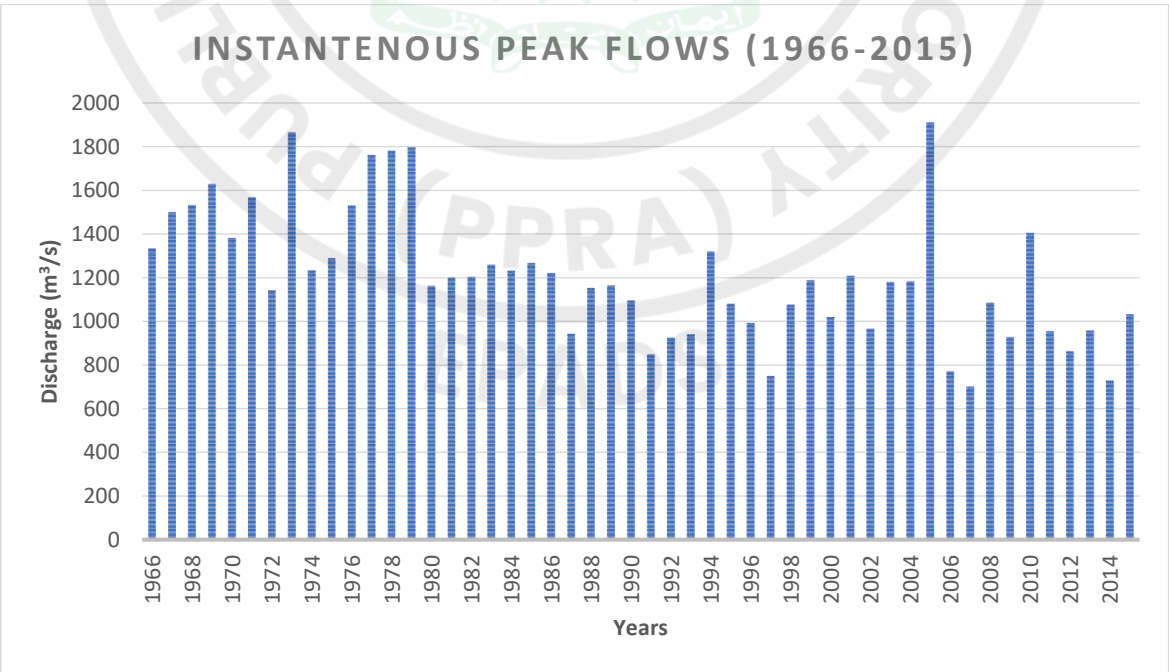


**Figure 4-12 Instantaneous Peak Flows at Attabad Lake HPP Site**



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### 4.10.1 Flood Estimation by Flood Frequency Analysis (FFA)

Flood Frequency Analysis (FFA) has been carried out to estimate the flood at different return periods. Three types of distribution series namely Gumble, Normal and Log Pearson Type-III Distribution series have been used to estimate the flood.

The estimated values of floods from FFA of various return period at Attabad Lake site are tabulated in Table 4 6.

**Table 4-6 Flood Frequency Analysis**

| Return Period (Years) | Gumble Distribution Estimated Flood ($m^3/s$) | Normal Distribution Estimated Flood ($m^3/s$) | Log Pearson Type-III Estimated Flood ($m^3/s$) |
|---|---|---|---|
| 2 | 1,142 | 1,232 | 1,155 |
| 5 | 1,411 | 1,426 | 1,428 |
| 10 | 1,589 | 1,579 | 1,596 |
| 25 | 1,813 | 1,767 | 1,796 |
| 50 | 1,980 | 1,910 | 1,939 |
| 100 | 2,145 | 2,073 | 2,077 |
| 1,000 | 2,691 | 2,520 | 2,518 |
| 10,000 | 3,237 | 2,984 | 2,915 |

Log scale graph has been plotted with respect to the peak flows at **Figure 4-13**.



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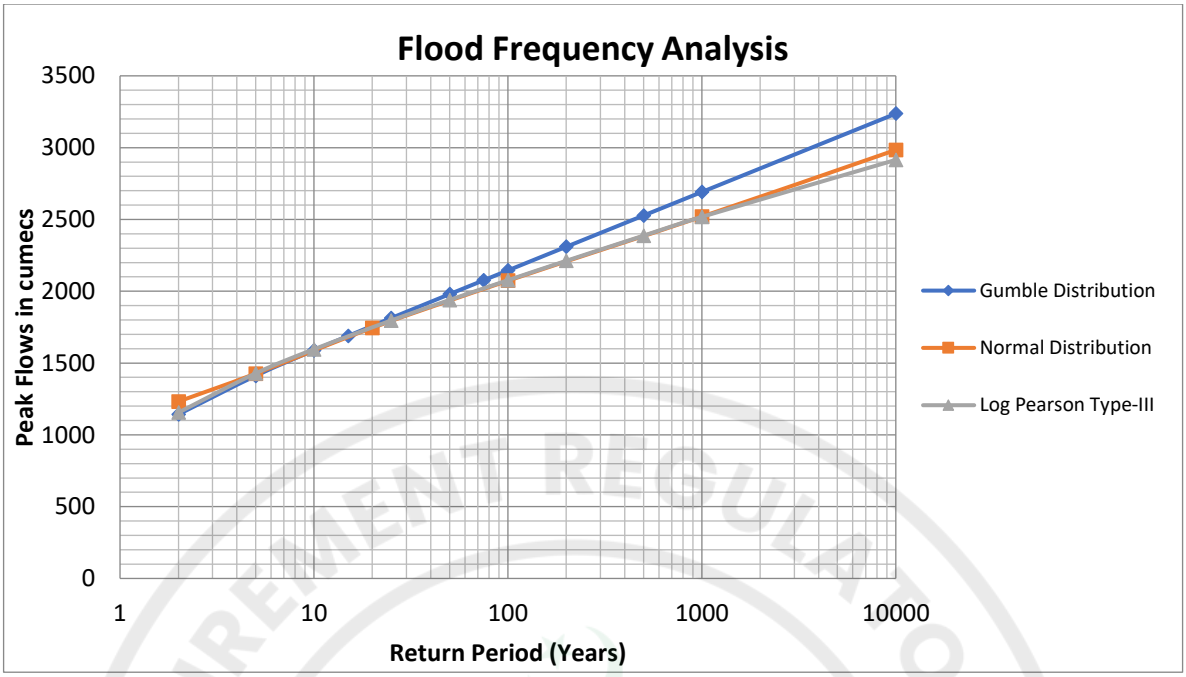


**Figure 4-13 Flood Frequency Analysis Graphs**

### 4.10.2 Flood Estimation by USACE HEC-SSP Model

Flood has also been estimated using the statistical model. The US Army Corps of Engineers (US-ACE) HEC SSP Model is used for this purpose. 17B Bulletin Method has been selected with Weilbul Plotting pattern in the model. Results of peak floods against percent chance exceedance been calculated and shown in **Figure 4-14**.

HEC-SSP 2.1.1 - Attabad Lake HPP

Frequency Curve for: Attabad Lake HPP

| Percent Chance Exceedance | Computed Curve Flow in cfs | Expected Prob. Flow in cfs | Confidence Limits Flow in cfs | |
|---|---|---|---|---|
| | | | 0.05 | 0.95 |
| 0.01 | 3016.3 | 3291.9 | 3662.3 | 2606.2 |
| 0.1 | 2559.0 | 2696.3 | 3030.7 | 2256.5 |
| 0.5 | 2236.4 | 2314.2 | 2567.6 | 2008.7 |
| 1.0 | 2096.0 | 2153.4 | 2396.2 | 1697.4 |
| 5.0 | 1759.1 | 1780.7 | 1952.6 | 1622.2 |
| 20.0 | 1430.8 | 1436.5 | 1543.1 | 1342.6 |
| 50.0 | 1154.0 | 1154.0 | 1224.7 | 1087.3 |
| 95.0 | 761.0 | 752.0 | 825.0 | 686.0 |
| 99.0 | 641.5 | 625.6 | 706.6 | 562.0 |

| Statistics | |
|---|---|
| Log Transform: Flow | |
| Statistic | Value |
| Mean | 3.063 |
| Standard Dev | 0.111 |
| Station Skew | 0.023 |
| Regional Skew | |
| Weighted Skew | |
| Adopted Skew | 0.023 |

| Number of Events | |
|---|---|
| Event | Number |
| Historic Events | 0 |
| High Outliers | 0 |
| Low Outliers | 0 |
| Zero Or Missing | 0 |
| Systematic Events | 51 |
| Historic Period | |

**Figure 4-14 Flood Estimation using HEC-SSP Model**

Flood Estimation using HEC-SSP Model. Confidence intervals of 5% and 95% have been used for the calculations.



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As per the model, flood for 1000-year return period from computed curve has been calculated as 2,559 $m^3/s$ and from expected probability curve it is 2,695 $m^3/s$. Flood for 10,000-year return period, it is 3,016 $m^3/s$ from computed curve and 3,292 $m^3/s$ from expected probability curve. With the confidence interval of 5% and 95%, maximum flood values are 3,682 $m^3/s$ and 2,606 $m^3/s$.

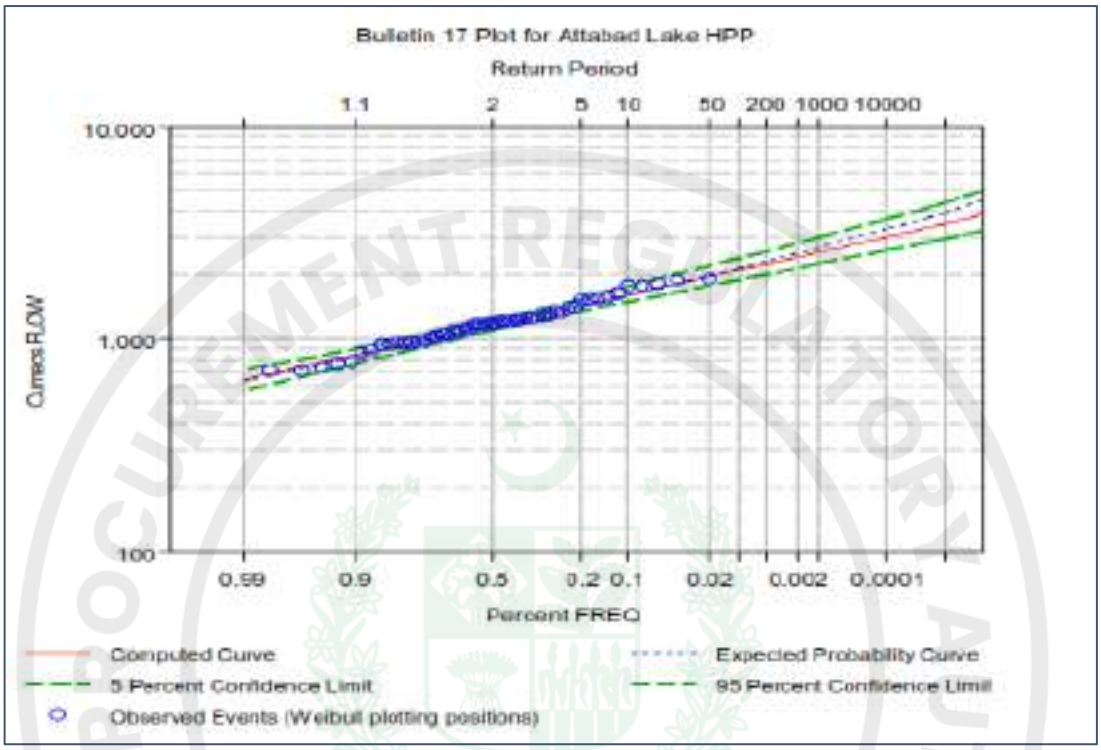


**Figure 4-15 HEC-SSP Model Graph**

### 4.10.3 Statistical Model Analysis

Statistical model results are tabulated at Table 4 7.

**Table 4-7 HEC-SSP Model Results**

| Return Period (Years) | Computed Flood from Curve ($m^3/s$) | Expected Probable Flood ($m^3/s$) |
|---|---|---|
| 1.01 | 641 | 626 |
| 2 | 1,154 | 1,154 |
| 5 | 1,431 | 1,436 |
| 20 | 1,759 | 1,781 |
| 100 | 2,098 | 2,153 |
| 200 | 2,238 | 2,314 |
| 1,000 | 2,559 | 2,698 |
| 10,000 | 3,016 | 3,292 |



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### 4.10.4 Recommended Design Flood

Keeping in view the different types flood estimations and generation of high peaks due to GLOFs, it is recommended to adopt design flood of 10,000 years return period at weir site. Therefore, design flood of 3,250 $m^3/s$ at weir site has been assumed for the calculations of design of structures.

## 4.11 HYDROLOGIC FLOOD ROUTING

Flood routing is a mathematical procedure for predicting the changing magnitude, speed, and shape of a flood wave as a function of time (i.e., the flow hydrograph) at one or more points along a waterway. Although, the lake has not much storage capacity but still it can lag and attenuate the peak generated by floods to minimize the adverse impacts on the downstream structures and areas. The temporarily stored water is then released through an outlet or spillway after the peak has passed.

U.S. Army Corps of Engineers' (USACE) Hydrologic Center's hydrologic Modeling System (HEC-HMS) is used for this Project. HEC-HMS uses level pool method also known as Modified Puls Routing method to route the flood wave. It uses the one-dimensional approximation of the continuity equation.

$$(Iavg - Oavg) = \frac{\Delta S}{\Delta t}$$

$I_{avg}$ = Average inflow during time interval
$O_{avg}$ = Average outflow during time interval
$\Delta S$ = Storage Change
$\Delta t$ = Time Change

### 4.11.1 Establishment of the HEC-HMS Model

Attabad Lake catchment has been delineated using the ArcGIS tool which is then exported to HEC-HMS model. To model a reservoir, source, reservoir and sink elements are incorporated. Catchment area is shown at **Figure 4-16**. To setup the HEC-HMS model, Storage-Discharge relationship has been developed for the reservoir keeping the proposed outflow system. Storage-Elevation relationship is available from the hydrographic survey of the lake which is then used as paired data along with Storage-Discharge relationship for the hydrologic model. Inflow hydrograph has been generated keeping in view the peak discharge of 3,250 $m^3/s$. Time interval of 2-hours has been used for the hydrograph and simulation.



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**Figure 4-16 Attabad Lake Catchment Area Marked in HEC-HMS**

### 4.11.2 Assumption for the Routing

The treatment of routing in this method is based on the assumption that the reservoir is level. This means that both the outflow and the storage depend only on the water level in the reservoir. It is not valid in reservoir where the backwater effect is such that a significant percentage of the temporary storage occurs as wedge storage between the sloping backwater surface and a horizontal plane extending upstream from the water surface elevation at the weir.

### 4.11.3 Results of Flood Routing

The routing exercise of the design flood was carried out with such scenario that outflow is being done by overflow weir (60 m in length) and assuming sediment flushing channel gates are not operating in case of flood. Under this scenario of discharge, the routed hydrograph is presented at **Figure 4-17** and results are tabulated at Table 4 8. As evident from the graph and table, it is deducted that the hydrograph with the peak of 3,250 $m^3/s$ has been entered in the lake as inflow and attenuated peak of 3,085 $m^3/s$ is attained after 4 hours of the inflow peak. The attenuated peak is attained at an elevation of 2421.3 m a s l. Thus, being a small level reservoir, Attabad Lake can play lag and attenuate the flood wave upto some extent as shown in the graph and table.



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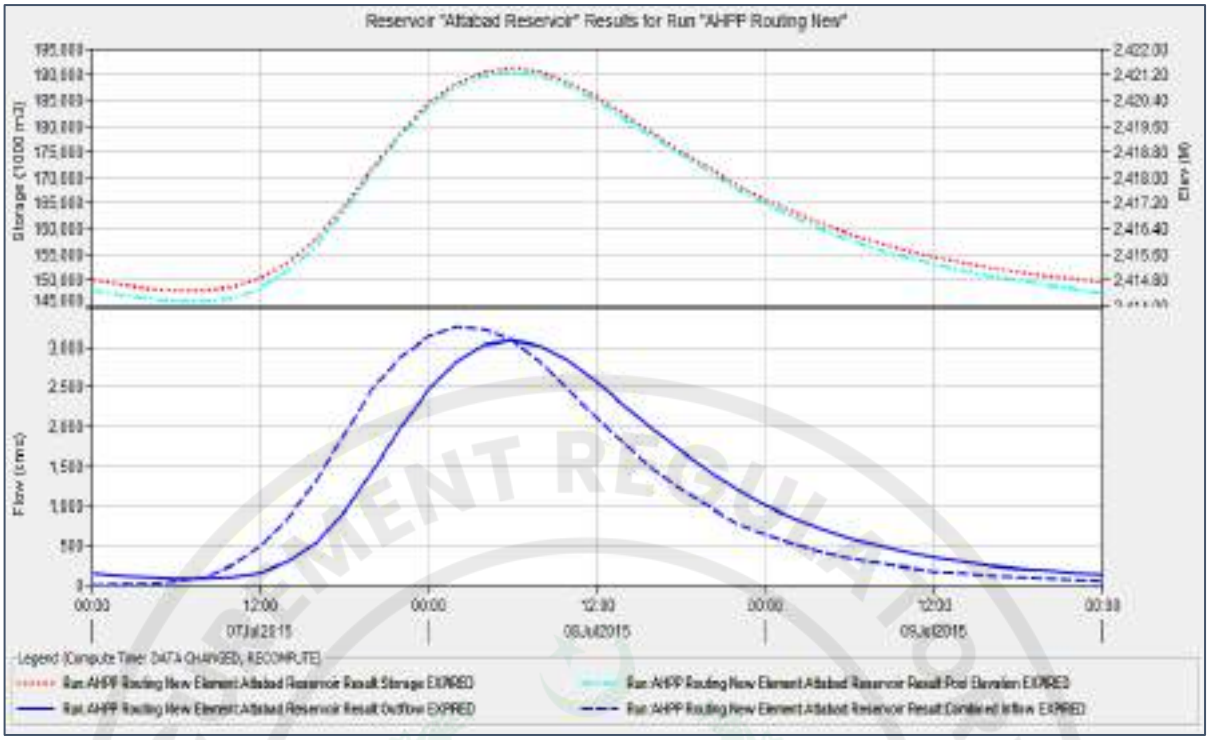


**Figure 4-17 Attabad Lake Flood Routing Graph**



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## Table 4-8 Attabad Lake Flood Routing Table

| Sr. No. | Days | Time (Hours) | Inflow ($m^3/s$) | Storage (1,000 $m^3$) | Elevation (m.a.sl) | Outflow ($m^3/s$) |
|---|---|---|---|---|---|---|
| 1 | Day-1 | 0:00 | 2 | 150,000 | 2414.5 | 142 |
| 2 | Day-1 | 2:00 | 4 | 149,094 | 2414.3 | 113 |
| 3 | Day-1 | 4:00 | 17 | 148,432 | 2414.2 | 92 |
| 4 | Day-1 | 6:00 | 43 | 148,036 | 2414.2 | 79 |
| 5 | Day-1 | 8:00 | 94 | 147,973 | 2414.1 | 77 |
| 6 | Day-1 | 10:00 | 225 | 148,508 | 2414.2 | 94 |
| 7 | Day-1 | 12:00 | 472 | 150,144 | 2414.5 | 148 |
| 8 | Day-1 | 14:00 | 832 | 153,290 | 2415.1 | 281 |
| 9 | Day-1 | 16:00 | 1,325 | 158,137 | 2415.9 | 529 |
| 10 | Day-1 | 18:00 | 1,907 | 164,555 | 2417 | 920 |
| 11 | Day-1 | 20:00 | 2,449 | 171,778 | 2418.2 | 1,430 |
| 12 | Day-1 | 22:00 | 2,867 | 178,673 | 2419.3 | 1,971 |
| 13 | Day-2 | 0:00 | 3,138 | 184,367 | 2420.2 | 2,452 |
| 14 | Day-2 | 2:00 | 3,250 | 188,414 | 2420.8 | 2,811 |
| 15 | Day-2 | 4:00 | 3,222 | 190,717 | 2421.2 | 3,021 |
| 16 | Day-2 | 6:00 | 3,074 | 191,400 | 2421.3 | 3,085 |
| 17 | Day-2 | 8:00 | 2,794 | 190,584 | 2421.2 | 3,009 |
| 18 | Day-2 | 10:00 | 2,441 | 188,462 | 2420.8 | 2,816 |
| 19 | Day-2 | 12:00 | 2,092 | 185,472 | 2420.4 | 2,549 |
| 20 | Day-2 | 14:00 | 1,763 | 182,061 | 2419.8 | 2,254 |
| 21 | Day-2 | 16:00 | 1,464 | 178,514 | 2419.3 | 1,958 |
| 22 | Day-2 | 18:00 | 1,200 | 175,013 | 2418.7 | 1,678 |
| 23 | Day-2 | 20:00 | 969 | 171,663 | 2418.1 | 1,421 |
| 24 | Day-2 | 22:00 | 775 | 168,530 | 2417.6 | 1,193 |
| 25 | Day-3 | 0:00 | 624 | 165,685 | 2417.2 | 996 |
| 26 | Day-3 | 2:00 | 504 | 163,164 | 2416.7 | 831 |
| 27 | Day-3 | 4:00 | 406 | 160,951 | 2416.4 | 693 |
| 28 | Day-3 | 6:00 | 327 | 159,014 | 2416.1 | 578 |
| 29 | Day-3 | 8:00 | 264 | 157,316 | 2415.8 | 485 |
| 30 | Day-3 | 10:00 | 213 | 155,833 | 2415.5 | 404 |
| 31 | Day-3 | 12:00 | 172 | 154,533 | 2415.3 | 341 |
| 32 | Day-3 | 14:00 | 139 | 153,393 | 2415.1 | 286 |
| 33 | Day-3 | 16:00 | 112 | 152,396 | 2414.9 | 241 |
| 34 | Day-3 | 18:00 | 90 | 151,517 | 2414.8 | 205 |
| 35 | Day-3 | 20:00 | 73 | 150,742 | 2414.6 | 173 |
| 36 | Day-3 | 22:00 | 59 | 150,071 | 2414.5 | 145 |
| 37 | Day-3 | 0:00 | 48 | 149,482 | 2414.4 | 126 |



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## 4.12 GLACIAL LAKE OUT BRUST FLOOD (GLOFS)

The most extensive glacier covers of the world outside Alaska and the Arctic is located in the Himalayan and Karakoram mountains. Pakistan is a home of more than 5000 snow reservoir and glaciers along with the second largest Siachen Glacier. The fresh water is preserved in these reservoir during the winter season and feed to the river in the summer season due to the gradual melting of ice and snow in upper parts of the country. They cover a surface area of 16,600 km2.Their runoff feeds the Hunza, Nagar, Gilgit and Indus rivers which in turn provide fresh water for about more than 100 million people residing in Indus Valley.

Lakes are water reservoirs existing in, under, beside or in front of a glacier, originated due to glacier ablation properties and retreat processes or damming of river valleys by advancing and/or surging glaciers. GLOFs result from the failure of natural dams formed from glacier ice and/or lateral and terminal moraines, which have impounded water. The moraines may be ice cored and contain unconsolidated debris, silt and large boulders. The lakes formed by these natural dams may vary in size from small marginal ice pools to lakes of several billion cubic meters.

The dams grow progressively owing to the glacier flow and deposition of debris. The advance and retreat process of a glacier contribute to the size and physical features of the moraine dams. They can rise to a few hundred meters in height. However, they are structurally unstable and likely to fail, as a result of overtopping, as a result of waves generated by avalanches and snowmelt and rainfall run-off, piping and sliding. The flood hydrographs arising from failure of glacial dams are attributable to several factors, such as the volume of the water in the lake, the height of the dam, the failure mechanism and the transient characteristics of the breach profile.

GLOFs are not a new phenomenon, however, with the current environmental and climatic changes, their probability has risen in most mountain ranges. Glacial lakes are particularly dangerous in the Karakoram ranges as they occur at low elevations and close to settlements. In some cases, potential outbursts allow only 10 to 40 minutes to trigger an alarm for the threatened population to evacuate to safety.

GLOFs can create two types of flooding:

- Upstream flooding as a result of impoundment, less dangerous for human life due to slow rise in water level but property damage can be substantial.
- Downstream flooding as a result of dam failure, significant threat to life and property.

Major glaciers of Hunza Watershed are:



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**Table 4-9 Major Glaciers of Hunza River Watershed**

| Major Glaciers | Area ($km^2$) | Length (km) | Elevations (m.a.s.l) |
|---|---|---|---|
| Hispar | 497 | 53 | 3040 - 7885 |
| Batura | 323 | 60 | 2540–7795 |
| Khurdopin | 280 | 41 | 3200–7760 |
| Virjerab | 189 | 36 | 3600–6600 |
| Yazghil | 145 | 30 | 3055–7880 |
| Barpu | 136 | 34 | 3050–7880 |
| Bualtar | 105 | 22 | 2450–7200 |

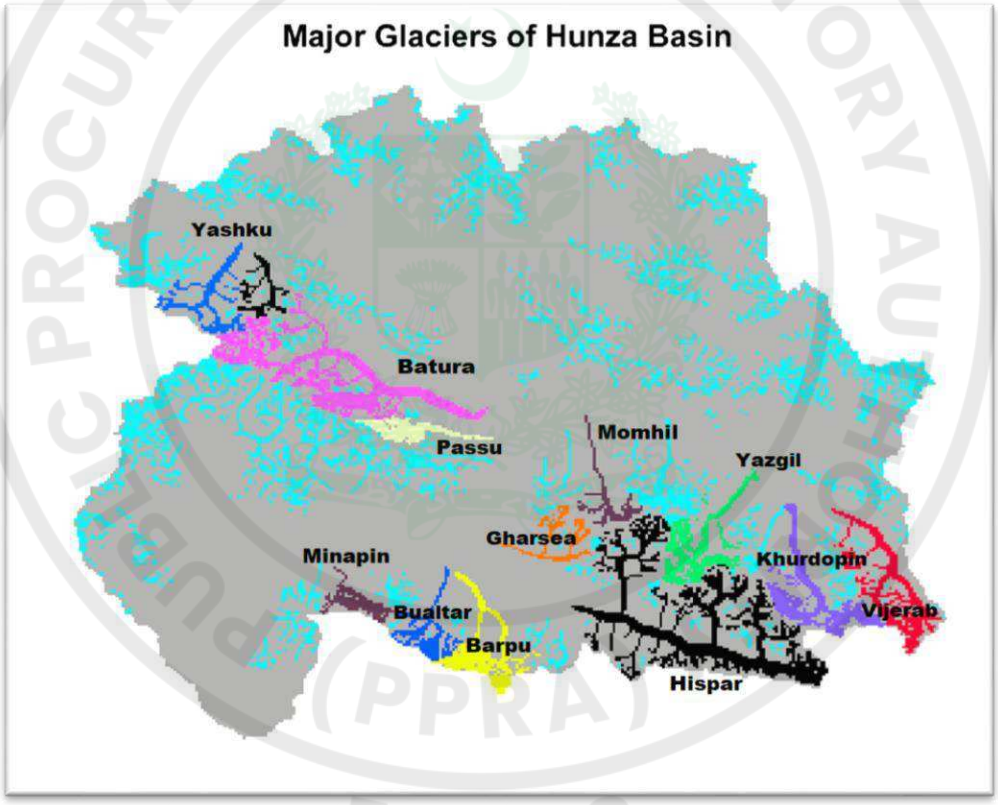


**Figure 4-18 Major Glaciers in Hunza River Watershed**



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**Table 4-10 Historical GLOFs in Gilgit-Baltistan**

| Year | Date | Glacier River |
|---|---|---|
| 1994 | 29-Jul | Sosot/Gupis Gilgit |
| 1999 | 6-Aug | Khalti/Gupis Gilgit |
| 2000 | 10-Jun | Shimshal Hunza |
| 2000 | 27-Jul | Kand/Hushe Indus |
| 2005 | 25-Jul | Sosot/Gupis Gilgit |
| 2007 | 5-Apr | Ghulkin Hunza |
| 2008 | 6-Jan | Passu Hunza |
| 2008 | 2-Apr | Ghulkin Hunza |
| 2008 | 22-May | Ghulkin Hunza |
| 2008 | 24-May | Ghulkin Hunza |
| 2008 | 14/15 June | Ghulkin Hunza |
| 2009 | 26-Mar | Ghulkin Hunza |
| 2012 | 08-Jul | Sosot/Gupis Gilgit |

Source, Archer 2001, UNDP 2007, NARC 2008, Pamir Times June 2008. FOCUS, 2012)

### 4.12.1 Update on Glacial Hazards in the Upper Indus Basin

A study has been carried out by Reynolds International, through Diamer Basha Dam Company, using numerical simulations for the possibility of GLOFs in the Upper Indus Basin and their impacts on Diamer Baha Dam Project (DBDP). Numerical simulations have highlighted that a sudden breach of Shisper ice-dammed lake under the current condition should not pose a major threat to the safety of the Diamer Basha Dam (DBD). As per the report, using observational information available for a significant outburst from Shisper Glacier in May 2020, the dataflow software simulation outputs have been cross-checked and found to give reasonable agreement. The simulation shows that the 2020 Shisper outburst, the flood would only propagate for about 20 km downstream from the source.

It is suggested to have close monitoring of Glaciers in Hunza Region should be undertaken to have better judgment of GLOFs and remedial measures for the safety of Attabad Lake and downstream areas and comprehensive study will be undertaken during Detailed Engineering Design of the Project.

## 4.13 SEDIMENTATION STUDIES

### 4.13.1 General

Most of the rivers of Pakistan carry large amounts of sediment in suspension and as bed load. Much of the land in Pakistan is highly erodible because of sparse vegetal cover, steep slopes, and non-resistant soils and rocks. As a result, serious consideration must be given to the sediment aspects of rivers and sediment records imperative for a good design of water sector and hydropower projects.



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The glacial lakes filled by moraines and ice core of retreating glaciers may breach suddenly due to unstable moraine 'dams', resulting in discharge of huge amounts of water and debris - known as 'Glacial Lake Outburst Flood (GLOF)'. The frequency of natural hazards like flash floods and GLOFs has increased in the Himalayan Region of Pakistan due to the global warming in recent decades. They often have catastrophic effects immediate downhill; even a small glacial lake associated with hanging glaciers poses high risk of a GLOF event.

According to Chaudhry, Mahmood, Rasul and Afzaal (2009), Pakistan experienced 0.76°C rise in temperature during the last 40 years. The frequency and persistence of heat waves in glaciated mountains has risen drastically causing rapid melting and sudden discharge of bulk of water to terminal lakes of glaciers increasing the risk of outburst. According to Goudie (1981) and Miller (1984), among 339 disastrous incidents identified along KKH in Hunza Valley in 1980, the most destructive ones were related to glacial movement that led to outburst floods of ice-dammed lakes.

The morphology of Hunza River has an important impact on the pattern of sediment transport. The River is a mountain river, where 98% of the catchment is built by mountains. The morphology of the River is characterized by boulders and gravels. The flow regime is mostly turbulent at lower reaches. The bed load of Hunza River and its flow regime are strongly influenced by the morphological structures of the area. The longitudinal water level profile is a parameter of the energy and shear stresses acting on the river bed and initiating sediment transport.

Sediment sources are glaciers, precipitation in the form of storms and heavy rains, hill slopes, landslides and gully erosion etc. The suspended load is influenced by availability of sediment sources and triggering events. In Karakorum and Himalayas large amounts of yearly suspended sediments per square kilometers of the catchment area (more than 2,000 tons/year/ km2) are reported in the river system. Based on the morphology, climate and flow regime of the area, the sediment load of the concerned catchment is thoroughly assessed.

The average sediment concentration is about 0.321% (by weight) or 3,210 ppm and the average suspended sediment yield per year is about 20.06 million metric tons. The observed minimum concentration is 2 ppm and observed maximum concentration is 21,300 ppm. Almost all of the suspended sediment is brought down by the river during the period of June to September. The river carries on the average, about 27% sand, 50% silt and 21% clay. The unit weight of fresh deposits of this sediment is about 1122.4 kg/m3.

### 4.13.2 Suspended Sediment Concentration

Normally, suspended sediments load and discharge observations are used to develop Sediment Rating Curve for the estimation of annual sedimentation of the reservoir. A relation between sediment concentrations and discharge is developed from available data of each year, and that relation or equation is then applied to daily flow series of each year to estimate annual sediment load at dam site. In this case for ALHPP, data of suspended load sediment concentrations is available from 1966 to 2015 at Danyor Station for the estimation of the annual suspended load calculation.

### 4.13.3 Sediment Sampling

The suspended sediment sampling of the Attabad Lake HPP at Daniyor is carried out from year 1966 to 2015. As per observed data, the number of suspended sediment observations taken



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during Low-Flows period and High- Flows periods in each year are presented below in Table 4.11.

**Table 4-11 Suspended Sediment Load Observations at Danyor**

| Year | Number of Observations During | | Total Observations | Year | Number of Observations During | | Total Observations |
|---|---|---|---|---|---|---|---|
| | Low Flows (Oct - Apr) | High Flows (May - Sep) | | | Low Flows (Oct - Apr) | High Flows (May - Sep) | |
| **1966** | 5 | 4 | 9 | **1990** | 19 | 9 | 28 |
| **1967** | 5 | 12 | 17 | **1991** | 15 | 13 | 28 |
| **1968** | 9 | 17 | 26 | **1992** | 11 | 12 | 23 |
| **1969** | 13 | 20 | 33 | **1993** | 12 | 13 | 25 |
| **1970** | 10 | 16 | 26 | **1994** | 14 | 10 | 24 |
| **1971** | 13 | 15 | 28 | **1995** | 12 | 15 | 27 |
| **1972** | 14 | 16 | 30 | **1996** | 13 | 17 | 30 |
| **1973** | 13 | 17 | 30 | **1997** | 10 | - | 10 |
| **1974** | 5 | 17 | 22 | **1998** | 12 | 10 | 22 |
| **1975** | 11 | 17 | 28 | **1999** | 9 | - | 9 |
| **1976** | 10 | 12 | 22 | **2000** | 12 | 13 | 25 |
| **1977** | 9 | 15 | 24 | **2001** | 14 | 7 | 21 |
| **1978** | 7 | 4 | 11 | **2002** | 13 | 11 | 24 |
| **1979** | 4 | 12 | 16 | **2003** | 12 | 15 | 27 |
| **1980** | 4 | 6 | 10 | **2004** | 8 | 3 | 11 |
| **1981** | 6 | 6 | 12 | **2008** | 10 | 16 | 26 |
| **1982** | 10 | 17 | 27 | **2009** | 13 | 17 | 30 |
| **1983** | 5 | 13 | 18 | **2010** | 27 | 30 | 57 |
| **1984** | 12 | 15 | 27 | **2011** | 23 | 24 | 47 |
| **1985** | 13 | 13 | 26 | **2012** | 25 | 20 | 45 |
| **1986** | 5 | 7 | 12 | **2013** | 18 | 17 | 35 |
| **1987** | 14 | 15 | 29 | **2014** | 28 | 34 | 62 |
| **1988** | 9 | 8 | 17 | **2015** | 14 | 34 | 48 |
| **1989** | 17 | 12 | 29 | | | | |

### 4.13.4 Sediment Grading

The particle size distribution of the sediment is an important parameter as it will determine the amount of the sediment that will be deposited in the reservoir and where and how long it will take to flush the reservoir. Very fine sediment may not be deposited in the reservoir and will pass through the turbines, or spilled when there is surplus inflow. On the other side, the coarsest sediment being carried by the river will be dropped first in the reservoir and will take longer to flush.

### 4.13.5 Available Data

There was limited sediment grading data available at the commencement of the study. The source of data came from the Surface Water Hydrology Project SWHP, (WAPDA) sampling at the Danyor Gauging Station between 1966 and 2015 and was in the form of proportions of sand, silt and clay, which have the following particle sizes:



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- Clay (< 0.0055 mm)
- Silt (between 0.0625 mm to 0.0055 mm)
- Sand (> 0.0625 mm)

The frequency of the readings is variable. In some years there were only a few readings and in others there are weekly readings. The percentage of sand in these readings varies between 36 and 85 %. The sieve analysis of suspended sediment samples carried out by SWHP (WAPDA) at Danyor Station showing mean fractions of sand, silt and clay of each year are given below in Table 4 12. The average percentage for all year of sand, silt and clay is 27.6 %,50.3 % and 21.6 % respectively.

As storage of a reservoir is mainly depleted due to the deposition of sand and coarse materials, while clay and fine silt remain in suspension even in low flow velocities.

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**Table 4-12 Mean Fractions of Sand, Silt and Clay at Danyor Station**

| Year | Fraction (%age) | | | Year | Fraction (%age) | | |
|---|---|---|---|---|---|---|---|
| | Sand | Silt | Clay | | Sand | Silt | Clay |
| **1966** | 24.6 | 49 | 26.4 | **1990** | 52.3 | 36.2 | 14.2 |
| **1967** | 29.9 | 50.5 | 19.5 | **1991** | 26.1 | 38 | 35.9 |
| **1968** | 33.6 | 43.2 | 23.1 | **1992** | 20.7 | 52.9 | 26.4 |
| **1969** | 32.3 | 45 | 23.8 | **1993** | 32.5 | 46 | 21.5 |
| **1970** | 28.6 | 47.5 | 19.7 | **1994** | 45.1 | 43.8 | 11.1 |
| **1971** | 32 | 49.3 | 18.7 | **1995** | 40.2 | 42.1 | 17.7 |
| **1972** | 25.5 | 51.3 | 23.2 | **1996** | 29.2 | 53.9 | 16.9 |
| **1973** | 27.5 | 54.9 | 17.5 | **1997** | | | |
| **1974** | 27.6 | 46.7 | 26.2 | **1998** | 21.8 | 59.2 | 19 |
| **1975** | 22.9 | 53.5 | 23.6 | **1999** | | | |
| **1976** | 25.3 | 44.4 | 32.8 | **2000** | 24.5 | 57.3 | 18.2 |
| **1977** | 27.9 | 41.6 | 28.6 | **2001** | 5.3 | 61 | 17 |
| **1978** | 46 | 38 | 16 | **2002** | 12.4 | 71.7 | 15.9 |
| **1979** | 27.5 | 49 | 17.8 | **2003** | 15.5 | 67.4 | 17.1 |
| **1980** | 24.8 | 61 | 14.3 | **2004** | 6 | 70.6 | 23.4 |
| **1981** | 28 | 46.4 | 25.6 | **2008** | 7.5 | 49 | 43.5 |
| **1982** | 45.8 | 41.8 | 12.4 | **2009** | 3 | 85.5 | 11.5 |
| **1983** | 25.9 | 48 | 26.1 | **2010** | 7.8 | 68.3 | 24 |
| **1984** | 45.2 | 38.4 | 16.4 | **2011** | 13.8 | 63 | 23.2 |
| **1985** | 12.1 | 52.4 | 35.5 | **2012** | | | |
| **1986** | 28.1 | 48.8 | 23.2 | **2013** | 7 | 64 | 29 |
| **1987** | 20.3 | 52.5 | 27.3 | **2014** | | | |
| **1988** | 27.1 | 46.4 | 26.3 | **2015** | 42.7 | 44.8 | 12.5 |
| **1989** | 24.3 | 47.8 | 28 | | | | |

### 4.13.6 Suspended Discharge Rating Curve

The sediment load versus river flow is a complex phenomenon. For the same value of discharge different values of the sediment concentrations in PPM can be obtained due to high variability of soil erosion on spatial and temporal scales. This is illustrated in **Figure 4 19** where discharge is plotted against observed sediment concentration in PPM to observe the variability of data. This scatter in values can be explained by initial flood flushes, the variability in the landslide triggering rates and abrasion of glacier fragments while sliding over the loose soil slopes. Intense rainfall over the lower part of watershed may also produce the variability in sediment discharges.



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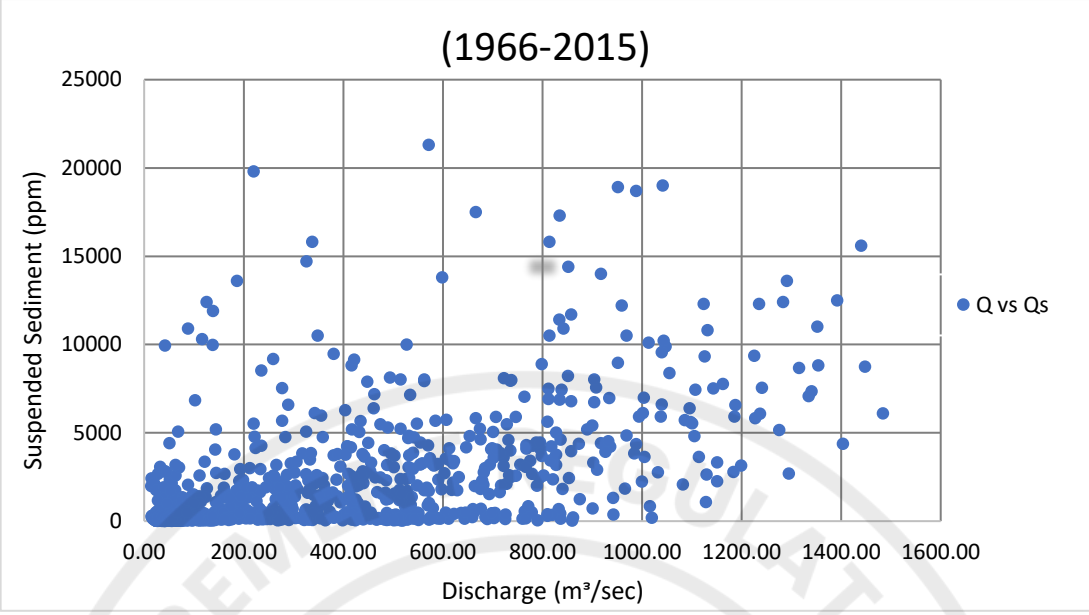


**Figure 4-19 Danyor Sediment Concentration Data**

Due to this variability, it is difficult to drive the relationship between discharge and sediment concentration as continuous and multiple recording of sediment concentrations would be required to obtain a complete understanding of the sediment regime. However, a general understanding may be obtained by pooling all the data and examining it on plot to obtain a trend line relationship, hence averaging the concentrations. Here, in this section, the suspended sediment rating curve is developed to estimate suspended sediment load at ALHPP site. The curve is developed by using data taken from Surface Water Hydrology Project (SWHP) WAPDA between sediment concentrations and corresponding discharge records as observed at Danyor station from year 1966 to 2015. The suspended sediment load in terms of metric tons per day is drown on scale against observed flows in Cumecs to get a relation between discharge (Q) vs sediment concentration (Qs) as shown is **Figure 4-20**.

The below Rating Curve is plotted based on 3 years' sedimentation concentration observations against their respective discharge. The equation of rating curve is applied to long daily flow series of each year to get annual suspended load as shown in Table 4 14 at Danyor station for year 1966 to 2015, thus the total average annual suspended load comes 33.43 Million Metric Tons with the range between 8.50 M Metric Ton and 90.35 M Metric Ton. The maximum annual suspended load for Danyor station is observed in 1978 i.e. 90.35 M Metric Ton.



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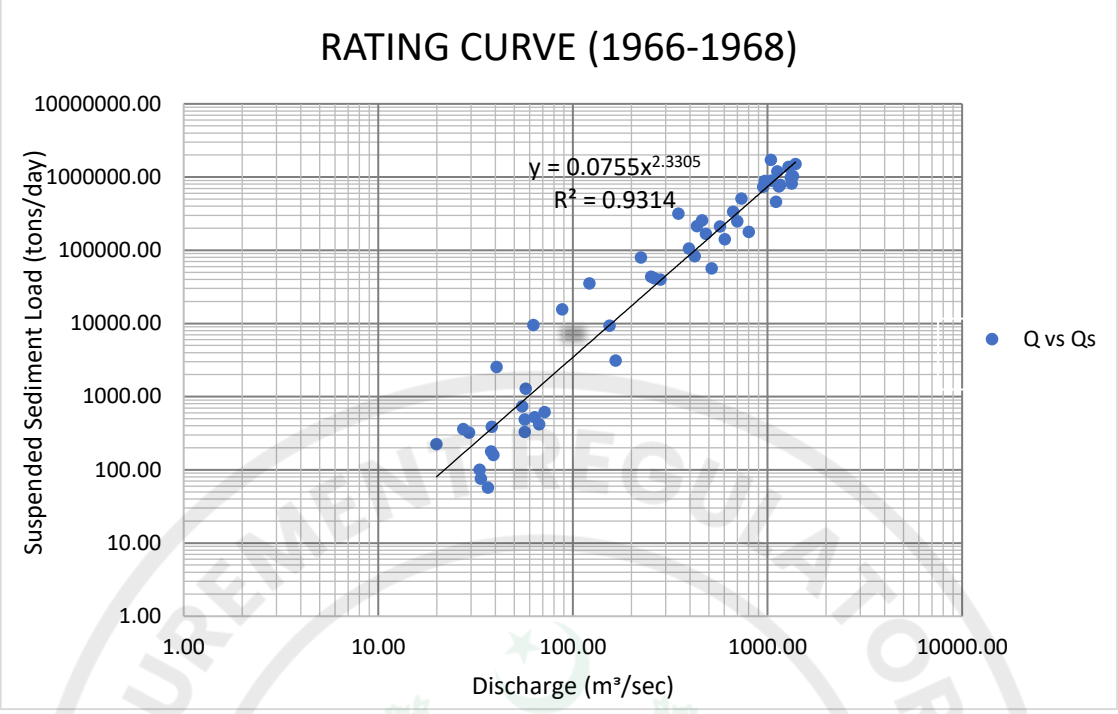


**Figure 4-20 Suspended Sediment Rating Curve at Danyor Station**

### 4.13.7 Sediment Yield

Hunza River is one of the rivers with highest annually sediment load due to major glaciers covering 18% of catchment area. Sediment load of the whole year and June to September is given in **Table 4-13** and sediment load computed at project site is available in **Table 4-14**. The table shows that river carries more than 89% sediment load during the four months of high temperature i.e. June to September.

**Table 4-13 Percentage of Sediment yield for the Period of Jun to Sep to Total Yield of Year**

| Years | Jan to Dec | Jun to Sep | Percentage |
|---|---|---|---|
| | M Metric Ton | M Metric Ton | % |
| **1966** | 46.74 | 46.44 | 99 |
| **1967** | 53.24 | 52.97 | 99 |
| **1968** | 61.58 | 61.32 | 99 |
| **1969** | 58.81 | 58.34 | 99 |
| **1970** | 58.51 | 57.73 | 98 |
| **1971** | 62.96 | 62.14 | 98 |
| **1972** | 17.36 | 17.02 | 98 |
| **1973** | 83.55 | 83.02 | 99 |
| **1974** | 23.48 | 23.13 | 98 |
| **1975** | 31.12 | 30.82 | 99 |
| **1976** | 38.37 | 37.96 | 98 |
| **1977** | 68.20 | 67.76 | 99 |
| **1978** | 90.35 | 89.77 | 99 |
| **1979** | 72.30 | 71.97 | 99 |



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| Years | Jan to Dec | Jun to Sep | Percentage |
|---|---|---|---|
| | M Metric Ton | M Metric Ton | % |
| **1980** | 30.18 | 29.70 | 98 |
| **1981** | 32.11 | 31.16 | 97 |
| **1982** | 24.38 | 23.98 | 98 |
| **1983** | 35.19 | 34.76 | 98 |
| **1984** | 44.43 | 44.30 | 99 |
| **1985** | 35.18 | 34.90 | 99 |
| **1986** | 27.06 | 26.62 | 98 |
| **1987** | 15.22 | 14.94 | 98 |
| **1988** | 32.32 | 31.84 | 98 |
| **1989** | 12.15 | 11.90 | 97 |
| **1990** | 36.59 | 35.43 | 96 |
| **1991** | 17.94 | 17.75 | 98 |
| **1992** | 15.39 | 15.14 | 98 |
| **1993** | 12.75 | 12.41 | 97 |
| **1994** | 50.29 | 49.90 | 99 |
| **1995** | 23.33 | 23.06 | 98 |
| **1996** | 18.24 | 18.04 | 98 |
| **1997** | 8.50 | 8.27 | 97 |
| **1998** | 27.70 | 27.11 | 97 |
| **1999** | 28.05 | 27.78 | 99 |
| **2000** | 17.59 | 16.54 | 94 |
| **2001** | 35.14 | 34.17 | 97 |
| **2002** | 15.47 | 15.07 | 97 |
| **2003** | 25.64 | 25.38 | 98 |
| **2004** | 12.41 | 11.93 | 96 |
| **2005** | 62.54 | 61.57 | 98 |
| **2006** | 14.29 | 12.78 | 89 |
| **2007** | 11.15 | 10.04 | 90 |
| **2008** | 31.22 | 30.64 | 98 |
| **2009** | 21.18 | 20.40 | 96 |
| **2010** | 31.13 | 30.83 | 99 |
| **2011** | 18.77 | 17.90 | 95 |
| **2012** | 19.52 | 18.93 | 96 |
| **2013** | 27.09 | 26.36 | 97 |
| **2014** | 13.93 | 13.59 | 97 |
| **2015** | 21.01 | 20.57 | 97 |

The catchment area of Hunza River at Central Hunza is 8,920 $km^2$. The bulk of runoff occurs during May to September during to snow melt.



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**Table 4-14 Annual Suspended Load of each year at Danyor**

| Year | Suspended load (M Metric ton) | Year | Suspended load Million Metric Ton(MMT) |
|---|---|---|---|
| **1966** | 46.74 | **1991** | 17.94 |
| **1967** | 53.24 | **1992** | 15.39 |
| **1968** | 61.58 | **1993** | 12.75 |
| **1969** | 58.81 | **1994** | 50.29 |
| **1970** | 58.51 | **1995** | 23.33 |
| **1971** | 62.96 | **1996** | 18.24 |
| **1972** | 17.36 | **1997** | 8.50 |
| **1973** | 83.55 | **1998** | 27.70 |
| **1974** | 23.48 | **1999** | 28.05 |
| **1975** | 31.12 | **2000** | 17.59 |
| **1976** | 38.37 | **2001** | 35.14 |
| **1977** | 68.20 | **2002** | 15.47 |
| **1978** | 90.35 | **2003** | 25.64 |
| **1979** | 72.30 | **2004** | 12.41 |
| **1980** | 30.18 | **2005** | 62.54 |
| **1981** | 32.11 | **2006** | 14.29 |
| **1982** | 24.38 | **2007** | 11.15 |
| **1983** | 35.19 | **2008** | 31.22 |
| **1984** | 44.43 | **2009** | 21.18 |
| **1985** | 35.18 | **2010** | 31.13 |
| **1986** | 27.06 | **2011** | 18.77 |
| **1987** | 15.22 | **2012** | 19.52 |
| **1988** | 32.32 | **2013** | 27.09 |
| **1989** | 12.15 | **2014** | 13.93 |
| **1990** | 36.59 | **2015** | 21.01 |
| | **Average** | | **33.43** |

The mean annual suspended load (million metric tons) as shown in above table is also presented in bar chart in **Figure 4-21**.



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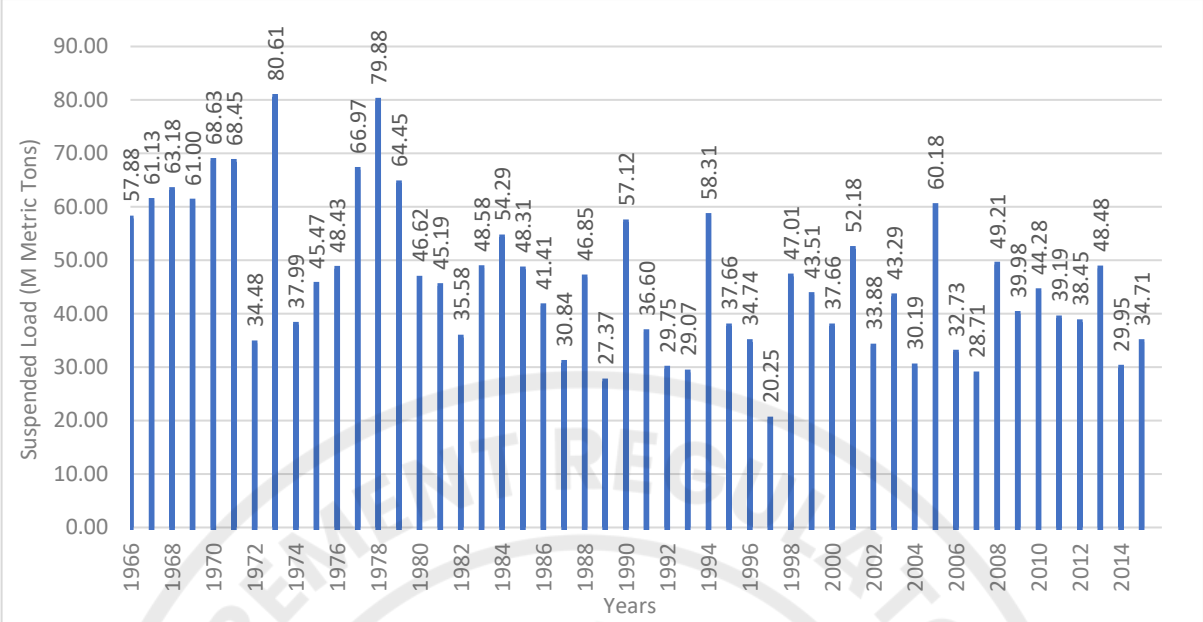


**Figure 4-21 Average Annual Suspended Sediment Load at Danyor Gauging Station.**

Average value of suspended sediment at Danyor comes out 33.43 MMT with data range 1966-2015 which falls on higher side and also differs from realistic value. To get a realistic value, we used lake capacity from recent hydrographic survey (2020), compared with 2010 capacity and do reverse calculation for sediment load which comes out about 20 MMT/year.

To remain on realistic side, we choose the period of 2011-2015 for the calculation of suspended sediment and the average of suspended sediment comes out 20.06 MMT.

### 4.13.8 Initial Density of Deposited Sediment and its Consolidation

Total sediment inflow to a reservoir is converted into volume by using the density of deposited sediment. In order to compute the initial density of deposited sediment, main factors are

i. The approach that is adopted to operate the reservoir and

ii. The texture and size of deposited sediment.

In present study, it was considered that reservoir operation is normally moderate to considerable reservoir drawdown. The same concept has also been adopted for the assessment of initial density of deposited sediment in this study. Therefore 561, 1140, and 1550 kg/m3 initial density of deposited sediment have been adopted for clay, silt and sand. The equation derived by Lara and Pemberton (1963) is used to estimate the initial density of deposited sediment which is:

$$W_o = W_cP_c + W_sP_s + W_{sa}P_{sa}$$

Where W0 is the initial density of deposited sediment, Pc, Ps and Psa are the percentages of clay, silt and sand, Wc, Ws, and Wsa are initial densities of clay, silt and sand. Initial density of the deposited sediment is thus computed as 1,122.4 kg/m$^3$.



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The accumulation of sediment deposits changes the density of previously deposited sediments. The consolidation of settled material results in an increase in density with time. Miller's (1953) equation is used for the prediction of consolidation that is:

$$W_t = W_o + 0.434 (K) (t/t-1) *((\ln t) - 1)$$

Where Wt is the average dry bulk density after t years of consolidation, Wo is initial density and k is the compaction factor based on type of reservoir operation and sediment size analysis.

### 4.13.9 Mean Annual Sediment Load

Mean annual total sediment load is normally estimated by adding unmeasured sediment bed load to the observed suspended sediment load. The sediment volume is determined from the total sediment load and the unit Wi sediment weight. The average volume of fresh sediment deposits for Attabad Lake HPP is estimated as: (20.06 MMT x 1000 kg/MT) / (1122.4 kg/m3 x 1234 m3 /acre-feet x 106) ~ 14,483 Acre-Feet/ year.

### 4.13.10 Bed Load

The sediment load of a river is one of the key variables in channel dynamics. Plan form pattern, morphology, erosion, deposition and migration of the channel are in a large part determined by the amount of sediment moved by the flow in relation to the water discharge. A river may transport sediment in two distinct modes. In bed load transport, the sediment particles travel by rolling, sliding or hops of the length of a few grain sizes (known as saltation), and they are thus in frequent contact with the channel bed. On the other hand, in suspended load transport, the weight of the particles is supported by turbulent forces in the water and they can travel considerable distances without coming into contact with the bed. Herein, the dissolved load, which can be substantial, is ignored. Grains with sizes that cannot be found in the shifting parts of the bed in appreciable quantities are known as wash load, which in general is a part of the suspended load. Whether an individual particle is transported as suspended load or as bed load depends on particle size, weight and shape and on the ambient hydraulic conditions. Bed load can be defined as the rate of movement of sediments particles along the river bed in the process of rolling, sliding and / or hopping. It is very difficult to measure bed load by sampling as we do for suspended load. As such, no practical device for measurement of bed load in the field is used by any concerned department. Consequently, estimates of bed loads are not available at any gauging site in Pakistan.

Generally, the amount of bed load transported by a large deep river varies from 5 to 25 % of the suspended sediment load. For computing the bed load, several formulas or relations have been developed by various researchers and departments. Some of the earlier formulas, such as those of Schoklitsch, and Meyer-Peter and Muller, were based purely on experimental results. However, more recent formulae such as those of Einstein have a semi-theoretical background. All these formulas involve huge amount of field data. The application of these formulas is for theoretical consideration, and may not produce satisfactory results. Thus, by using the recommended guidelines, based on experience and observations, are considered acceptable for estimation of bed load.

Two guidelines have been considered. Firstly, a guideline presented by E.W. Lane and W.M. Borland (1951) as shown in **Table 4-15**: according to these guidelines the bed load being transported by the Hunza river based on the Daniyor sediment concentrations may range from 10 to 35 %. Secondly, the USBR guidelines (1987) based on the Modified Einstein Procedure.



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In these guidelines, which are reproduced in **Table 4-16**, five conditions are given for defining bed load dependent on suspended sediment concentration and size analysis of river bed material and suspended materials. According to this procedure, Condition 2 is close to the river bed conditions. This gives a recommended range of the bed load in terms of suspended load of 10 to 35 %. In view of these recommendations, a bed load concentration of 20% of the suspended sediment has been adopted. Here to calculate bed load of sedimentation of Attabad Lake HPP, 20% of suspended load has been taken as un-measured sediment load. Therefore, the annual bed load for Attabad Lake HPP site is estimated to be 4 Million Metric Tons.

**Table 4-15 Lane and Borland Guidelines for Estimating Bed Load**

| Condition | Suspended Sediment Concentration (ppm) | Stream Bed Material | Texture of Suspended Material | Bed load in Terms of Suspended Load (%) |
|---|---|---|---|---|
| 1 | < 1000 | Sand | Similar to bed | 25 to 150 |
| | | Compacted clay | Small amount of sand | 5 to 12 |
| | | Gravel, cobbles & boulders | Small amount of sand | 5 to 12 |
| 2 | 1000 to 7500 | Sand | Similar to bed | 10 to 35 |
| | | Compacted clay | 25% sand or less | 5 to 12 |
| | | Gravel, cobbles and rocks | 25% sand or less | 5 to 12 |
| 3 | > 7500 | Sand | Similar to bed | 2 to 8 |
| | | Compacted clay | 25% sand or less | 2 to 8 |
| | | Gravel, cobbles and rocks | 25% sand or less | 2 to 8 |
| 4 | Any Concentration | Clay and silt unconsolidated | Silt and clay | < 2 |



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**Table 4-16 USBR Guidelines for Estimating Bed Load**

| Condition | Suspended Sediment Concentration (ppm) | Stream Bed Material | Texture of Suspended Material | Bed load in Terms of Suspended Load (%) |
|---|---|---|---|---|
| 1 | < 1000 | Sand | 20 to 50% Sand | 25 to 150 |
| 2 | 1000 to 7500 | Sand | 20 to 50% Sand | 10 to 35 |
| 3 | > 7500 | Sand | 20 to 50% Sand | 5 |
| 4 | Any Concentration | Compacted clay, gravel, cobbles, or boulders | Up to 25% sand | 5 to 15 |
| 5 | Any Concentration | Clay and silt | No sand | < 2 |

### 4.13.11 Trap Efficiency

Trap efficiency (TE) is the proportion of the incoming sediment that is deposited, or trapped, in a reservoir or pond:

$$TE = \frac{S_{inflow} - S_{outflow}}{S_{inflow}} = \frac{S_{settled}}{S_{inflow}}$$

Where:

$S_{inflow}$ is the sediment mass entering a reservoir (the sediment yield or delivery);

$S_{outflow}$ is the sediment mass leaving the reservoir with the outflowing water;

$S_{settled}$ is the sediment mass deposited within the reservoir.

The TE of reservoirs and ponds is dependent on several parameters (an overview of the processes taking place in a reservoir is given by Heinemann, 1984). Since TE is dependent on the amount of sediment deposited, parameters controlling the sedimentation process are very important. Therefore, the particle-size distribution of the incoming sediment controls TE in relation to retention time (i.e., the average time the incoming runoff remains in the reservoir or pond). Coarser material will have a higher settling velocity, and less time is required for it to be deposited. Very fine material, on the other hand, will need long retention times to deposit.

The particle-size distribution of the incoming sediment is dependent on the soils in the catchment that are being eroded and on the sediment delivery processes. The retention time of a reservoir or pond is related to the characteristics of the inflow hydrograph and the geometric characteristics of the reservoir or pond, including storage capacity, shape and outlet typology. A small runoff volume will have a larger retention time for a given pond than a very large runoff event, whilst the distance between the inlet and outlet controls the time it takes the runoff water to leave the reservoir or pond. The shape of the reservoir or pond (e.g., expressed as a stage-area curve) can also govern the retention time. Similarly, the location of the principal spillway can also control the retention time. If located at the bottom, the water will flow out directly while, if it is located at the top of the embankment, the runoff water will, first, have the opportunity.



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Two methods are widely being used for the estimation of trap efficiency i.e. the method of Brune (1953), which is based on the capacity-inflow ratio and the method of Churchill (1948), which is based on a sedimentation index obtained by dividing the retention period by the average flow velocity in the reservoir.

US Army Corps of Engineers (1989) developed a regression using Brune's curve to estimate trap efficiency (T.E), which is:

$$T.E = 100 \times 0.97^{0.19^{\log (S/I)}}$$

Where S is the storage and I is the inflow rate. Using this equation, initial trap efficiency is to be 58% and its value decreases as the reservoir is silted up progressively

### 4.13.12 Life Assessment of Attabad HPP Reservoir

According to UNESCO (1985), life of a reservoir is the time from first impoundment till it is filled with sediments to a certain point, where it no longer serves the intended purpose.

For Attabad HPP, initial trap efficiency was estimated to be 58%. In order to do the reservoir sediment empirical modeling, the average sediment inflows have been taken as

24.06 million metric tons. Furthermore, an initial density of 1,122.4 kg/m3 has been used for the conversion of sediment load to sediment volume. By using above sediment flow in Attabad Lake, it will be filled in 10 years. So, reservoir life of the Attabad Lake HPP is about more than 11 years without flushing. **Table 4-18** shows in detail the life of reservoir



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## Table 4-18 Life of Attabad Reservoir

| Sr. No. | Capacity | | Inflow | Cap. /Inflow | Trap Efficiency | | Annual Sediments | | Loss of Capacity | No. of Years in which capacity is lost |
|---|---|---|---|---|---|---|---|---|---|---|
| | (% age) | (MAF) | (MAF) | Ratio | From Brune | Average | Transported | Trapped | | |
| | | | | | Curve | Incremental | (MAF/Year) | (MAF/Year) | (MAF) | (Years) |
| I | II | III | IV | III / IV | VI | VII | VIII | VII x VIII | X | X / IX |
| 1 | 100% | 0.1 | 5.3 | 0.019 | 58.00% | | 0.017 | | | 0 |
| | | | | | | 56.50% | | 0.010 | 0.010 | |
| 2 | 90% | 0.09 | 5.3 | 0.017 | 55.00% | | 0.017 | | | 1.0 |
| | | | | | | 53.50% | | 0.009 | 0.010 | |
| 3 | 80% | 0.08 | 5.3 | 0.015 | 52.00% | | 0.017 | | | 1.1 |
| | | | | | | 50.00% | | 0.009 | 0.010 | |
| 4 | 70% | 0.07 | 5.3 | 0.013 | 48.00% | | 0.017 | | | 1.2 |
| | | | | | | 46.50% | | 0.008 | 0.010 | |
| 5 | 60% | 0.06 | 5.3 | 0.011 | 45.00% | | 0.017 | | | 1.2 |
| | | | | | | 42.50% | | 0.007 | 0.010 | |
| 6 | 50% | 0.05 | 5.3 | 0.009 | 40.00% | | 0.017 | | | 1.4 |
| | | | | | | 39.00% | | 0.007 | 0.010 | |
| 7 | 40% | 0.04 | 5.3 | 0.008 | 38.00% | | 0.017 | | | 1.5 |
| | | | | | | 34.50% | | 0.006 | 0.010 | |
| 8 | 30% | 0.03 | 5.3 | 0.006 | 31.00% | | 0.017 | | | 1.7 |
| | | | | | | 25.50% | | 0.004 | 0.010 | |
| 9 | 20% | 0.02 | 5.3 | 0.004 | 20.00% | | 0.017 | | | 2.3 |
| | | | | | | | | | **Total** | **11** |



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# 5 GEOLOGY AND GEO TECHINCAL STUDIES

## 5.1 GENERAL

Geologically, the Project Site is located in Karakorum Block (KB) further to the north of Main Karakorum Thrust (MKT). The Karakorum Block consists of sedimentary, metasedimentary, igneous as well as metamorphic rock, throughout its extension from Karakorum Fault (KF) in the east, Chaman and Herat Fault in west (Zanchi 1993) ranging in age from Precambrian to Cretaceous. The overburden material, consist mainly of Angular Boulder Gravel with sand and appreciable amount of fines (ABGM) and Rounded Boulder Gravels with sand and appreciable amount of fines (RBGM). The talus deposits are main constituents of ABGM and well developed mostly in Shamshal Valley and along Hunza River in upstream reaches. There are many evidences (the deposition of clayey silt along both banks of Hunza River) along the road indicate that river might be chocked many time in recent past. Prior to Attabad slide, the slope failure occurs at Salmanabad in 1958 and chocked the Hunza River.

The topography and geological conditions present in this valley indicate that it is glacial originated valley modified later on by river system. There are many glaciers that feed the Hunza River, from south to north i.e. Hassanabad, Gulmit, Gulkin, Passu, and Batura Glaciers, from right side and Shamshal Valley Glacier from left side. Morphologically the valley is lithological as well as structurally controlled. Weak lithology i,e slates as well as fault system attributed to the development of present shape of the Hunza Valley in upper reaches and near MKT.

This report is mainly based on the annotations observed during geotechnical investigations carried out at Attabad Lake Hydro Power Project (ALHPP). The geological and geotechnical investigations include Surface Geological Mapping, Drilling at weir site, sediment flushing channel/undersluice, head race tunnel and powerhouse area, and identification of borrow area for construction material. Samples collected during geotechnical investigations have been tested to ascertain geotechnical properties at Central Material Testing Laboratory (CMTL), Lahore.

## 5.2 SCOPE OF WORK

During the Feasibility Study (FS) of ALHPP, Hydro Planning (HP), WAPDA, has identified the deficiencies of geotechnical investigations in pervious Feasibility Study and carried out detailed geotechnical investigation for comprehensive FS at present. The layout plan was completely changed during present FS and investigation were conducted according to new layout. One of most important aspect is Neo-tectonic studies, because this area is affected by Attabad Slide in 2010. It is very important for the development of hydropower Project in this area to develop the understanding the Neo-tectonic setting operating under regional tectonic forces for the stability and planning of the hydropower Project. All the geotechnical data collected during geotechnical investigations have been utilized for foundation evaluation of all structures of ALHPP.

## 5.3 REGIONAL GEOLOGY

The Project Area lies in the KB bounded in north by Central Pamir through Rushan Pshart Suture, in east by KF, in the west by Herat Fault and in south by Kohistan Island Arc (KIA) through Main Karakorum Thrust (MKT) (Pashkov & Shvol'man, 1979 & 1981). The Karakorum Block have classified as a part of Gondwana Land in pre-collision history. The rocks of KB have



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stratigraphic association with rocks of Indian Plate as indicated by Paleozoic to Mesozoic sequence of both plates. It is likely to be considered that Karakorum micro plate and Indian Plate were united till Mesozoic Era.

The stratigraphic sequence of the KB is metamorphic equivalent of sedimentary rock in Indian Plate which shows that both plates have pre-collision similarities. Also the KB consists of sedimentary (well exposed is in Chitral Area along Mastuj River), igneous rocks (Karakorum Batholith) and metamorphic rock (slates, schist and marbles).

### 5.3.1 Stratigraphic Sequence

The area under study mostly includes part of the Northern Karakorum Terrain, which comprises intensively folded and thrusted sedimentary rocks with a very low metamorphic imprint, locally reaching low grade conditions (Zanchi,1993). The Lower Permian to Upper Cretaceous succession of the North Karakorum represents one of the few terrains which escaped strong metamorphism during the Indian-Eurasian collision, thus permitted a detailed reconstruction of its stratigraphic framework **(Vol-2, DWG-1301)**. Plutonic bodies mainly of mid-Cretaceous age intruded the sedimentary cover forming a discontinuous granitic belt developed about 100 km north of the Karakorum Axial Batholith (KB). Four main tectonic units have recognized in the Project Region (Gaetani et all., 1990). These include;

### 5.3.2 Misgar Unit (MU)

This unit consist mostly of slates, with few intercalations of metacarbonate quartzite and black terrigenous slates, mostly exposed at the Northern part of the Project Area. In some areas, its thickness increases up to thousand meter. It is strongly folded with intensive developed of slaty cleavage. The fold axes generally trend E-W up to the Khunjerab Pass, where they turned to NNW-SSE. The unit has low grade metamorphism indicated by chlorite, biotite, and muscovite. This unit is intruded by granitoide pluton in northern and eastern terrain having western extension up to Sost. This unit belongs to different stratigraphic formations of Paleozoic age.

The southern boundary of Misgar Unit is faulted with south vergent thrust plane, the northern fault stacking the Misgar Slate over Jurassic limestone and sandstones of Sost belt (Gaetani et al. 1990). Large recumbent folds present along the northern flank of the Chapursan Valley suggest southward movement of MUT.

### 5.3.3 Sost Unit (SU)

It consists of grey to dark grey slates, meta-limestone, and quartzite. At places, it has dolomitic patches (Gojal Formation). Some sandstone beds with slate intercalations overlain by argillaceous limestone are present (Gircha Formation). It comprises thick pile of folded and thrusted sheets forming in the whole antiformal stack, later disrupted by strike-slip faults. The unit is bounded by two major faults, the Upper Hunza Fault (Desio, 1979) to the south-east and the Northern Fault to the north. Complexity of the tectonic pattern often prevented the reconstruction of continuous stratigraphic successions, as in the Middle Late Jurassic sediments. Fold axes and fault striations along the main thrust surface generally indicate a N-S compression. The well-developed schistosity is defined by sericite, muscovite and fine grained biotite with occasional occurrence of epidote and chloritoid. This suggests that low grade condition of metamorphism with an important increase of temperature with respect to other thrust sheets of the SU. These shear zones is still poorly understood and may possibly be related to the eastward prosecution of Hunza Fault (HF) juxtaposing the Gircha Slates of Gojal



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Unit to analogues metasediments of Sost. The stratigraphic succession present in the SU spans from Permian to Late Cretaceous.

### 5.3.4 Gojal Unit (GU)

This tectonostratigraphic unit was defined by Gaetani et al. (1990) and includes the sediments lying between the KAB and the Upper Hunza Fault (UHF). It is composed by two units, a terrigenous unit (Passu Slates) below and a calcerous-dolomitic unit above. In the lower Shamshal Valley, dolomitic marbles terminate along a sub vertical NS trending fault while southward this unit is intruded by KAB. Contact metapelites generally undeformed or poorly deformed intrusive that grades into biotite, muscovite, and andalusite. Folds within the unit trend from NW-SE to NNW-SSE and are generally NE-facing. Thrust planes show the same trends and are NE-vergent, as in case of UHF.

### 5.3.5 Karakorum Axial Batholith (KAB):

The KAB crops out along the southern part of the studied area, where two major plutonic complexes were recognized, the Hunza and Batura Units (Debon et al., 1987). The Hunza Unit exists in a huge plutonic unit extending for more than 250 km, made up of medium grained granodioritic in composition, locally recrystallized. They represent a calc-alkaline association. Mafic enclaves of various sizes are abundant and a conspicuous network of Cenozoic leucocratic dykes is locally present.

The Batura Unit (BU) intrusive, spanning in age from Paleocene to Eocene, is mostly new, as well as the findings of plutonic bodies belonging to this unit in upper Chapursan Valley. The BU includes two main intrusive; the Kuk and Sarbzea Plutons.

The Kuk Pluton consists of pinkish, undeformed and unfoliated granitoides of various grain size, locally with porphyritic, microgranular and rapakivi textures. The Sarbzea Pluton mainly differs from the Kuk Pluton by its very coarse to medium grained rocks, and sometimes by the deformation it had under gone.

### 5.3.6 Ganesh Formation:

This Formation consists of pelite-psammite turbidite unit and overlying calc-pelite marble unit and are intercalated with each other. These units are metamorphosed up to upper amphibolite facies and therefore have well developed sheets of amphibolite. The formation has well developed ruby and spinal. Different mines are also established in this unit, as can be seen along road near Ganesh Bridge.

### 5.3.7 Hassanabad Granite:

It is well exposed in the Lower Hunza Valley and consists mainly of lower s-type granitoid-migmatite complex with metasedimentary enclaves. These garnet-tourmaline bearing two mica granitoids and migmatites are well exposed in Hasanabad Nullah and in Hunza Valley along Hunza River.

### 5.3.8 Chalt Formation:

It consists of dark grey quartz biotite schist with subordinate quartz, marble and conglomerate. It is exposed along overturned anticline and faulted against Dumordo Formation. Permo-Carboniferous age is assigned to this Formation.



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## 5.4 REGIONAL TECTONICS

Before the Northward flight of the Indian Plate, small continental pieces (Cimmerids, i.e. KB, Helmand Block, Hasha Block etc.) were broken up from the northern edge of Gondwana Land and welded with the southern edge of Eurasian Plate, consuming the Old Tethey and opening the Neo Tethey, (Tapponnier, 1975, 1977; Molnar, 1977a).

In general, due to the subduction of the oceanic part of the Indian Plate beneath the Eurasian Plate, the Island Arc emerged in Middle Cretaceous age. The Arc Complex consists of calc-alkaline plutonic rocks mainly mafic in nature. The presence of blue schist metamorphism in Swat and Shangla Areas indicate the trench environment.

The collision of the Indian and Asian plates has been described as a “head on” north-south collision (Shackleton and Ries, 1984). This is generally accepted by many workers to have occurred in Eocene times (55-40Ma) (Powell, 1979; Klootwijk et al, 1979; Dewery et al, 1988; Treloar and Coward, 1991; Serrle et al, 1987, 1988). The terminal collision between Indian and Asian Plates is suggested to have occurred between 45-40 Ma (Molnar and Tapponnier, 1975; Klootwijk et al, 1985). It is generally agreed, however, that by 55Ma, the Kohistan Island Arc (KIA) was already sutured to the Asian Plate, probably since the Late Cretaceous, forming the MKT zone. This is confirmed by the presence of 85-80 Ma thermal event at this time (Treloar and Rex, 1990). The collision between the Indian Plate and KIA is recognized as when the Tethyan Ocean disappeared and the continental masses docked. Following features recognized the main arguments for the Eocene age of collision: -

- Sediments deposited on the northern margin of the Indian Plate being of Eocene age.
- Subduction of the oceanic crust stopping, as recognized by the end of calc-alkaline magnetism north of the Indus Suture.
- The blue schist facies are not developed along MKT zone showing the collisional belt.
- Slowing down of the Indian Plate motion, as recognized by magnetic anomalies.
- After collision, continued suturing occurred, associated with a 35˚ anticlockwise rotation of the Indian Plate relative to Eurasia. As a result of collision mighty mountain ranges of Himalayas were developed having Island Arc Sequence in the North.

Anticlock wise rotation of Mega Lhasa followed the Late Triassic docking of the Iranian Spur, using the later as pivot. The rotation was completed during the Middle Jurassic, when SE Pamir, Shaksgam and Karakorum joined the Qiangtang, more closely assembling Mega Lhasa as it approached the Asian margin (Maurizio Gaetani, 2007). The KB bounded in the East by KF, in the North by Rushan- Pshart Suture, in the west by Herat Fault and in south by MKT.

Structurally the KB is characterized by broad asymmetrical to tight, isoclinal folds which are commonly imbricated. A number of large regional scale thrust faults, e, g. the Tirchmir Fault, Reshun Fault, Baltit Fault, UHF, and Chapursan Fault and the MKT extends for a distance up to 100 km or more. The KB has undergone multiple deformations since the Cambrian. Parts of the KB have undergone at least four more deformations since the Kohistan-Karakorum collision from Paleocene to Pliocene.



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After the collision, due to further northward subduction of the Indian Plate, still active 2-2.5 mm/yr, the stresses were accommodated by the imbricate thrust faults from north to south (Treloar et al, 1989). The collisional history along with metamorphic events, trapped many clues between these fault systems. These are very useful to delineate the historic events and to reveal the movement of Indian Plate, collision environment and modern deformational style.

## 5.5 REGIONAL FAULTS

The major regional faults of the region include, from north to south, the MKT, Main Mantle Thrust (MMT), Panjal Thrust (PT), Main Central Thrust (MCT), Main Boundary Thrust (MBT), Kashmir Boundary Thrust (KBT) / Himalayan Frontal Thrust (HFT) and Salt Range Thrust (SRT) **(Vol-2, DWG-1302)**.

Along with these regional faults, many local faults were developed to accommodate the regional stresses, these may be thrust fault or strike slip fault in nature. In most of the area many small scale strike slip faults are associated with the thrust faults to accommodate the deformation.

The general trend of these faults excluding MKT is predominantly east-west with change in trend due to syntaxial bends. The general description of these major faults is as follows: -

### 5.5.1 Karakorum Fault (KF)

Dextral Strike Slip fault of about 800 Km long bounds western Tibet. The KF represents a much younger terrane boundary, juxtaposing rocks of the Ladakh and Saltoro Blocks to those of Karakorum terrane. U-Pb zircon age of leuco-granites intrusion shows that it must, therefore, be younger than 15Ma old. Movement on the fault displaces the sequence approximately 200-250Km to south eastern Tibet where the regional rock sequence can be regained (Burtman et al. 1963, Srimal 1983). It merges at the confluence defining a triple point and three blocks; the Ladakh block to the south, Saltoro block to the northwest, and the Karakorum block to the northeast.

A number of tele seismic events have occurred along the fault. Interpretation of seismic data from 1975 Kinnaur earthquake confirms right-lateral strike slip motion on this fault. Three events were recorded from KF Zone at the head of the Nubra Valley, since 1980, recorded by portable seismic stations, established by International Karakorum Project (IKP). It is seismically an active fault.

### 5.5.2 Upper Hunza Fault (UHF)

It is east west trending thrust fault that runs along the depression formed by the Chapursan and Upper Yarkhun Valleys (Zanchi 1973, Kazmi 1979b, Gaetani et al. 1995). In this region it runs parallel to the northern margin of the KAB. Southeast of Morkun (upper Hunza) three tele seismic events of magnitude 5-7 and focal depth of less than 50km have been recorded. These epicenters form a cluster very close to the mapped trace of the UHFt. It means that the northern and western margin of the KAB is characterized by active zone of faulting along Upper Hunza-Reshun Fault zone.

### 5.5.3 Main Karakorum Thrust (MKT)

The MKT is a low angle mega-shear with strike slip component, which on eastern side passes through Machlu in Hushe Valley, Shigar Valley, Zuhri Brook in Shyok Valley and Chalt in Hunza



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Valley extends westward through Ishkuman, Yasin and Shishi Valleys **(Vol-2, DWG-1302)**. Its general trend swings between E and E-NE at low to medium dips towards the north. It is believed that this fault is seismically active.

### 5.5.4 Main Mantle Thrust (MMT)

The MMT, which is aligned with the Nanga Parbat-Haramosh tectonic line on east, span an area of about 400 km through Diamer, Kohistan, Swat, Dir and Banjaur Areas, before entering Afghanistan **(Vol-2, DWG-1302)**. The general trend of MMT is NE-SW. It is located along the contact of the mafic/calc-alkaline meta igneous rocks and the meta-sediments belonging to the Indo-Pakistan continental mass. Along this megashear near Jijal Village on Indus River (right bank), the igneous rocks have over thrusted the meta-sediments to the south over a 10-15 km wide zone. The thrust also manifests as the broad high topography of Kohistan relative to the Hazara adjacent to the south. In addition, numerous auxiliary fractures are developed and across the thrust frequent brecciation and mylonitization are also present along the contact. It is seismically active fault.

## 5.6 SITE GEOLOGY

### 5.6.1 Soil Units

The recent deposits are the most widely spread soil units overlies the bed rocks. The slopes are covered with overburden having variable thickness. Terrace deposits comprise of mixtures of clay, sandy silt, boulders and gravel in various proportions. These units include ABGM, RBGM, Terrace deposit and Moranic deposits. These units are mostly present in Aliabad, Karimabad, Nagar and Gojal Areas **(Vol-2, DWG1305 to 1324)**.

### 5.6.2 Rock units

The main rock units exposed in Project Area explored during neo-tectonic study are as follows:

IX. Granitic gneiss

X. Granodiorite

#### 5.6.2.1 Granitic Gneiss

It is light grey to grey in color on fresh surface and weathers to light brown, coarse to very coarse grained, moderately to highly jointed, highly sheared up to higher elevation due to faulting, sparsely to moderately weathered, moderately hard to hard. It has well developed foliation with trending value N61ºW and plunging value 79ºNE. It is exposed at the right as well as at the left bank of the Hunza River. Some shear zones are also present with in the unit **(Vol-2, DWG-1305 to 1324)**.

On the basis of petrographic analysis, it is evident that the major constituents' minerals present in granitic gneiss are quartz, oligoclase, biotite while amphibole, chlorite, muscovite, epidote, and tourmaline are present as minor constituent minerals. The high percentage of quartz grains show strong strain extinction, indicating that this unit has Alkali Silica Reaction (ASR) potential. The rock may therefore not be used as a coarse aggregate with Ordinary Portland Cement (OPC) or High Alkali Cement. It may be used with low alkali cement, slag cement or cement with additives likes fly ash, pozzolan. Some chemical additives like lithium nitrate or silica fume can also be used to control this reaction. The Schmidt Hammer values ranges from **35** to **45**



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**MPa** indicating that rock is moderately strong to very strong. But in some shear zone where rock is tectonized locally, this value reduces up to **18-22 MPa**.

#### 5.6.2.2 Granodiorite

It is dark grey to blackish grey in color, weathers to brownish grey, medium to coarse grained, moderately weathered, moderately hard to hard, moderately jointed intruded by pegmatite and granitic gneiss. It is foliated with trend and plunge values of N60ºW/79ºNE. Further downstream it becomes light grey to grey in color, coarse to very coarse grained. It is crushed, mylonized, and sheared at places. It is well exposed at both banks where it is intruded by many pegmatite dykes. Some shear zones are also present in this unit.

On the basis of petrographic analysis, it is evident that granodiorite is quite dominate in the Project Area. The major constituent's minerals present in this unit are plagioclase, quartz, biotite, and amphibole while Iron, muscovite, chlorite, and epidote are minor constituents. The high percentage of Quartz grains show strong strain extinction, indicating that this unit has ASR potential.

## 5.7 GEOLOGICAL STRUCTURES

As the Project Area has undergone multiple episodes of tectonics events, many regional as well as local faults and their splays have formed. Many thrust fault systems related to regional faults are present in the Project Area. There are many faults present in the vicinity of proposed ALHPP **(Vol-2, DWG 1305-1324)**. These faults are splays of MKT and Karakorum Strike Slip Fault, and lies in between these two fault systems. Some of these faults have been observed during surface geological mapping and marked on geological maps **(Vol-2, DWG-1305 to 1324)**. The brief description of these units are: -

#### 5.7.1.1 Attabad-Hispar Valley Fault

It is thrust fault striking N30°E and dipping 40°SE, and is well exposed at the left side slope near the Project Area **(Vol-2, DWG-1305 to 1324)**. This fault crosses the Hunza River and forming a junction point with Hunza River and Attabad Fault in Attabad Village. The whole rock mostly granitic gneiss along its alignment is sheared / brecciated, forming fault breccia at many places. Due to high degree of shearing, many active slides have been originated along the slope. Rolling down of large boulder is quite common, and can be seen on old KKH. The retaining wall along this slide is fractured/jointed into parts due to operational stresses and downslope load movement. The ABGM along the slope is folded. It is clear indication that this fault has some movement, and is seismically active.

#### 5.7.1.2 Attabad Fault

This thrust fault is striking N60°W and dipping 52°NE, exposed in area at rear side of Attabad Village. It is a small scale fault and terminates along junction point of three faults. A large brecciated and sheared rock is present along this thrust fault. At the junction point of these faults **(Vol-2, DWG-1305 to 1324)**, a large slide originated and destroyed about 2 Km of KKH. Sheared and brecciated rocks can be seen on outcrop at right side slope up to higher elevations in **(Vol-2, DWG-1305 to 1324)**.



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#### 5.7.1.3 Attabad River Fault

The exposure of this fault is present at right side slope of Hunza River. The breccia is well exposed at right side, just downstream of Sarat Suspension Bridge. The intensity of brecciation increases towards Salmanabad Village. In fact, Salmanabad Village was founded on this breccia. It may be present up to higher elevation **(Vol-2, DWG-1305 to 1324)**.

## 5.8 GEOLOGICAL & GEOTECHNICAL INVESTIGATIONS

## 5.9 SURFACE INVESTIGATIONS

The surface investigations / observations are one of the most important tools to reveal the geological conditions prevailing at the site. The natural processes operating on surface left clues to unfold the environments present in ancient time. During FS, surface geological mapping is carried out to record the geological conditions and to assess the deformation status of rock units exposed in the Project Area

### 5.9.1 Surface Geological Mapping

The surface geological mapping of the Project Area has been carried out on 16 Nos. topographic sheets prepared by Survey Division Peshawar, HP on scale 1:1000 with contour interval of 2m, with the help of Total Station, Plane Table and Brunton Compass in the field and presented at scale of 1:2000 **(**Photo 5.1**)**. The contacts between different rock units e.g. granitic gneiss and granodiorite as well as between different soil units have been marked. Structural features like joint sets, faults, foliation and shear zones along with dip and strike values have been marked on these sheets **(Vol-2, DWG-1305 to 1324)**. Four Nos. geological cross section were prepared along different alignments including, weir site, power tunnel intake area, and penstock alignment & powerhouse area.

**Photo 5-1 Surface Geological Mapping**

### 5.9.2 Neo-tectonics Study

During the FS, the understanding the Neo-tectonic setting operating under regional tectonic forces for the stability and planning of ALHPP has been studied in detail. The area under study has covered by the two Nos of GT sheets 42 L/15 and 42 L/11 at scale of 1:50,000, covering 40



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km upstream and 50 km downstream of slided mass. These GT sheets were enlarged and printed at scale of 1:15000 and presented at scale of 1:30000, and used in field for alignment of local as well as regional faults **(Vol-2, DWG-1335 to 1337)**.

## 5.10 SUBSURFACE INVESTIGATIONS

Sub-surface geological and geotechnical investigation program was prepared to probe the sub-surface foundation conditions at weir site and its appurtenant structures including borehole drilling and test pits excavation. Drilling of exploratory bore holes was executed by Drilling Division, Hydroplaning, and supervised by Directorate of Geology, Hydro Planning WAPDA, Lahore.

### 5.10.1 Drilling

The main objective of drilling was to determine the nature and engineering characteristics of soil and rock units at Weir site and its appurtenant structures. It was performed to observe the subsurface geological conditions at depth in order to find out nature of the different strata in subsurface, to estimate the behavior and nature of overburden material, the depth of water table encountered. A total 06 bore holes with total drilling of 401m have carried out for subsurface exploration at different structures i,e Weir site, Sediment Flushing Channel (both at intake and outlet), Power tunnel alignment, Power house and tailrace area **(Vol-2, DWG-1330)**. The coordinates, structure, and depths of borehole are given in **Table 5-1**;

**Table 5-1 Co-ordinates of Boreholes**

| Sr. No | Bore hole | Depth (m) | Northing | Easting | Elevation (m) | Location |
|---|---|---|---|---|---|---|
| 1 | BH-1 | 90 | 4018100.45 | 484075.46 | 2415.79 | Weir site (Left abutment) |
| 2 | BH-2 | 60 | 4017996.26 | 484089.59 | 2452.81 | Sediment Flushing Channel (Intake Area) |
| 3 | BH-3 | 61 | 4018061.58 | 483541.73 | 2456.92 | Sediment Flushing Channel (outlet Area) |
| 4 | BH-4 | 80 | 4017721.34 | 482609.57 | 2445.37 | Power Tunnel Alignment |
| 5 | BH-5 | 50 | 4017906.94 | 481690.72 | 2318.04 | Power House area |
| 6 | BH-6 | 60 | 4017906.55 | 481605.02 | 2313.84 | Power House area |



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**Photo 5-2 Drilling Rig at BH-02 Sediment Flushing Channel**

Permeability tests were performed using constant head method in overburden material at 3m interval whereas water pressure tests (Lugeon tests) in bed rock were performed at interval of 5m or at change of strata. Rock core and soil samples were collected from all the bore holes at various depths for lab testing. All the tests have been conducted at CMTL, WAPDA Lahore. The logs of drilled bore holes were prepared, Permeability values in overburden material and lugeon values in rocks were calculated and discussed structure wise and presented in **Volume 4B.**

The Standard Penetration Test (SPT) has been carried out in boreholes in overburden which mainly consists of Silty Sand with clay intercalations. The Cone Penetration Test (CPT) have been carried out in boreholes in gravelly Silty Sand with clay intercalations. CPT relied upon to provide information about the properties of soils / weak rocks. In foundation designs, SPT in overburden material, blow counts (N Values) are typically used to estimate nature and strength properties of soils to calculate the bearing capacity for foundation. The results are presented in bore hole logs **Volume 4 A**.

### 5.10.2 Test Pits

Ten test pits (3×3×3) m have been excavated in overburden material at weir site, slope along sediment flushing channel and power house area. Composite samples by con and quarter method from each test pit has been collected. Different tests have been conducted on these samples to estimate the engineering properties of the material.

To identify and proven source for coarse as well as fine aggregate, four test pits have excavated. Samples collected from these pits have been tested at CMTL, WAPDA, Lahore to check their suitability for fine as well as coarse aggregate. The logs of test pits have been prepared and presented in **Volume 4A.**

### 5.10.3 Laboratory Testing

Different rock core samples, to investigate the engineering properties of rock as well as soil (from test pits) at weir site, sediment flushing channel, power tunnel and powerhouse i have



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been tested at CMTL, Lahore, to envisage their engineering properties and to check its suitability as construction material.

A total ten rock core samples from BH-04 (Power tunnel alignment) selected for evaluation of geotechnical engineering parameters for design purpose. The table below shows the testing program proposed in BH-04 at different depths.

Fifteen samples, i.e. 3 Block Samples and 3 samples from borrow area and 9 test pit samples have been selected for investigation. Samples from all tests pits have been selected by cone and quarter method and different test have been proposed to check their engineering properties and confirm their suitability as aggregate material.

All the laboratory tests on rock core samples were conducted in CMTL, WAPDA, Lahore. The detailed results are presented in laboratory testing **Volume 4B**.

## 5.11 GEOLOGY AND FOUNDATION EVALUATION

On the basis of surface geological mapping, geological x-sections, borehole logs, test pits excavation and laboratory test results, the foundation evaluation of various engineering structures proposed for ALHHPP have been made and described in the following sections: -

## 5.12 WEIR SITE

The surface geological mapping of the main weir area has been carried out at scale of 1:1000 with the help of Total Station, Plane Table and Brunton compass and presented at 1:2000. A geological X-section along line AA` has been developed and presented as drawing **(Vol-2, DWG-1326)**. The main purpose of geological x-section is to estimate condition prevailing in subsurface i.e. overburden thickness, extension / alignment of faults, extension / trend of rock units in the subsurface strata.

**Photo 5-3 View of Weir Site.**

An overtopping concrete weir founded on slided mass is proposed after foundation treatment. Geological rock units with which weir has to be abut, includes granodiorite, intruded by



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pegmatite veins at right side. On left side weir has to be abut with ABGM formed by slided mass **(Vol-2, DWG-1309 & 1310)**. Some treatment / engineering solution have to be implemented for stability of the weir. A borehole BH-1, has been drilled at left side slope to investigate the subsurface geological conditions.

**Table 5-2 Permeability Values in Soil and Rock**

| PERMEABILITY TEST IN OVERBURDEN | | PERMEABILITY TEST (Lugeon) IN ROCK | |
|---|---|---|---|
| $<10^{-6}$ | Impervious | 0 to 5 | Low Permeable |
| $10^{-6}$ to $10^{-4}$ | Semi-pervious | 5 to 15 | Slightly Permeable |
| $>10^{-4}$ | Pervious | 15 to 25 | Permeable |
| | | >25 | High Permeable |

No rock has been encountered in this borehole up to 90m. The core recoveries CR (%) are graphically presented in **Figure 5-1.** The permeability test was conducted after every 3 meters, in most of test head could not be maintained due to cavities encounter in subsurface strata.

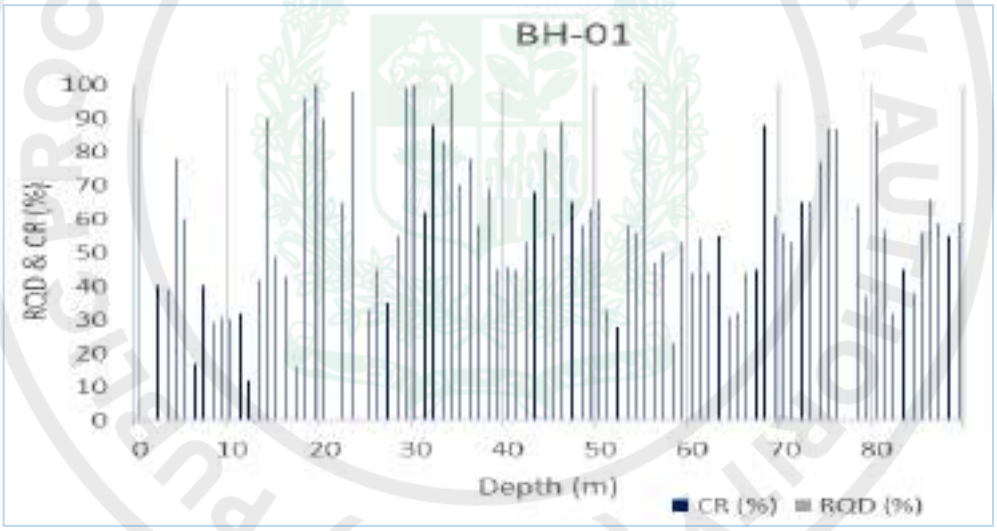


**Figure 5-1 Graphical Representation of CR Vs Depth of BH-01.**

It is noticed that head could not be maintained throughout the drilling of borehole. 100 % water loss has been observed throughout drilling activity. It indicates that slided mass is highly permeable with large cavities and open works as also testified by cementing job to stabilize the bore holes during drilling.

## 5.13 INTAKE AREA

The surface geological mapping of the intake area has been carried out at scale of 1:1000 and presented at 1:2000. A geological X-section along line BB` has been developed and presented as drawing **(Vol-2, DWG-1327)**



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**Photo 5-4 Proposed Intake Area for Power Tunnel**

The main purpose to develop geological x-section is to estimate condition prevailing in subsurface strata i.e. overburden thickness, extension/alignment of faults, and extension/trend of rock units. The intake area is proposed at the left side of the Hunza River. Granodiorite rock is exposed at steep angle where rock is hard, massive, strong to moderately strong with Schmidt hammer values ranges from 40 to 58 MPa **(Vol-2, DWG-1307&1310)**. The rock in foliated where platy minerals are aligned in specific orientation with trending at N42°W and plunging at 52°NE. Granodiorite is hard, strong to moderately strong, and sparsely to moderately jointed **(Photograph 5-4)**. But at higher elevation the rock is highly jointed and sheared, having vertical open joints which must be treated for stability and safety purpose.

## 5.14 POWER TUNNEL

It is observed during surface geological mapping that a fault is running obliquely across the alignment of power tunnel alignment **(Vol-2, DWG-1308,1309,1312,1315,1316 &1319).** A geological X-Section CC` has been developed to estimate the subsurface conditions and presented as **(Vol-2, DWG-1315).** The power tunnel has to be excavated mostly through the granodiorite with subordinate granitic gneiss at the left side slope of Hunza River. The strength of rock reduces downstream and near the termination point of slided mass, brecciated/ gaugic rock is present/exposed **(Vol-2, DWG-1315).** Rolling down of large boulders are quite common at this point. The rock units are quite crushed, sheared and brecciated forming active slides throughout its alignment.

A borehole BH-04 has been drilled to estimate the rock conditions in the subsurface strata. Lugeon test has been conducted in the field to check the permeability condition of the rock mass at every 5m interval. On the basis of data collected during borehole logging, a graph has been developed between depth Vs Rock Quality Designation (RQD) and Core Recovery(CR) and presented as **(Figure 5-2)**.



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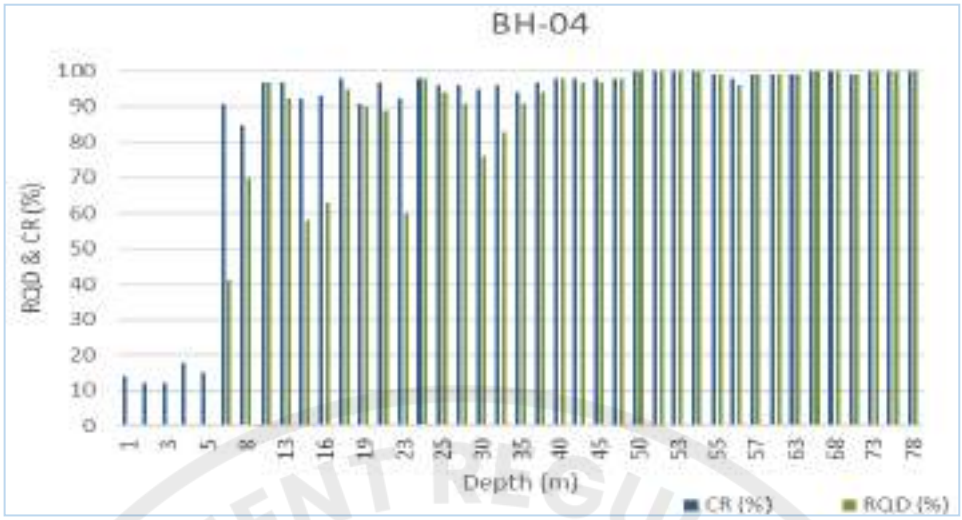


**Figure 5-2 Graphical Representation of RQD&CR Vs Depth of BH-04.**

During drilling work, it is estimated that the RQD values in upper 23m is moderately low after that the value increases/improved up to 100%. The lugeon values calculated after every 5m interval indicate that rock is low permeable. It shows that rock in sparsely jointed in subsurface. The lab test results indicate that RQD is quite high in lower portion but the strength index is moderate. The value of all test indicates that the rock in BH-04 is moderately hard and moderately strong with low cohesion “C” and low angle of internal friction “Ø”. While excavating through this portion, some treatment is required to enhance the stability of structure.

## 5.15 UNDER SLUICE SECTION/SEDIMENT FLUSHING CHANNEL

The surface geological mapping of the power tunnel alignment has been prepared at scale of 1:1000 in the field and presented at 1:2000. It is proposed at the left side of Hunza River **(Photograph 5-5)**. It is observed during surface geological mapping that the sediment flushing channel has to be excavated through ABGM of slided mass **(Vol-2, DWG-1309&1310)**.

Slided mass covers an area of about 1 Km and consists of huge volume of ABGM. One of the difficult and critical task is to stabilize the both side slopes along the sediment flushing channel. The large boulders of more than 25 m in length are present in slided mass. Benching in one of the best solution for such type of slope to stabilize. At some place, mashing or gabion may be helpful for slope stabilization/protection.



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**Photo 5-5 Intake Area of Sediment Flushing Channel.**

To investigate the nature of material exposed at left side slope, borehole BH-2 and BH-3 have been drilled at outlet and intake of sediment flushing channel respectively.

Permeability tests were performed at every 3m interval. It is noticed that throughout the borehole drilling, head could not be maintained and 100% water loss is observed during drilling.

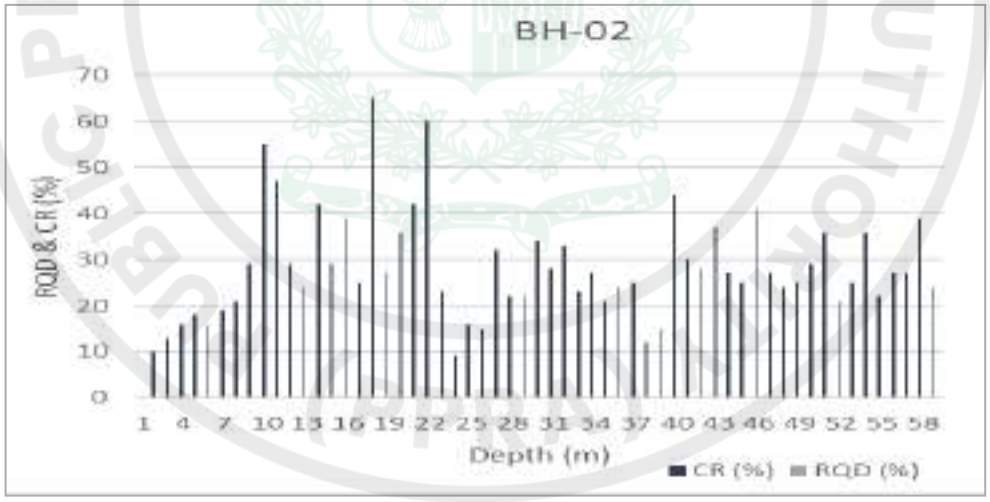


**Figure 5-3 Graphical Representation of CR Vs Depth of BH-02.**

On the basis of data collected during borehole logging, a graphs have been developed between depth Vs RQD and Core and presented as **Figure 5-3 & 5-4**.



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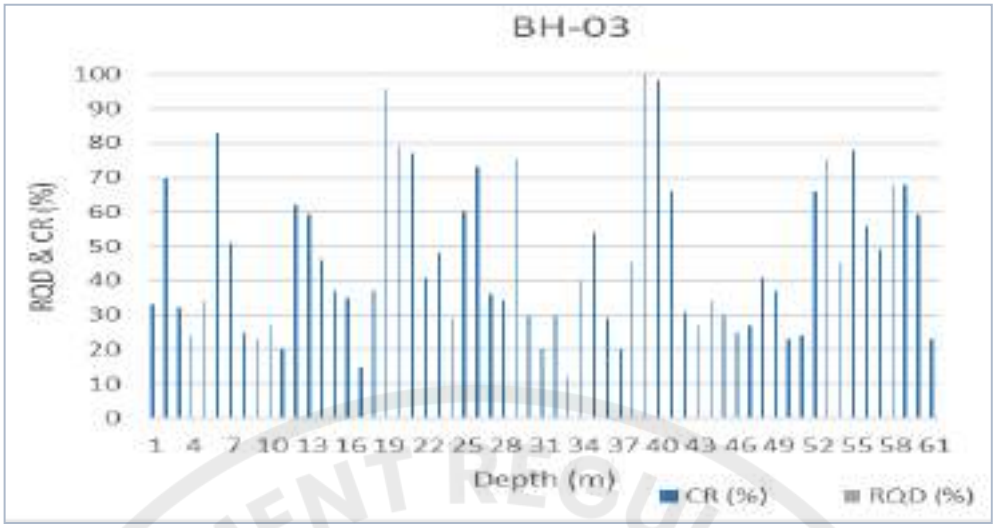


**Figure 5-4 Graphical Representation of CR Vs Depth of BH-03.**

Permeability tests have been performed at every 3m interval. These values indicate that the material is highly pervious.

It is clear from the drilling logs that rock is not encountered upto 60.0m in both boreholes. The drilling data and lab test results show that the boulders of overburden material ABGM) are hard and moderatly strong. The slope can be stablized by benching, but the permeability in BH-02 is quite high as head could not be maintained throughout drilling while in BH-03 is value shows that strata is pervious.

## 5.16 SURGE TANK AND PENSTOCK ALIGNMENT

It is proposed at the left side of Hunza River **(Photograph 5-6)**. It is observed during surface geological mapping that the granodiorite rock with granitic gneiss is exposed in surge tank area. It is moderately hard, sheared and highly jointed **(Vol-2, DWG-1319)**.

**Photo 5-6 Proposed Area for Surge Tank.**



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From surge tank 450m long penstock with diameter of 3.6m is proposed up to power house. Piers will support penstock alignment. The foundation of piers will be laid on overburden material **(Vol-2, DWG-1318 & 1321)**. The presence of clayey silt may create problem and might be removed prior to establish foundation for piers **(Photo 5-7)**.

**Photo 5-7 Proposed Alignment of Penstock**

## 5.17 POWER HOUSE

The surface geological mapping of the power tunnel alignment has been carried out at scale of 1:1000 and presented at 1:2000. It is proposed at the left side of Hunza River on a flat area **(Photo 5-8)**.

**Photo 5-8 Proposed Power House Aarea.**

It is observed during surface geological mapping that thick clayey silt has been deposited having depth of about 30 m as confirmed by drilling (BH-5 & BH-6). It is interbedded in upper



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layers by RBGM while pure clayey silt is found in depth. It is deposited due to choking of Hunza River due to Salamanabad Slide **(Vol-2, DWG-1321).** A geological X-section DD` has been established to estimate the sub surface conditions and presented as **(Vol-2, DWG-1329).**

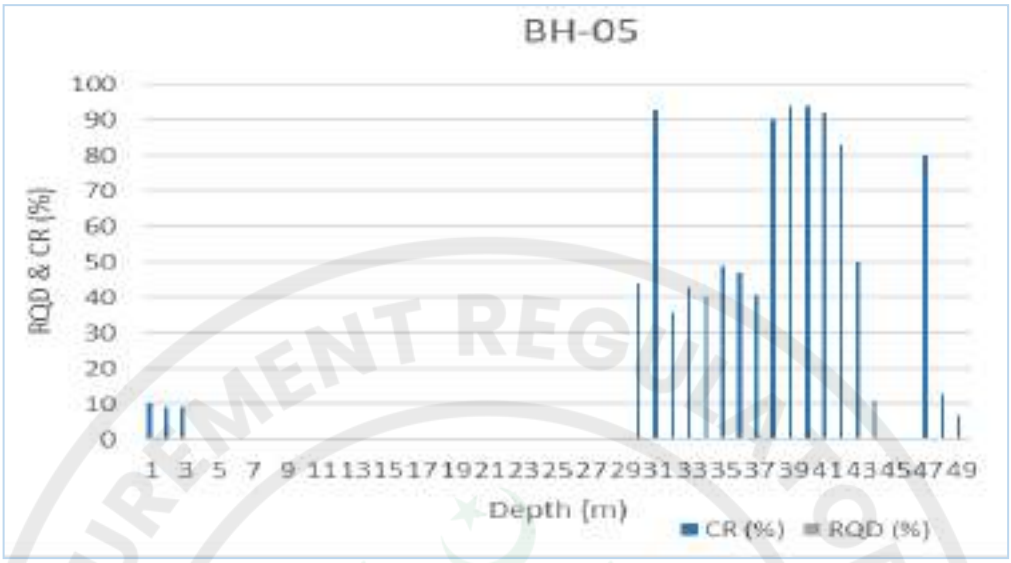


**Figure 5-5 Graphical Representation of CR Vs Depth of BH-05.**

To explore the nature of material present in subsurface, two boreholes, BH-05 and BH-06 with drilled depth of 50 m and 60 m respectively, have been drilled at powerhouse area. The summary of these boreholes is given in Figure 5-5 and 5-6.

On the basis of data collected during borehole logging, a graph has been developed between depth Vs CR and presented as **Figure 5-5**. Permeability tests have been performed. On the basis of data collected during borehole logging, a graph has been developed between depth Vs CR and presented as **Figure 5-6**. Permeability tests have been performed at every 3m interval

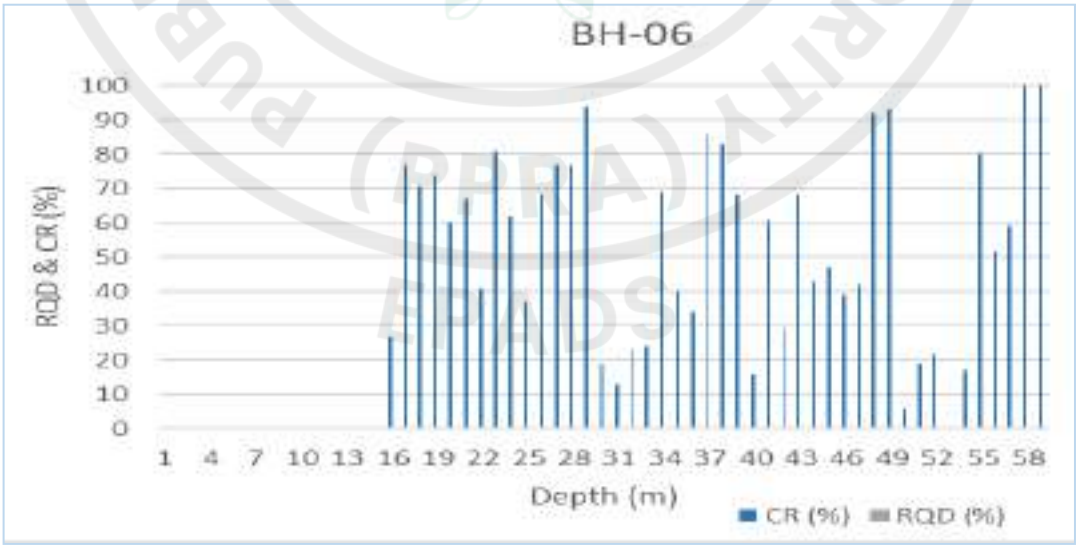


**Figure 5-6 Graphical Representation of Depth Vs CR of BH-06.**

It is clear from the drilling data that about 15 m and 30 m clayey silt have been encountered in BH-06 and BH-05 respectively. SPT have been conducted in the clayey silt for 18 inches'



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penetration in these boreholes. It is estimated from this data that firm to stiff clayey silt is present. The permeability test conducted in this strata show that they have relatively high hydraulic conductivity. The lab test results indicate that the clayey silt has swelling potential.

Foundation of the powerhouse will be laying on overburden material. The whole thickness of clayey silt layer has to be removed/excavated prior to establish the foundation for power house.

## 5.18 TAILRACE CHANNEL

The surface geological mapping of tailrace channel has been carried out at scale of 1:2000. It is proposed at the left side of Hunza River. It is observed during surface geological mapping that the whole channel has to be excavated through the overburden material **(Vol-2, DWG-1321)**. Water after generating electricity will again fall into Hunza River near Sarat Village suspension bridge.

## 5.19 CONSTRUCTION MATERIAL

The rocks granodiorite and grantic Gneiss are exposed in/near the Project Area. Both are acidic rocks and cannot be used as coarse aggregate with Ordinary Portland Cement (OPC) due to Alkali Silica Reaction (ASR). Both rocks show deleterious quartz more than 5%. However, a huge outcrop of marble is exposed in/near Passu Village. More over ten test pits have been excavated for the study of aggregate material and foundation condition. These were excavated in river bed, slided mass and fine deposits near old Chinese Camp in power house area. Samples of marble has been collected from Passu Area to conduct laboratory testing in CMTL WAPDA, Lahore.

## 5.20 FINE AGGREGATE

Two types of fine aggregate sand and clayey silt have been selected for testing and proven source for fine aggregate. Samples were collected from 0 to 3 m depth (by coning and quartering method) for laboratory testing at CMTL, WAPDA, Lahore.

### 5.20.1 Sand Quarry

To fulfil the quantity of sand material during construction of ALHPP, ample quantity of this material is deposited in the tail area of Attabad Lake near Shishkat Bridge **(Photograph 5-9)**. A test pit TP-1 has been excavated, for sampling for lab testing. Log of test pit is given in **(Volume 4A)**. Gradation test indicates that 99% sand with only 1% silt and clay is present. The results of Accelerated Mortar Bar indicate minimum average expansion (0.039) for 28 days. Specific gravity and water absorption values also fall in permissible limits. The results of lab testing is provided in **Volume 4B.**



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**Photo 5-9 Quarry Area Selected for Sand Near Shishkat Bridge.**

The lab. test results show that it can favorably be used as sand quarry site during construction of ALHPP.

### 5.20.2 Silt and Clay Quarry

For fine aggregate (Clayey silt) three test pits 3x3x3m have been excavated to analyze the nature of material present in river bed. Two test pits TP-2 & TP-3 in Helipad/power house area and TP-10 near Klin area, near Ganesh Bridge, have been excavated to asertain the subsurface geological conditions prevailing in the area **(Photograph 5-10 & 11)**. Both composite as well as block samples from each test pit have been collected for lab testing.

**Photo 5-10 TP-3, Excavated for Clayey Silt in P/H area.**



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**Photo 5-11 View of Clayey Silt in P/H area.**

Lab test results indicate that the material consists of clayey silt with clay index ranges from 40- to 45%. Atterberg Limits and Swell Potential shows that some treatment may be needed prior to their use. Results of Modified Proctor Test on block and composite samples indicate that Max Dry Density (MDD) 1.7 to 1.8 mg/m$^3$ for clayey silt can be attained in range of 10 to 13% Optimum Moisture Contents (OMC). The laboratory test results can be seen in **Volume 4B**.

Another huge source of borrow area for silt and clay is present at brick kiln near Ganesh Bridge along KKH. It lies in economic haulage. A test pit TP-10 has been excavated in clayey silt and two block samples have been collected from this pit and sent to CMTL to conduct different tests. The log of test pit is presented in **Volume 4A.**

It indicates from lab test results that, clayey silt is present and can be used as fine aggregate material i.e. blanket material to minimize the seepage. The ratio of silt and clay naturally present in 60 and 40% respectively. It is present in adequate quantity in P/H area and near Ganesh Bridge.

## 5.21 COARSE AGGREGATE

The rock units exposed in the Project Area are acidic in nature on the basis of silica contents i.e. granodiorite and granitic gneiss. Due to sliding of huge mass down slope, large material is deposited in foothills which chocked the Hunza River. For coarse aggregate, three sites have been selected. Samples from slided mass, powerhouse area/river bed and Passu Area has been tested at CMTL, WAPDA, Lahore.

### 5.21.1 Passu Area

It is located about 35 km upstream of Attabad Lake along KKH near Passu Village **(Photo 5-12)**. Bulk samples have been tested at CMTL, WAPDA, Lahore. Petrographic analysis shows that marble is exposed. It consists of 97% of calcite, with specific gravity 2.84 and 0.37 water absorption, Los Angeles Abrasion has uniformity of wear 0.20, Crushing Value 24, with Flakiness Index of 22. Sulphate Soundness Test result has weight percent loss 0.89 **(Volume 4B)**.



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**Photo 5-12 Exposure of Marble in Passu Village Area.**

The laboratory test results indicate that the rock mostly consists of calcite with no ASR and no Alkali Carbonate Reaction (ACR). This material has no deleterious quartz, therefore it can be use with OPC. The values of tests results fall in permissible limit, therefore, it can be used as coarse aggregate for concrete with OPC.

### 5.21.2 Power House Area

Large quantity of RBGM is deposited near old Chinese Camp along old KKH route. Bulk sample from TP-2 has been tested at CMTL, WAPDA, Lahore. **(Photo 5-13)**.

**Photo 5-13 View of RBGM in TP-2 at P/H Area.**

It consists of marble, granite, granitic gneiss, with some slate pieces. As per lab. test results, material has specific gravity 2.78 with 0.33% water absorption. Los Angeles Abrasion value with uniformity of wear is 0.20, Crushing Value is 27, Flakiness Index is 21. Sulphate Soundness value is 0.81 and average expansion for 28 days in Accelerated Mortar Bar is 0.099, and Point Load Index is 4.15 MPa **(Volume 4B)**.



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Petrographic analysis indicates that the rock is mostly granitic in composition and has more than 20% deleterious quartz, therefore, it cannot be used with OPC. To minimize the ASR, low alkali cement, cement with some additives like slag, fly ash, pozzolan can be used. Some chemical additives like lithium nitrate or silica fume can also be used. The finalization of the additive material depends upon the other strength and expansion tests during concrete mix design. Moreover, all the values of other tests fall in permissible limit, therefore, it can be used as coarse aggregate material for concrete with OPC by abiding the exceptions as described above.

### 5.21.3 Slided Mass

Sample from TP-7 have been collected to conduct different lab tests **(Photo 5-14)**.

Petrographic analysis shows that rock is granodiorite and has more than 20% deleterious quartz and cannot be used with OPC. Point Load Strength test result is 5.94 with diametrically failure, Specific Gravity 2.72 and Water Absorption 1.04%. Los Angeles Abrasion Test show 0.41 uniformity of wear, Crushing value 22 with Flakiness Index of 21. The value of Sulphate Soundness Test for this material is 1.87 **(Volume 4B)**.

**Photo 5-14 View of Slided Mass in TP-6 at Left Side Slope of Hunza River.**

Higher Los Angeles Abrasion, Sulphate Soundness and presence of deleterious quartz values, shows that this rock cannot be favored to be used as coarse aggregate material when compared with other two quarry sites. Thus this material is not recommended as coarse aggregate for concrete works.

## 5.22 BUILDING STONE

The granodiorite and granitic gneiss rocks are available in the Project periphery, for masonry works in sufficient quantities. Moreover, the large boulders, present in slided material can be used as rip rap material. To control the erosion/ wave action of water, this material has high strength UCS value ranges up to 72 MPa in TP-8. Similarly, the values of Property Index Test, Los Angeles Abrasion Test fall in permissible limits. The slided mass may therefore be used as rip rap material.



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## 5.23 FILL MATERIAL

For protection works along slopes and structures, shoulder fill, construction of coffer dams, fill material of heterogeneous nature e.g. silty sand, sandy silt, gravelly sand etc. is available in river bed as well as in slided mass (**Photo 5-15**). This material is present in ample quantities in the economic haulage of the Project Area.

**Photo 5-15 Fill Material (Boulder and Gravels) in Slided Mass.**

The test pits excavated in the powerhouse area / river beds shows that large quantities of gravels and cobbles with subordinate sands are present. This material satisfy the quality test , therefore it can be used as fill material.

## 5.24 CEMENT AND STEEL

Cement and steel is required in adequate quantity for the construction of ALHH. The cement should be supplied from nearby cement factory. The most nearer unit of cement is situated in Haripur/WAH areas includes Askari Cement, Wah cantt unit with capacity of 3500 Ton/day; Fauji cement near Fateh Jang has two units one with 3500 ton/day and other with 6700 ton/day. It can be considered for the supply of cement

The steel has to be transported from Rawalpindi to fulfil the requirement of the Project. It is suggested that laboratory tests on representative samples should be carried out to determine the engineering characteristic of cement and steel prior to their use.



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# 6 NEO TECTONICS AND SEISMIC HAZARD ANALSIS

## 6.1 GENERAL

A large slided mass move down and chock the Hunza River and KKH for more than 2km in January 2010 from right side near Attabad Village. This large slide causes a 25km long lake to develop upto Khyber Village in Gojal. Due to excavation and development of channel through this slided mass, the level of lake decreases down and extension reduces upto Shishkat Bridge. This large mass slided down due to some regional stress operating in this region. To understand these regional forces and their effect and vulnerability of expected slope material to slide, a Neo-tectonic study was conducted.

During the Feasibility Study, the colossal slide and as a result damping of Hunza River in 2010 has made the Neo-tectonic studies as core point. It is therefore, very important for the development of hydropower project in this area that understanding of Neo-tectonic setting should be explore to know the regional tectonic forces. Regional tectonic forces responsible for the massive slide, affecting project area severely as indicated by diverse features.

## 6.2 OBJECTIVES

Main objectives are:

- Evaluation of the regional tectonic setting of the area and recognition of fault (regional or local) which may act as a seismic source.
- Detailed investigation of the fault geometry, alignment, and structural deformations associated with these fault. These may include shear zones, fault bend folds, active slides and fault breccias.
- Recognition of active fault zones and their distinction from older, dormant fault zones.
- Assessment of the vulnerability of neo-tectonic activity along the fault/slides around the project area so that the movement along the affected area may be predicted.
- Identification of deformation/displacement in recent deposits to evaluate the activity of area.

## 6.3 METHODOLOGY

An array of activities including literature review, image analysis, field studies and data compilation is involved in Neo tectonic evaluation as per standard practices in Industry. These include:

- Collection of previous research on regional as well as on local geology, geomorphology and tectonics of project area.
- In-depth studies on satellite image analysis using GIS techniques by applying various image-enhancing techniques e.g. Digital Elevation Model (DEM) have studied, the lineaments and faults on regional as well as on local scale were recognized.



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- Detailed geological map of the project site, regional and local faults within the vicinity covering the upstream and downstream of the project area have been marked on GT sheets at scale of 1:15000 in the field area to understand the trend of regional tectonic forces.

- During field visit keen concentration has been given to characterize the kinematics of fault where possible e.g. sense of fault (Strike and Dip), alignment and type of fault, through and heave, dip direction and other associated characteristics.

- Development of fault-source map indicating various regional scale faults that may contribute seismic affect in the project area.

- The relationship of older tectonic features to the recent ones.

- Field evidences of Neo-tectonic features have captured in photographs including active slides, tiltness in recent deposits, folding, faulting, step fault, fault associated folding in recent deposits, topographic features including drainage pattern at slopes and abrupt shifting of river/stream course.

## 6.4 FIELD OBSERVATIONS

This study covers the 30 km upstream and 30km downstream of the project site covering the both banks of the Hunza River. Different features related to Neo-tectonics activity have been observed during site visit. In this study the focus was given to the recent deposits, at the both bank of river.

The main objective of the Neo-tectonic study was to identify/observe the feature of active tectonic events occurred in recent past about 0.1Million years ago. There are many field observations regarding the Neo-tectonic activity. Some of the Neotectonics features/observation are as under: -

- The tiltness in recent deposition, i.e. to study the slopes of gravels, clays, and sand layers w.r.t slope of the stream beds.

- Intersection of faults in recent deposits i.e. lacustrine deposits, terraces/ alluvial deposits or in any cultural features (houses, roads). The amount of displacement, Heave as well as Throw measurement, dip and strike of the fault.

- The presence of active slide zones.

- The displacement /uplift in fluvial as well as lacustrine deposits on each side of the lake/stream and magnitude of its displacement.

- Identify the zones of brittle as well as ductile deformation.

- To observe the movements along slicken sides / fault / joints blocks.

- The presence of hanging valley along the main streams

- The presence of escarpment slope along the plainer area



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- The presence of hanging valleys /cirques along main stream, in series and presence of waterfalls along it.

- Folding/bending in the recent deposits (alluvium, morainic, lacustrine).

The Neo-tectonic features at the right as well as left bank of Hunza River in different village from upstream to downstream **(Vol-2, DWG-1335 to 1337)** is described below: -

### 6.4.1 Passu Village:

Passu is one of the largest village in Gojal valley situated at the right bank of Hunza River along KKH about 35km from Attabad site. The great Passu Glacier, 56km in length is present near the village. Many deformational evidences were observed in recent deposits along the road.

- 2-3km Upstream of Passu village

N 4038610.325m

E 489292.583m

Ele. 2470.03m a s l

The coordinates measured by mobile topographer application.

A large deposit of RBGM material is present along the right side slope of the river along KKH. This material consists mostly of gravel, cobble, and pebbles with subordinate sandy material. Some inclinations in these deposits have been observed along roof and sole beds. This inclination varies from 15° to 35° layer-by-layer **(Photo 6-1).**

**Photo 6-1 Inclined Gravel Layer under Effect of Shearing.**

Some shearing effect has been chronicled along these planes in numeral layers. This shows that the area is tectonically active.

The clay deposit is overlain by morainic material of Batura Glacier. The clay deposits are tilted upward at an angle ranging from 10° - 15°. The area has undergone compressional regime, which uplifted the clay beds **(Photo 6-2)**



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**Photo 6-2 Recumbent Fold Strata with Crenulation in Limbs in Clay Strata.**

The clayey strata is folded with straight horizontal limbs and horizontal hingline. This shows that the horizontal compressional stress is applied on this material that turned this unit into folded strata **(Photo 6-3).** Many micro folds (crenulations) in both limbs of fold are present. The Hinge area toward outer layers are point out, that intense compressional stress is applied to the strata.

**Photo 6-3 Stylolite/Pressure Solutions in Clay Strata.**

The strata show some stylolite structures that are formed by expulsion of water through pressure solutioning. Alignment of wavelength and geometry of Hinge area indicates that the compressional stress is applied horizontally **(Photo 6-4)**. This shows that the recent stresses are functioning in this area.

Many joints are developed in the clay beds showing that there are relative movement in blocks along the plane, which might be act as micro faults **(Photo 6-5)**. The relative movement of hanging wall block moves down relative to the footwall block, signposted the development of Normal Fault.



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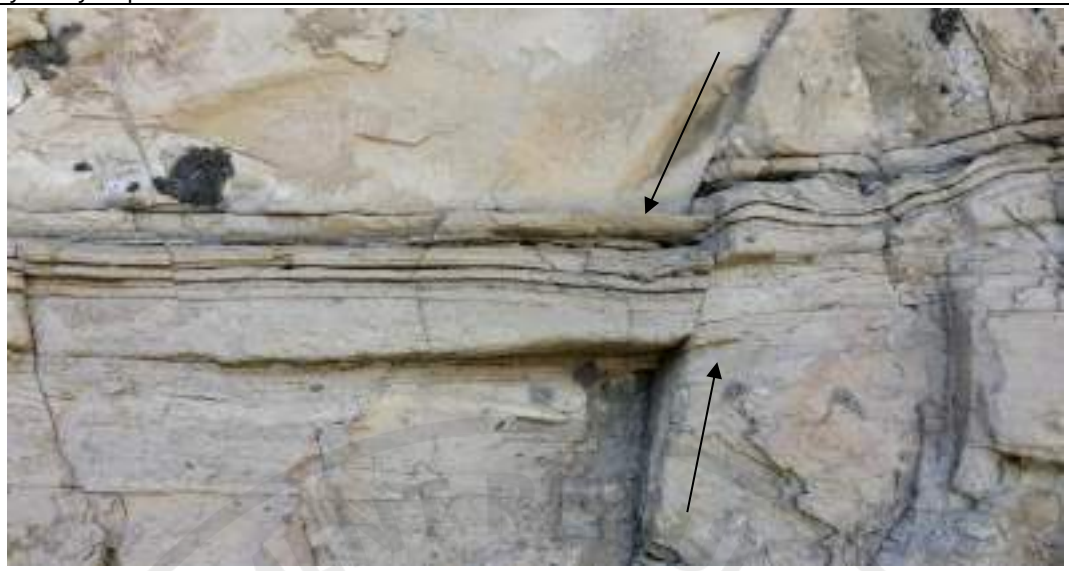

**Photo 6-4 Micro Fault in Clay Beds.**

At the same location there are cross cutting faults, dipping towards each other in clay beds. The block between two micro faults moves downward forming Graben structure while the block, that cannot move forming Horst structure **(Photo 6-5)**.

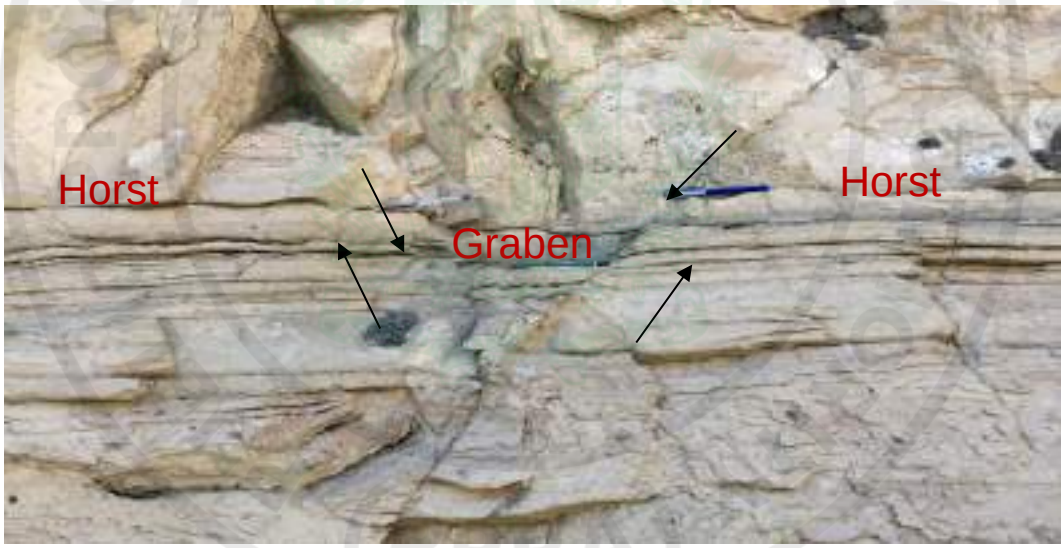


**Photo 6-5 Horst and Graben Structure along Micro Fault in Clay Beds.**

The formation of these structures in clay bed shows that there is relative movement along the micro faults in recent deposits.

The development of these Normal Faulting system in such compressional regime indicates that these deposits are under such environment where two thrust faults dipping toward each other are present. The upthrown block between these two faults undergone extensional regime where normal faults are developed. This indicates that this area is under active tectonics regime.



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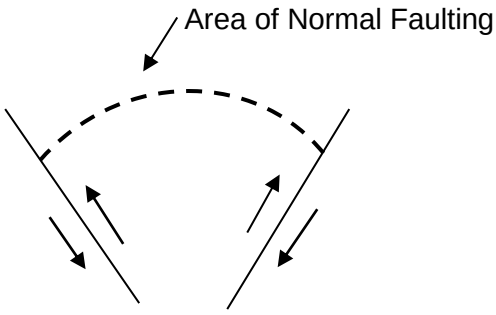


**Figure 6-1 Development of Normal Faults under compressional regime.**

### 6.4.2 Road section from Murradabad to Hussani Village:

Coordinate

N 4033080.557m

E 489417.275m

Ele. 2656.69 m a s l

Just upstream of Hussani village a large mass of ABGM and Brecciated rock is exposed along the road. It is present in the alignment of thrust fault where crushed marble is in contact with Passu Slates. The faulted contact between slate and marble is well exposed along road **(Photo 6-6)**.

**Photo 6-6 View of Brecciated Rock Upstream of Passu Village.**

In this area two faults are intersecting each other, one is striking N60°E and dipping 40°NW while other is striking NW and dipping NE **(Vol-2, DWG-1335)**. Due to these faults discrete hillocks have formed with thin overburden overlain by fault breccia. At few feet away from breccia, a slided material consist of ABGM is present along road. Apparently this material seems to be stable but in excavated portion, this material is folded. Compressional forces are responsible for this deformation exposed at slope **(Photo 6-7)**.



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**Photo 6-7 View of Folded ABGM Just Upstream of Passu Village.**

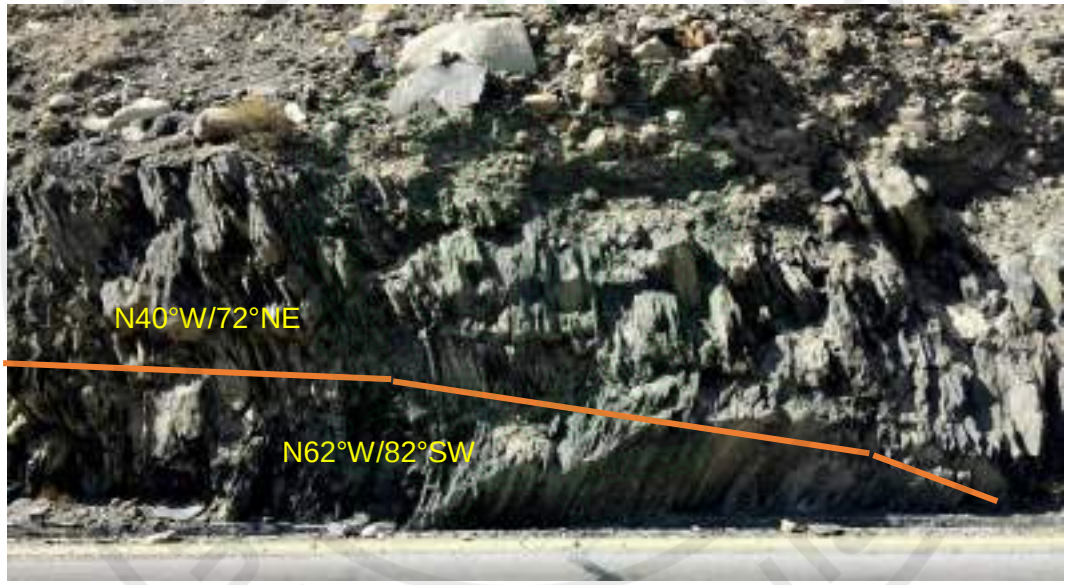


**Photo 6-8 Change of Dip along Shear joint.**



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Rock (Passu Slates) is locally folded, some shear joints along which the cleavage plane (originally bedding planes) across shear joint has different dip values. The overall strike of slates is NW and Dipping in NE. but along this shear joint some movement took place and the value of dip changes from SW to NE **(Photo 6-8)**. Change of sense of dip along the shear joint shows that some shear forces are active in the area. The development of such joints indicate the brittle deformational style.

### 6.4.3 At Sarat Village:

Coordinates:

N 4018254.850m

E 481549.816m

Ele. 2371.35m a s l

Due to Salmanabad slide in 1858, a large lake developed in upstream reaches. The depositional clayey silt can be seen on both bank of Hunza River. Due to operational neo-tectonic forces, deformation including folding, jointing, micro faulting has been developed in these deposits.

Both vertical and oblique joints can be seen in clayey silt at right side near Sarat suspension bridge. The strike and dip values of vertical and oblique joints are N38°W/87°NE and N32°E/63°SE respectively **(Photo 6-9)**.

**Photo 6-9 View of Vertical and Oblique Joints in Clayey Silt at Sarat Village.**

Clayey silt beds are striking N 80°E and dipping 18°NW at the left side of road to Sarat Village while at the right side of the road these beds have strike N 32°E and dipping 9°SE **(Photo 6-10 & 6-11)**.



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**Photo 6-10 Tiltness in Clayey Silt Beds, Left Side of Road at Sarat Village.**

The strike of the beds is NE while the dip is in opposite direction, indicating that it forms some sort of antiform. Formation of antiform in recent deposits clearly indicates that lateral shear compressional force are operational in this area.

**Photo 6-11 Tiltness in Clayey Silt Beds, Right Side of Road at Sarat Village.**

Just downstream of Sarat village near the suspension Bridge, fault breccia is exposed along the river showing the alignment of fault.



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**Photo 6-12 Folded and Sheared Clayey Silt at Sarat Village.**

**Photo 6-13 Sheared and Smeared Clayey Silt at Sarat Village.**

**Photo 6-14 Fault Breccia just D/S of Suspension Bridge at Sarat Village.**



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Folding, jointing, smearing and shearing of clayey silt **(Photo 6-12, 6-13, 6-14)** deposit shows some lateral stresses are actively operating in this area. The active slides and rolling down of brecciated material from this slope indicate that it is tectonically active area.

### 6.4.4 Inside Tunnel 2:

Many cracks/joint are going to develop in the concrete specially in crown area in tunnel-2. The pattern of the cracks indicates stress release and shear oblique joints **(Photo 6-15)**.

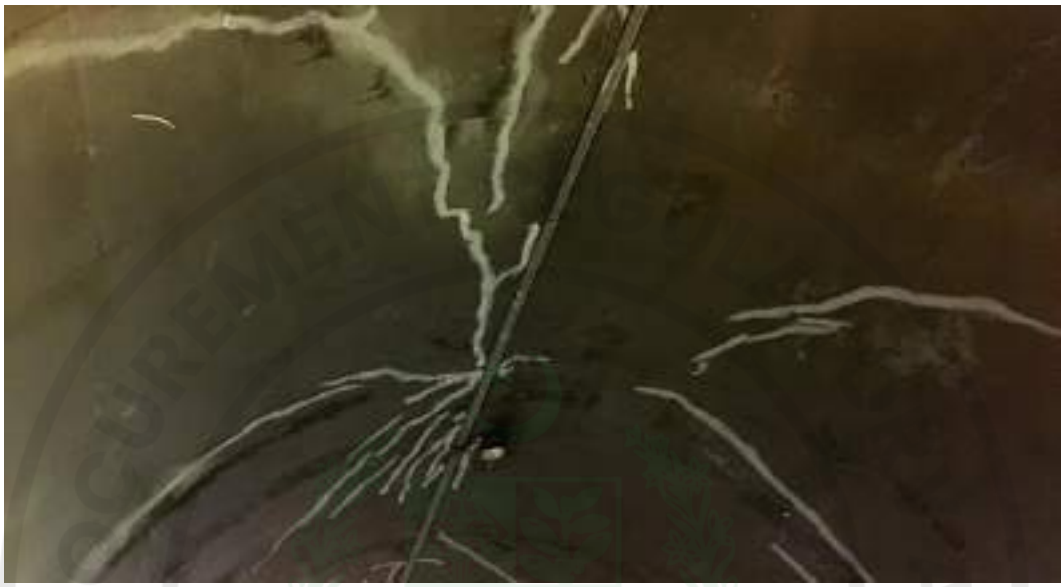

**Photo 6-15 View of Recently Generated Joints Tunnel-2.**

As per geological conditions concerns, this portion of tunnel in is under influence of two faults **(Vol-2, DWG-1336)**. Rock is highly crushed, rolling down of boulders is quite common along these active faults. The active tectonic forces are responsible for the development of fractures in this terrane. The same features are also being noted in concrete area in between tunnel 2 and 3 **(Photo 6-16)**.

**Photo 6-16 View of Recently Generated Joints Between Tunnel-2 & 3.**



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The concrete slab fractured between tunnel 2 and 3. It is evident that some tectonic forces are recently operative in this area.

### 6.4.5 Power House area:

In powerhouse area near helipad along old KKH, clayey silt is present where Chinese camp was established. The clayey silt was deposited after river choking due to Salmanabad slide.

**Photo 6-17 Micro thrust fault in clayey silt beds near helipad.**

Due to operational compressional stresses, some deformations including faulting, shearing, folding, and tiltness in clayey silt have been observed. The relative movement of both blocks against fault plane indicates compressional environment, moves the hanging wall block upward **(Photo 6-17)**.

**Photo 6-18 Inclination of Clayey Silt near Helipad.**



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The clayey Silt beds are well exposed at the left side of Hunza river near Sarat bridge. The clayey silt beds are well jointed and tilted upward at an angle ranging from 10° to 15° **(Photograph 6-18)**. The inclination of the beds is in recent soil is active tectonic feature.

Near old Chinese camp, at powerhouse area, the clayey silt is folded **(Photograph 6-19)**. Folding in recently deposited clayey silt may result of slipping along fault plane under regional compressional shear force, results in the formation of folding and faulting.

**Photo 6-19 Folding in Clayey Silt near Helipad/Power House Area.**

Near the SCO building, along old KKH, near tunnel-1, some cracks are going to develop in recently deposited material. The development of joints is mostly parallel in nature but occasional cross cutting joints also present **(Photo 6-20)**.

**Photo 6-20 Development of Parallel Joints near SCO Building.**



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### 6.4.6 At Murtazabad- Shahyar Road:

Coordinates:

| | |
|---|---|
| N | 4016299.113m |
| E | 465418.47m |
| Ele. | 2095m a s l |

Just crossing the Murtazabad to Shahyar bridge, a thick alluvial deposit consists of gravels, cobbles, pebbles interbedded with silty sand is exposed. This material moves upward against fault plane and form fault bend fold **(Photo 6-21)**.

**Photo 6-21 Inclination in Clay Silt and Gravels.**

The beds are tilted at an angle of 22° to 30°. Many micro fault in sand beds have been observed in hinge area of the fold. The ramp and flat geometry having NE striking and Dipping SE **(Photo 6-22)**.

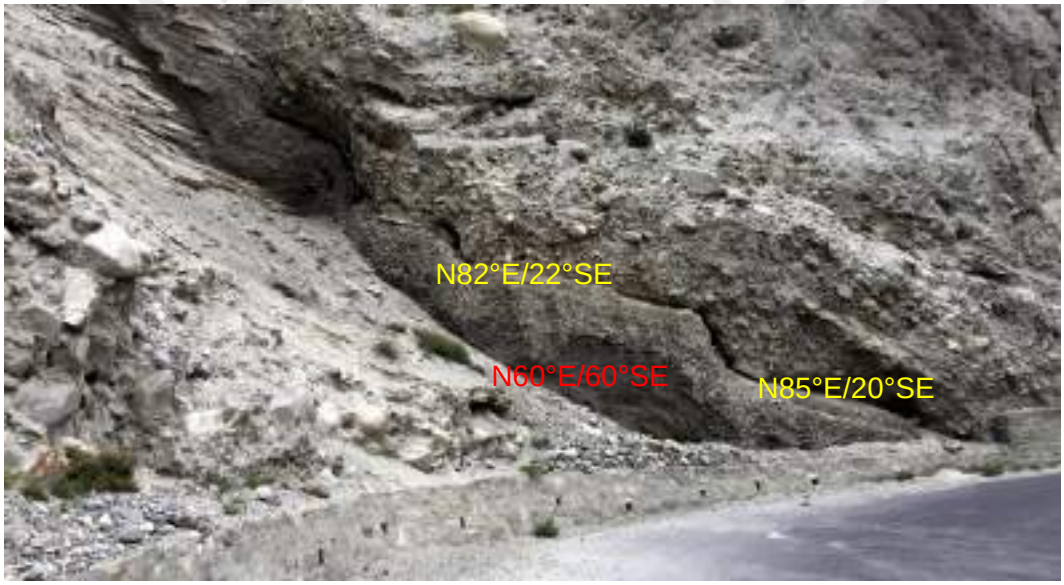


**Photo 6-22 Ramp and Flat Geometry along Fault.**



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Some micro faults have been observed in this alluvium. Step faulting on micro level is well preserved in sandy material **(Photo 6-23)**. This alluvium is overlain by morainic material; same joint pattern is going to be develop in it. Some open joints ranging from 10cm to 150cm have been observed there. All these features indicate that the tectonic forces are active in this area.

**Photo 6-23 Development of Micro Faults in Sand.**

### 6.4.7 In Tashot Village:

Coordinates:

| | |
|---|---|
| N | 4012830.531m |
| E | 462157.244m |
| Ele. | 2111.0ma s l |

After crossing suspension bridge near Tashot Bridge, a thick deposit of RBGM and Clayey silt is exposed along the road toward Phakhar village. Due to some recent activity, clayey silt is displace and smeared along micro fault.

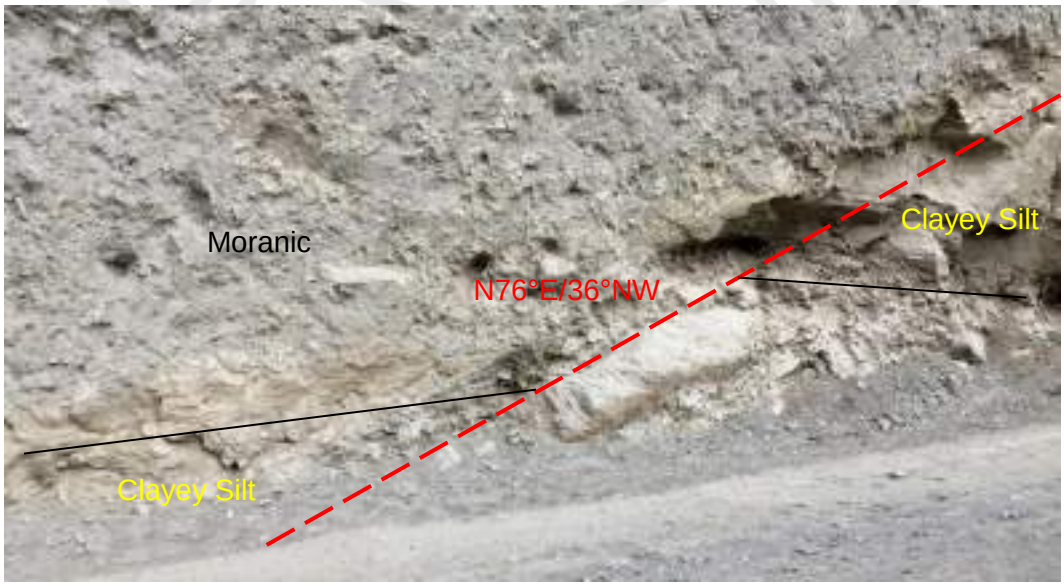


**Photo 6-24 Development of Micro Faults in Clayey Silt.**



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Upward inclination of 6°in recent RBGM in measured along the road **(Photo 6-24, 6-25)**.

**Photo 6-25 Inclination in RBGM in Tashot Village along Road.**

## 6.5 SEISMIC HAZARD ANALYSIS

The quantitative and qualitative seismic hazard analyses presented in this study were preceded by a detailed appraisal of the structure, geodynamics and neotectonics, to characterize the on-site and regional tectonic scenario to assist in proposing a suitable earthquake resistant design. This study has used the seismic source characterization deduced in the accompanying Neotectonic studies and calculated the earthquake potential hazard and related ground motions as presented in this report.

### 6.5.1 Probabilistic Hazard Analysis

Both PSHA and DSHA were carried out using EZ-FRISK software Version 7.65 developed by Risk Engineering Inc. USA. The latest version of R-CRISIS Software version 21.1.1 developed by PEER, USA was also used during the current study. The purpose of using both software was to cross check the validation comparing the quality of the seismic hazard analysis of the two software for the project. During the study it was found that Ez-Frisk software is more standardized as compared to R-CRISIS software in quality of analysis as well as the smart outputs of the analyzed results. Therefore, Ez-Frisk software has been preferred and used in the in the final analysis.

Important input parameters for different seismic zones used in probabilistic approach are presented in **Table 6-1**. It is assumed that weir/dam foundation will mainly be placed on gravelly soil (alluvium) therefore the site condition was taken as gravelly soil with average shear wave velocity at 30 meters' depth ($V_{s30}$) of 450 m/sec for soil site (alluvium) and 760 m/s for rock sites. The mean total hazard curve was obtained by giving equal weighting to all the Five NGA W2 Ground Motion Prediction Equations.

The total hazard curve obtained for the project area is shown as **Figure 6-2** and the total mean Hazard Spectra showing combination of all used Ground Motion Prediction Equations for Attabad HPP is presented as **Figure 6-3**.



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**Table 6-1 Seismic Source Parameters for Probabilistic Analysis**

| Source Zone | Seismic Source Zone | Min. Magnitude Mw | Activity Rate / Year | β | Max. Magnitude Mw |
|---|---|---|---|---|---|
| 1 | Karakorum | 4.0 | 1.929 | 1.120 | 7.3 |
| 2 | Nanga Parbat | 4.2 | 1.112 | 1.101 | 7.0 |
| 3 | Western Himayan | 4.1 | 5.339 | 1.44 | 7.0 |
| 4 | Hindukush | 4.2 | 59.107 | 1.20 | 8.0 |
| 5 | Kashmir Himalaya | 4.2 | 7.143 | 1.13 | 7.8 |
| 6 | Kohistan | 4.1 | 10.500 | 1.07 | 7.5 |

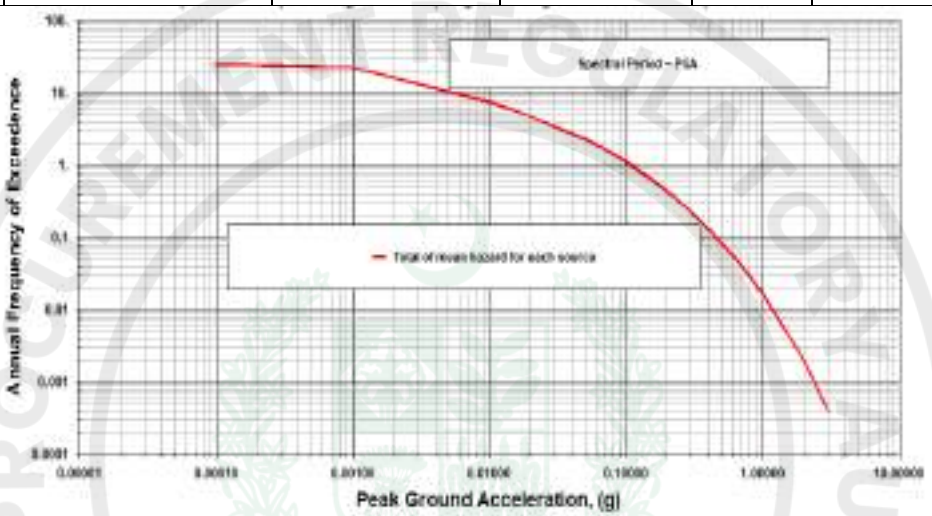


**Figure 6-2 Total Hazard Curve for Attabad HPP**

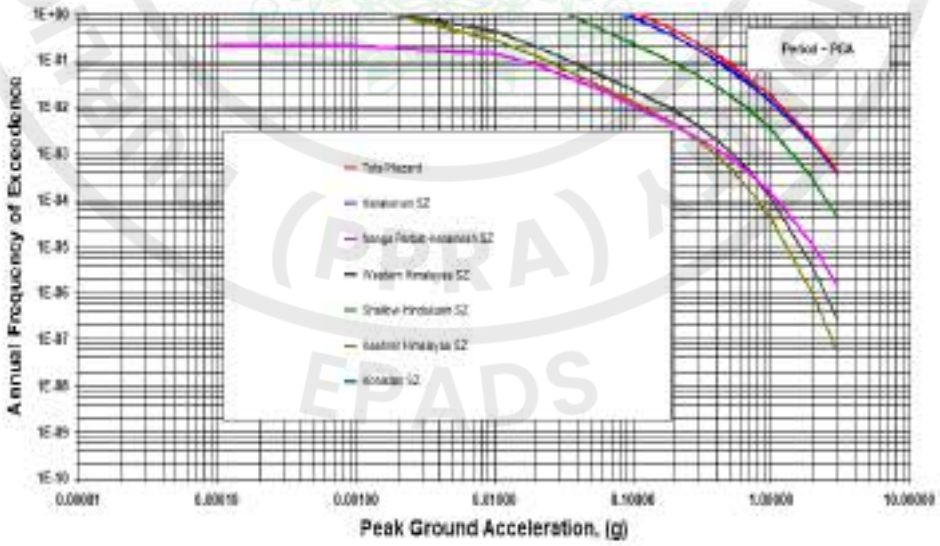


**Figure 6-3 Earthquake Hazard by Seismic Sources, showing spectral response.**

## 6.6 DETERMINISTIC SEISMIC HAZARD ANALYSIS (DSHA)

The capability of the faults to generate earthquakes is ascertained by means of analysis of historical and instrumental seismic data and geological criteria such as rupture length – magnitude relationship or fault movement – magnitude relationship.



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The main tectonic features around the project site within a radius of 200 km which could be controlling the maximum earthquake hazard are as follows:

- Hunza Fault
- Main Karakoram Thrust (MKT)
- Main Mantle Thrust

Empirical correlations have been developed between maximum potential of a fault and key fault parameters like rupture length, fault area, fault displacement and slip rate. Out of these fault parameters, only fault lengths are known with sufficient accuracy. For the faults around the Attabad Lake hydropower project site, the half rupture length of the faults has been taken for determination of maximum potential magnitude. The maximum earthquake magnitude (in moment magnitude $M_W$) of each of the fault was calculated using Wells & Coppersmith (1994) relationship between fault rupture length and magnitude and the input data given in **Table 6-2** has been used for deterministic approach.

**Table 6-2 The Controlling Faults with Quantitative Features (input values of DSHA)**

| Controlling Faults | Fault Type | Fault Rupture Length (km) | Distance (km) | Maximum magnitude potential | |
|---|---|---|---|---|---|
| | | | | Catalogue data | Conservatively Assigned |
| Hunza Fault | Thrust | 5 inferred | 1.4 | 6.1 | 6.7 |
| MKT | Thrust | 200 | 32 | 7.0 | 7.6 |
| MMT | Thrust | 260 | 71.69 | 6.9 | 7.6 |

Ground motion prediction equations developed under the Next Generation Attenuation (NGA) West 2 Project of PEER (Pacific Earthquake Engineering Research Center, University of California at Berkeley, USA) are used to obtain the median and median plus-one percentile levels of peak horizontal ground acceleration (PGA) in deterministic approach.

The NGA equations are developed using a large worldwide database of strong motion recording of earthquakes of magnitude 4-8 and distances ranging from 0-200 km in accordance with ICOLD Guidelines. The NGA equations are preferable over the older equations for the evaluation of seismic hazard particularly in the near field as these are based on a broad spectrum of data recorded in the near field. The same attenuation equations were used for the PSHA approach too.

For all the seismic sources, thrust rupture mechanism has been considered. It is assumed that dam foundation will mainly be placed on gravelly soil therefore the site condition for dam/weir was taken as gravelly soil with average shear wave velocity for top 30 meters ($V_{s30}$) of 760 m/sec. The depth to basement rocks ($Z_{25}$) is taken as 5 km. The Peak Horizontal Ground Acceleration (PGA) g values have been calculated using the latest Five sets of NGA West 2 Ground Motion Prediction Equations (GMPEs).

Input values in DSHA are given in **Table 6-2**. The analyzed results obtained through DSHA (Deterministic Seismic Hazard Analysis) are presented in Figures.



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## 6.7 DETERMINISTIC RESPONSE SPECTRA

Deterministic response spectra for SEE at 50th percentile and 84th percentile levels over the Five NGA West 2 equations are shown in **Figure 6-4 & 6-5** respectively.

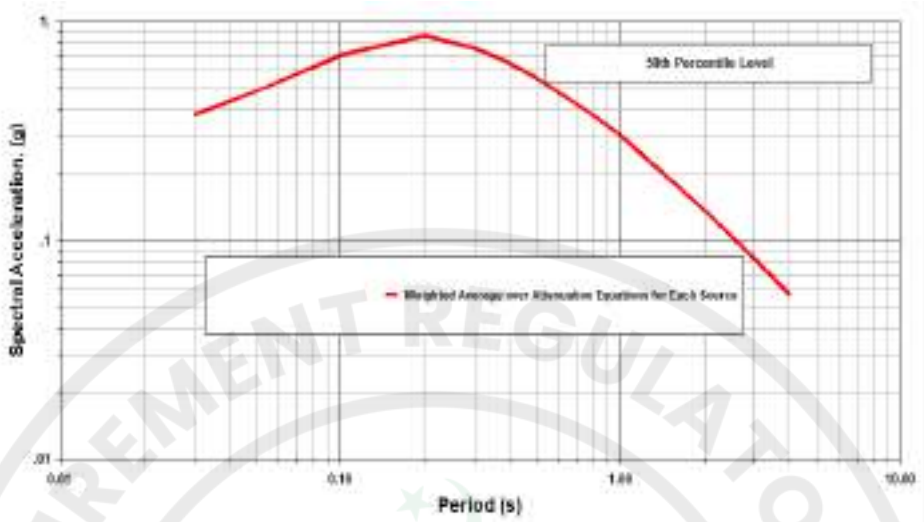


**Figure 6-4 Deterministic Spectra at 50th percentile level weighted average**

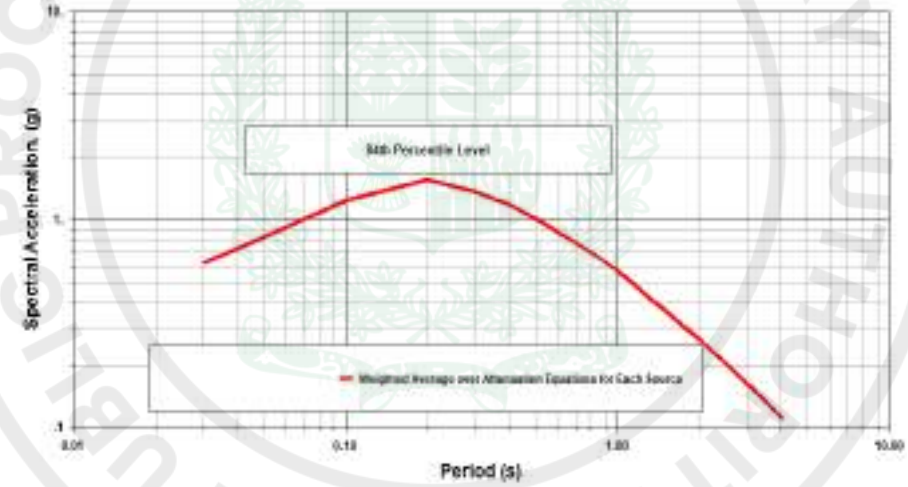


**Figure 6-5 Deterministic Spectra at 84th percentile.**

### 6.7.1 Deterministic Pseudo Spectral Acceleration (PSA)

Pseudo spectral acceleration has been worked out using the latest version of R-CRISIS software. Pseudo spectral acceleration Vs time is given in **Figure 6-6**.



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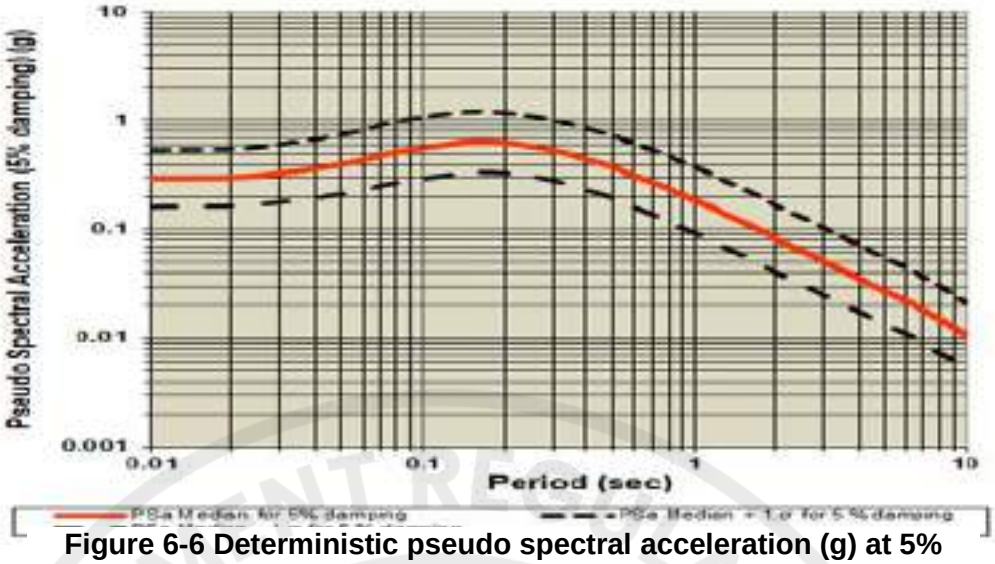


**Figure 6-6 Deterministic pseudo spectral acceleration (g) at 5% Damping.**

## 6.8 SELECTION OF SEISMIC DESIGN PARAMETERS

### 6.8.1 Safety Evaluation Earthquake (SEE)

As per ICOLD guidelines (2016) the Safety Evaluation Earthquake (SEE) will produce the maximum level of ground motion for which the dam should be designed or analyzed. For dams whose failure would present a great social hazard, the SEE will normally be characterized by a level of motion equal to that expected at the dam site from the occurrence of deterministically evaluated MCE or of the probabilistically-evaluated SEE earthquake ground motion with a very long return period, for example 10,000 years for high consequence large dams. Depending on the circumstances (e.g. the importance of the dam, the consequences of a dam failure, it is recommended to design safety-critical elements such as the bottom outlet and/or spillway gates for the SEE. It will be required at least that there is no uncontrolled release of water when the dam is subjected to the seismic load imposed by the SEE.

As per the latest ICOLD Guidelines, for medium consequence dams, median value ($50^{th}$ percentile level) is recommended whereas for high consequence dams, the SEE ground motion parameters should be estimated at median plus one ($84^{th}$ percentile level) if developed by a deterministic approach and need not have a mean annual exceedance probability (AEP) smaller than 1/10,000 if developed by a probabilistic approach. For a particular project of importance such as hydropower project, optimum percentile level may be any optimum percentile level between $50^{th}$ percentile level to $95^{th}$ percentile level. For Attabad Lake HPP, $66^{th}$ percentile level has been worked out and the same is recommended.



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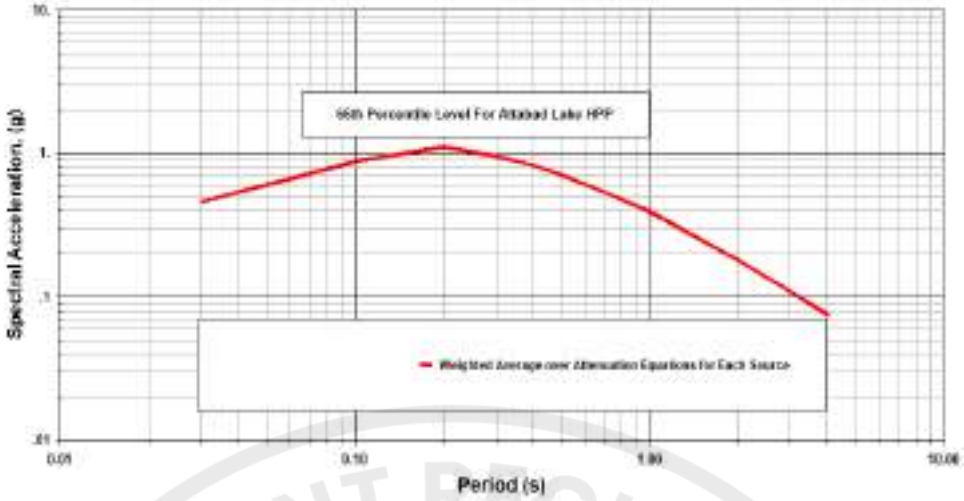


**Figure 6-7 Deterministic Spectra at 66th percentile level of SEE.**

### 6.8.2 Operating Basis Earthquake (OBE)

The Operating Basis Earthquake (OBE) represents the level of ground motion at the dam site at which only minor damage is acceptable. In theory the OBE can be determined from an economic analysis, but this is not always feasible and, in many cases, it will be appropriate to choose a return period of about 145 years (i.e. a 50 % probability of not being exceeded in 100 years). The dam, appurtenant structures and equipment should remain functional and damage easily repairable, from the occurrence of earthquake shaking not exceeding the OBE.

Since the consequences of exceeding the OBE are normally economic, the circumstances in a particular case may justify use of a more severe or less severe event for the OBE. The resulting return period depends on prevailing conditions.

Because of the above definition, the OBE is the best determined by using probabilistic procedure. OBE ground motions are significantly lower than those for SEE.

### 6.8.3 Uniform Hazard Spectra (UHS)

Uniform hazard spectra for Attabad Lake Hydropower Project for OBE (145 year return period), DBE (475 year and 2475 years return period) and SEE (10,000-years return period) are presented as **Figure 6-8.**

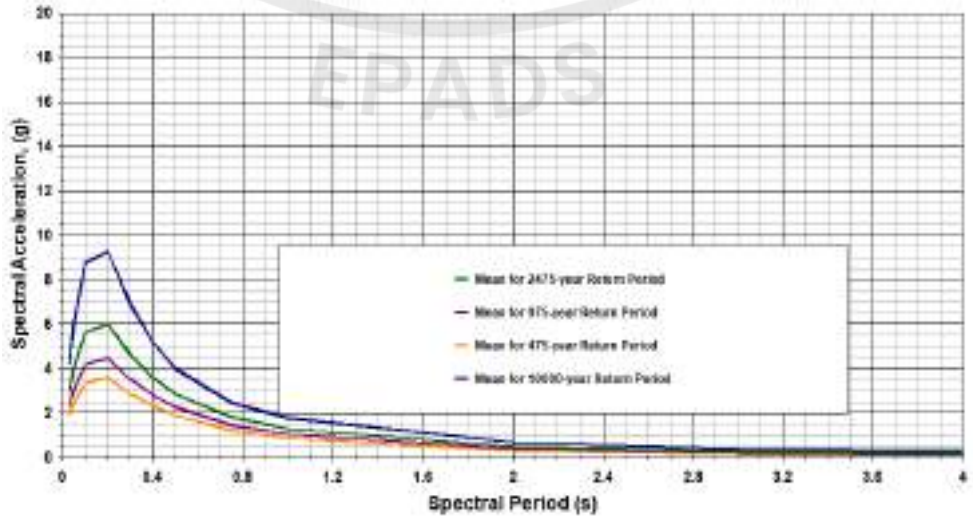




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**Figure 6-8 Uniform Hazard Spectra (UHS) showing mean hazard for various return periods.**

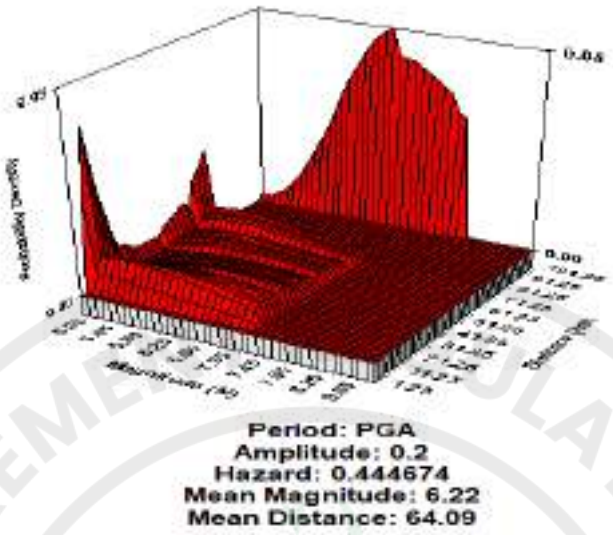


**Figure 6-9 Deaggregation of Mean Hazard, Mean Magnitude and Mean Distance.**

## 6.9 RESULTS

Based on the analysis results, the following earthquakes design parameters are concluded and recommended for Attabad Lake Hydropower project.

**Operation Basis Earthquakes (OBE):**

OBE at return period of 145 years is recommended as follows:

OBE Horizontal = 0.24 g

OBE Vertical = 0.17 g

**Safety Evaluation Earthquakes (SEE):**

For the design of dam / weir, the following PGA 'g' values for SEE (Safety Evaluation Earthquakes) are recommended:

SEE Horizontal = 0.44g

SEE Vertical = 0.29g

For the design of appurtinent structures including spillway gate betc. the following PGA 'g' values for SEE (Safety Evaluation Earthquakes) are recommended:

SEE Horizontal = 0.38g

SEE Vertical = 0.26



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# 7 PROJECT LAYOUT

## 7.1 GENERAL

Attabad Lake Hydropower Project (ALHPP) has been identified on Hunza River downstream of Attabad Lake due to creation of dam because of land slide from right bank of Hunza River in January, 2010, 20 km upstream of Aliabad, Hunza Valley, Gilgit-Baltistan. ALHPP is proposed on Attabad Lake. Attabad Lake is about 15 km upstream of Ganish Bridge and about 111 km upstream from Gilgit.

The Dam due to landslide created a Lake behind it at Attabad not only possess a threat but at the same time an opportunity for making use of the head due to this Earthen Dam. Due to lake formation, there is potential drop of more than 100 m in 2.5 km river reach. The mean annual flow of Hunza River at Attabad Lake is 204 $m^3/s$. The Project Layout is to be configured considering the power demand and demand pattern of regional grid. Attabad Lake storage can be used for daily peaking. A design discharge with peaking storage facility is to be selected to generate the installed capacity 95% time of the year in peak hours. From the available flow data and estimated flow series at Project Area, a discharge of 60 $m^3/s$ has been taken as design discharge.

The Project Layout options are to be studied with due consideration of topographic and geological features of the Area. In the Project Layout configuration, the existing natural dam treated will be used as diversion structure. The present river width has been narrowed due to land slide downstream of lake. The river width in the slided area is to be increased with proper control structure for design flood. In addition, sediment flushing arrangement is to be provided, so that a live storage of lake could be maintained. The water conveyance channel from reservoir to powerhouse is to be made that is technically sound and economical option. Considering the topography and geological features, surface powerhouse is viable at a site, 2.5 km downstream of the Lake. Alternative Project Layout are considered to arrive at the better option both technically and economically.

In this section, alternative Project Layouts have been discussed based on the investigations and studies. The selection of Project Layout has been made on the basis of technical soundness and economic viability.

## 7.2 ALTERNATIVE PROJECT LAYOUT

The Project layout has been considered on either bank with powerhouse near Attabad. Options for structures' location are limited due to land slided area, steep slope in reservoir area, and weak geological formation in the Project Area.

### 7.2.1 Alternative-I: Project Layout on the Left Bank

The left bank has been examined in detail to propose Project Layout with power intake, 2.3 km low pressure headrace tunnel, surge tank, embedded penstock and surface powerhouse near Hunza river, 2.5 km downstream of Attabad Lake.

The main access road to Project Area from down country is KKH passes on the left bank in Project Area leading to Chinese Boarder through Khunjerab Pass. After land slide, about 7 km highways tunnel has been constructed on the left bank because about 19 km was submerged



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in the lake. The access to the area and for construction activities, the left bank is the suitable bank to propose the Project Layout. Since the slide did not initiate from left bank the slopes are more stable. The geological conditions favour intake, headrace tunnel and surface powerhouse. The slided area of about 500 m is to be stabilized by excavating material on the left bank.

The following observation have been made

- An overflow weir is to be constructed to pass the 1000-year flood. The river diversion during construction is to be managed through a deep cut channel on the left bank. Later on the same deep channel is to be used for sediment flushing by installing gates.
- For power intake, there is sound rock formation on the left bank just upstream of weir site. The access to the area can be made through adit and headrace tunnel. Steep slopes and weak geology have been observed for the headrace, penstock and powerhouse area.
- Headrace tunnel can be constructed at lower elevation of highways tunnel in same geological formation upto surge tank. The access to surge tank and headrace tunnel is available through old KKH.
- From surge tank to powerhouse area, embedded penstock can be laid down over mild slope terraces. The anchor block can be placed over rock/boulders.
- At the proposed site, surface powerhouse can be constructed. Surface powerhouse, tailrace channel and bifurcated penstock can be placed at required elevation by excavating the alluvium.

The Project Layout on the left bank is presented in Figure 7-1. Topographic conditions to propose Project Layout on the left bank are found favorable and considered suitable to propose a Project Layout.



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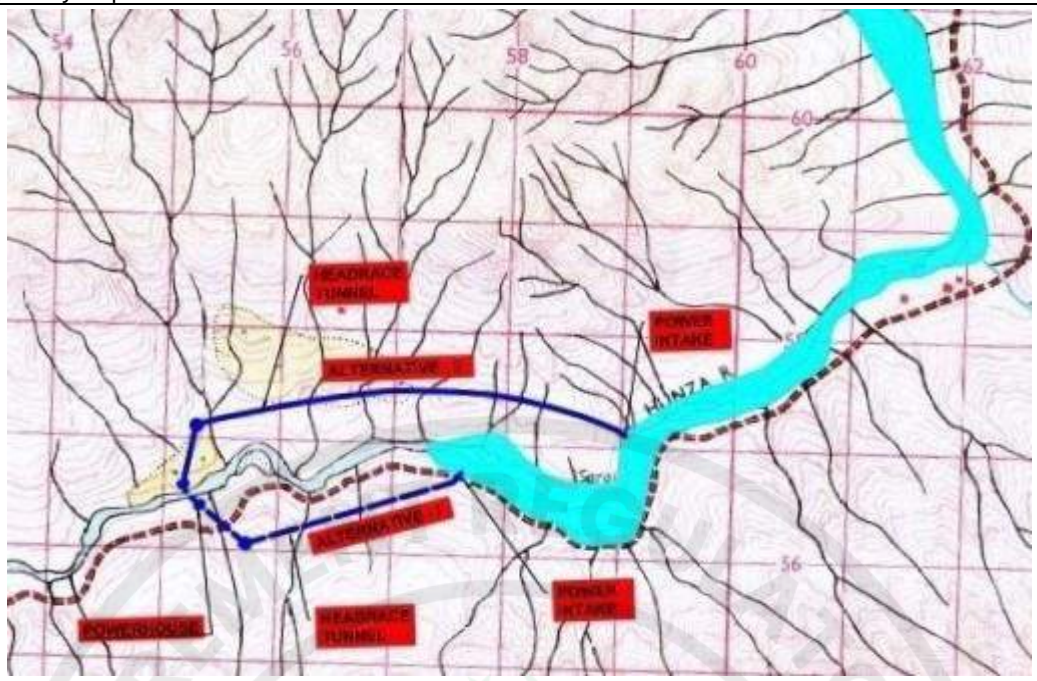


**Figure 7-1 Alternative Project Layout on the Left and Right Bank**

### 7.2.2 Alternative-II: Project Layout on the Right Bank

A Project Layout on the right bank have been studied with intake 1.6 km upstream and powerhouse 2.0 km downstream of weir site. A low pressure tunnel about 3.8 km length is to be constructed to utilize the available head at ALHPP.

The Project Layout on the right bank has geologically disturbed area and Attabad slide originated from the right bank and slided material fallen on the left bank. On the right bank of the River, there is excessive loose material present and it is considered susceptible to rock fall and minor slides due to its being fragmented. The accessibility to the right side is difficult and construction and operation of scheme on the right bank is technically unfeasible.

The right bank of the river is where the slide basically was initiated from, therefore, there is excessive loose material present and the mountain side is quite fragmented. Clearing the overburden to reach the rock face will not only require a lot of excavation, but also the site will remain susceptible to rock fall and minor slides due to its being fragmented. Operability of Project components on this bank will remain a challenge.

Considering the Project construction, operation and maintenance, environmental issues, stability of structures, the left bank layout has been preferred over that of the right bank and is selected for further studies.

## 7.3 FIELD INVESTIGATIONS FOR PROJECT LAYOUT

For Feasibility Study, field investigations like topographic survey, geological mapping, borehole drilling, test pits, environmental survey, flows and sediment observations have been carried out. For the identified dam / weir and the powerhouse site on the left bank of Hunza River near Attabad, topographic survey has been carried out, which is duly connected with Survey of Pakistan (SOP) Grid. The long term flow data of Hunza at Danyor Station has been used to estimate the daily flows and flow duration curves at the weir site. All the field data helped to finalize the structure locations and sizes for a technically feasible and economical layout.



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Considering topographic and geological conditions at the weir and upstream valley, an overflow concrete weir at El. 2414 m a s l has been proposed with normal operating pond level as 2414 m a s l. The tailrace outlet of ALHPP has been planned at El. 2300 m a s l. Further 2 options have been studied on the left bank of Hunza River. i.e.

a. Alternative -I A Headrace Tunnel Option

b. Alternative -I B Headrace with Embedded Pressure Pipe T

### 7.3.1 Alternative-I A Headrace Tunnel Option

ALHPP has been envisaged with a 14 m high weir on Hunza River identified, 4 km downstream of Attabad Lake confluence with Hunza River and the powerhouse near Batakundi Village. The Project Layout includes power intake, sandtrap, headrace tunnel, surge shaft, in addition to ungated weir spillway and surface powerhouse on the right bank.

For the water ways from intake to surge shaft, two options have been considered; either headrace tunnel or pressure pipe. These two options have been studied with respect to powerhouse and preliminary cost estimates.

The salient features of Alternative Project Layout on the right bank are as under;

**Salient Features Headrace Tunnel Option**

The Salient Features of ALHPP layout for Alternative-IA are listed below.

| | | |
|---|---|---|
| a. | Weir/Dam Height | 2.0 m |
| b. | Normal Reservoir Level | 2414.0 m a s l |
| c. | Minimum Operating Level | 2412.0 m a s l |
| d. | Live Storage | 3.0 Million $m^3$ |
| e. | Mean Annual Flow | 209.0 $m^3/s$ |
| f. | Design Discharge | 60.0 $m^3/s$ |
| g. | Turbine Level | 2300.0 m a s l |
| h. | Maximum Net-Gross Head | 108.1 m |
| i. | Minimum Net-Gross Head | 105.6 m |
| j. | Headrace Tunnel Length | 2300 m |
| k. | Penstock Length | 550 m |
| l. | Type of Turbine | Francis |
| m. | Installed Capacity | 54.0 MW |
| n. | Annual Energy Generated | 374.0 GWh |
| o. | Plant Factor | 79.0 % |



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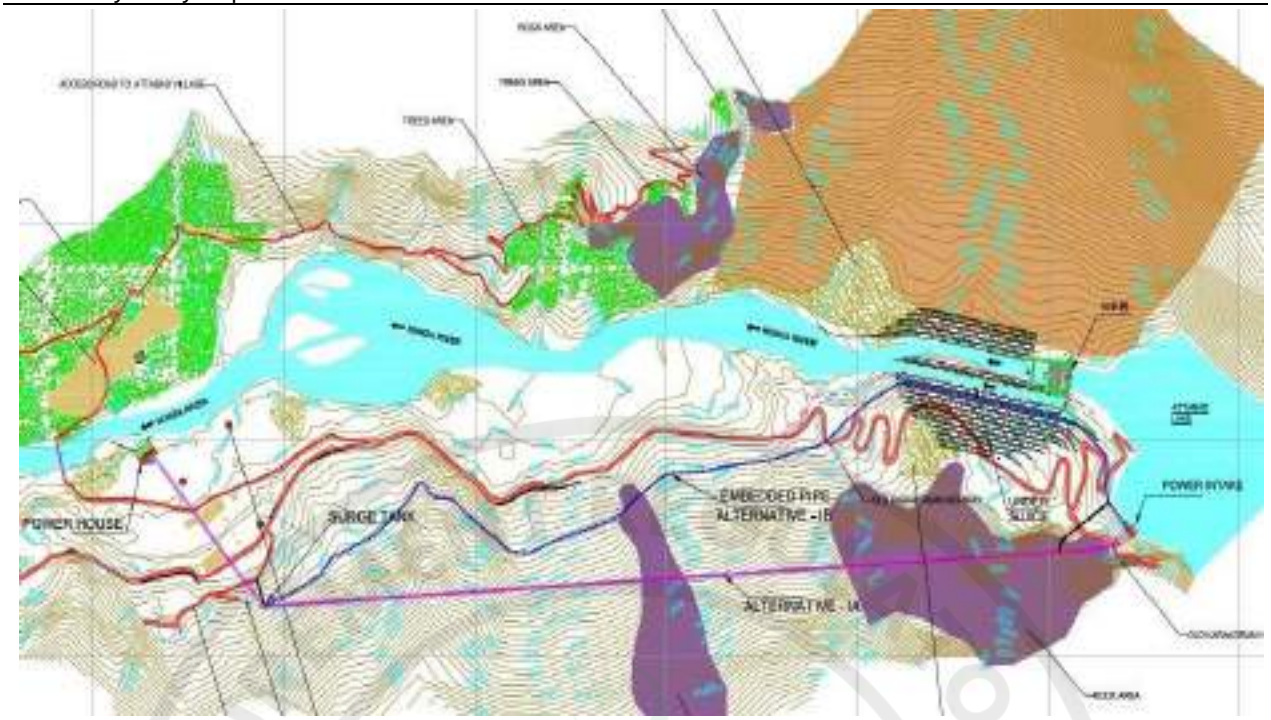


**Figure 7-2 Project Layout on the Left bank with Tunnel and Penstock Options**

### 7.3.2 Alternative-I B Headrace with Embedded Pressure Pipe.

The salient features of ALHPP layout for Alternative-IB are same except the following:

| | | |
|---|---|---|
| a. | Maximum Net-Head | 102.1 m |
| b. | Minimum Net-Head | 99.6 m |
| c. | Headrace pipe length | 2.8 km |
| d. | Penstock Length | 550 m |
| e. | Installed Capacity | 51.7 MW |
| f. | Annual Energy Generated | 357.8 GWh |
| g. | Plant Factor | 79.0 % |

## 7.4 EMBEDDED PENSTOCK VERSUS TUNNEL

Both the embedded penstock and tunnel options are considered for the conveyance of lake water for power generation along the left bank of the Attabad Lake. On the basis of field observations, on topographic survey, geological & geotechnical investigations, the embedded penstock route passes through overburden and its construction/installation will be quite hazardous as observed during geotechnical investigation. The cost comparison of tunnel and embedded penstock has also been carried out to check the suitability of conveyance of lake water. Cost comparison also shows that power tunnel option is more appropriate in view of least cost with less operation and maintenance issues that may encounter in case of embedded penstock alternative. Necessary geological studies, mapping and geotechnical studies including topographic surveys of cross drains along tunnel route and embedded penstock have also been carried out.



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### 7.4.1 Geology along the Embedded Penstock Route

The scree, moraines, debris flow, creeps and landslides are common along the whole ridge from intake area to powerhouse. These deposits are the results of broken rock fragments at the toe of hill slopes, mountain cliffs, and valley shoulders that has accumulated through periodic rock fall from adjacent cliff faces. These rock spreads have been marked on the geological map of the Project Area.

### 7.4.2 Geology along the Tunnel Route

Gneisses of Baltit Group are well exposed along the proposed power tunnel. These rocks are mostly over run by very loose unconsolidated material. This overburden material is composed of boulders, cobbles, pebbles, gravels and with fine grained sand and clays. To ascertain the dimensions of the spread of overburden, electrical resistivity survey along the power tunnel has been conducted.

## 7.5 POWERHOUSE LOCATION

Powerhouse location is affected by factors primarily associated with availability of head, favorable geology, availability of land and accessibility besides impact of powerhouse construction on habitants in the area (locality). Issues relating to protection against land sliding and flooding have also been taken into account. Keeping the above in view, only one location has been considered for powerhouse for both the alternates.

A surface power house is being considered on the left bank of Hunza River about 300 m upstream of Sarat Bridge. The terrace is large enough space for powerhouse, switchyard, offices and/or staff residences in the close vicinity of the powerhouse. The river bed level at the site is 2306 m.a.s.l.

### 7.5.1 Geology of Powerhouse

The proposed powerhouse is located on alluvium deposits. The slope is gentle along penstock area which is covered by overburden material. The rocks of Baltit Group are exposed along the penstock. Quaternary alluvium has been recorded along slopes and in the river banks and along the main tributaries. Scree and unconsolidated colluvial debris have been recorded along slopes which are commonly loose and un-cemented in nature.

For confirmation of thickness and properties of overburden material; four boreholes drilled at powerhouse, tailrace, penstock and surge tank locations have been drilled the detail of locations is marked on topographic survey map.

## 7.6 COST ESTIMATES

For the identified Project Layouts, based on preliminary dimensions of structures, cost estimates have been prepared for Alternative-I A and – I B. The summary of cost of various project components and E&M equipment are presented in Table 7-1



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**Table 7-1 Estimated Project Base Cost**

| Sr. No. | Description | Total (Million Rs.) | |
|---|---|---|---|
| | | Alter-IA | Alter-IB |
| **A** | **Preliminary Works and Environmental Cost** | 1,161.40 | 1,161.40 |
| **B** | **Civil Works** | | |
| B-1 | Main Weir | 2,008.821 | 2,008.821 |
| B-2 | Sediment Flushing Channel | 2,326.679 | 2,326.679 |
| B-3 | Power Intake | 429.289 | 429.289 |
| B-4 | Low Pressure Headrace Tunnel | 1,820.182 | 0.000 |
| B-5 | Surge Shaft | 132.728 | 132.728 |
| B-7 | Penstocks | 713.256 | 3242.063 |
| B-8 | Powerhouse | 624.474 | 624.474 |
| B-9 | Tailrace Channel | 84.318 | 84.318 |
| B-10 | Check Dams at Shimshal Nullah | 392.500 | 392.500 |
| | **Sub Total B** | 8,532.247 | 9,240.872 |
| | **Total for Civil Works (A+B)** | **9,693.642** | **10,402.267** |
| **C** | **HSS, Mechanical & Electrical Works** | | |
| C-1 | Hydraulic Steel Structures (HSS) | 139.730 | 139.730 |
| C-2 | Power House Mechanical Works | 1,690.890 | 1,690.890 |
| C-3 | Power House Electrical Works | 2,249.339 | 2,249.339 |
| C-4 | Switchyard works | 428.453 | 428.453 |
| C-5 | Transmission Line (Single Circuit Attabad to Sost & Double Circuit Attabad to Aliabad) | 1,500.135 | 1,500.135 |
| | **Sub Total for C-1 to C-5** | 6,008.547 | 6,008.547 |
| C-6 | Transportation Charges of E&M Equipment @ 7% | 420.598 | 420.598 |
| C-7 | Erection & Commissioning Charges @ 8% | 480.684 | 480.684 |
| C-8 | Government Taxes on E&M Equipment @ 16% | 961.368 | 961.368 |
| | **Sub Total C for E & M** | **7,871.197** | **7,871.197** |
| **D** | **Project Construction CostSub Total A, B & C** | **17,564.84** | **18,273.46** |
| **E** | Indirect Cost | 2464.076 | 2563.48 |
| F | **PROJECT BASE COST** | **20,028.916** | **20,836.94** |

For the two alternatives, power and energy have been computed for a design discharge of 60.0 $m^3/s$. The comparison of cost/kWh is presented in Table 7-2.

**Table 7-2 Comparison of Alternatives**

| **Project Components** | **Alternative-I A** Headrace Tunnel | **Alternative-I B** Pressure Pipe |
|---|---|---|
| **Project Base Cost (US$)** | 20,028.916 | 20,836.94 |
| Power (MW) | 54 | 51.7 |
| **Energy (GWh/year)** | 373.69 | 358 |
| **Energy Cost/ (USc/kWh)** | 3.61 | 3.93 |

The comparison of two alternative layouts indicate that Alternative IA has lower cost and will produce more energy/year, therefore cost/kWh is less as compared with that of Alternative-II B. Project layout with headrace channel is recommended for further studies.



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## 7.7 SELECTED PROJECT LAYOUT

With favorable topographic and geological conditions for the Project Area. The Project Layout (Alternative-I A) with low pressure tunnel on the left bank is preferred over other available options. The availability of recorded flows of Hunza River at Attabad provide the basis to have design discharge of 60.0 $m^3/s$ and installed capacity of 54 MW for ALHPP.

The Project Layout (Alternative-I A) on the left bank with identified weir site, 2.3 km long headrace tunnel, 550 m embedded penstock and surface powerhouse near Hunza River is considered the only technically sound and economical layout. Hence, it is recommended for further studies.

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# 8 POWER POTENTIAL

## 8.1 GENERAL

The demand for electricity varies seasonally. In lower areas of the country demand reaches to its maximum in summer season and remains lower in winter. But in northern area of the country specially in Gilgit-Baltistan (GB) demand for power and energy is maximum in winter season and remains within lower ranges in summer. Electricity demands also vary during the same day, people use more power in the morning and in the evening. Therefore, many powerhouses are managed to tackle such peak times. For this purpose, temporary storage is done in the lake/pond/forebay and releases during peak hours. Such projects have small storage as compared to large dam's storage.

As the lake had already been developed so reservoir capacity has not been enhanced than present to avoid inundation of upstream areas due to increase of water levels, however, flushing will be carried out to retain the present capacity of the lake.

## 8.2 RESERVOIR OPERATION SYSTEM

ALHPP is located on Hunza River and there is no other considerable power project on main Hunza River which could influence the operation of ALHPP, further, there is no irrigation system which could be supplemented from Hunza River. Therefore, the Project is only for power generation.

The amount of hydropower generated depends upon the volume of water and the effective head. Reservoir operation and corresponding power potential has been studied for 50 years (1966 – 2015) in order to assess the true power potential of the Project.

It is proposed to operate the reservoir to provide diurnal storage in the low flow periods to enable peaking energy to be generated in preference to base energy when there is insufficient flow to generate continuously. The daily storage required for 4 hours peaking is 0.864 Mm3and storage required for 24 hours at full capacity is 5.18 Mm3, which is equivalent to all the volume available in the upper 1.25 m of the reservoir.

The following definitions of Peak Energy, Primary Energy and Secondary Energy were used:

- On-Peak Energy is defined as the energy that the plant can produce during four hours per day (peak demand hours) with at least 95% reliability. The On-Peak Energy is assumed to be the best remunerated.

- Off-Peak Energy is defined as the energy produced by the plant off the assumed 4 hours of daily peak demand.

- Firm Energy is defined as the energy that the plant can generate with 95% reliability, which is, deficits shall not occur for more than 5% of the time.

- Secondary Energy is the energy that the plant can produce in excess of the Firm Energy. Secondary Energy is produced only when the reservoir is full, and is limited by the capacity of the plant.



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From power generation point of view, the primary target of the operation is to assure the highest possible peak generation: a general criterion considered was to assure at least 4 hours per day of operation at full capacity.

A second target of the operation is to maximize the firm energy production, which is the energy which can be guaranteed in each month with a sufficiently high level of reliability: in principle, a 95% reliability criterion for the firm energy has been considered.

## 8.3 ATTABAD RESERVOIR

As discussed earlier, reservoir capacity of the lake has been reduced from 250 Mm3 to 125 Mm3 which indicates that half lake capacity has been filled with sediments during the last 10 years. Therefore, in order to retain the lake capacity and utilize this hydro potential for the generation of electricity regular flushing would be carried out along with power generation. Under sluice Channels proposed for this purpose.

To study the power and energy potential of the Project, hydrographic survey is used to assess the lake's capacity with respect to the elevation. The present reservoir extends more than 12.5km, to actualize the present storage with respect to area and elevation in terms of Storage-Area-Elevation curve is given below

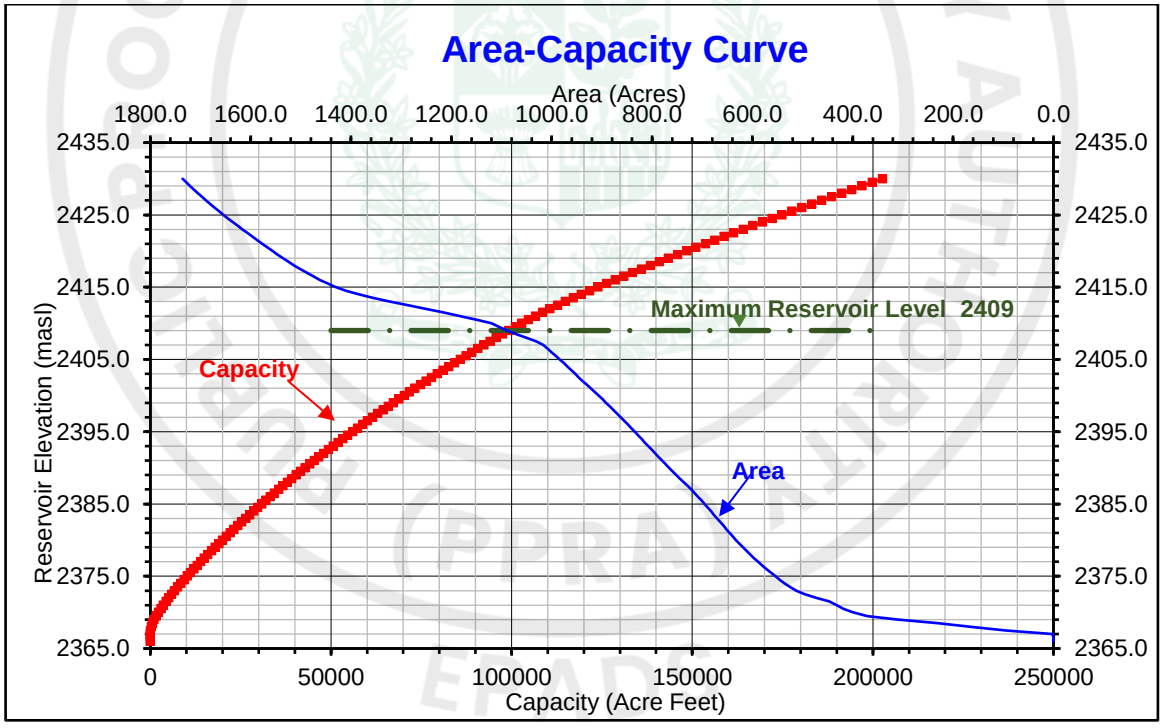


**Figure 8-1 Area Capacity Curve**



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## Table 8-1 : Area-Elevation-Capacity Data

| Sr. No. | Reservoir Elevation (m.a.s.l) | Water Surface Area (Acres) | Storage Capacity (Acre Feet) | Storage Capacity $Mm^3$ | Sr. No. | Reservoir Elevation (m.a.s.l) | Water Surface Area (Acres) | Storage Capacity (Acre Feet) | Storage Capacity $Mm^3$ |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2366.0 | 0.0 | 0 | 0.00 | 66 | 2398.5 | 884.4 | 65872 | 81.25 |
| 2 | 2366.5 | 0.0 | 0 | 0.00 | 67 | 2399.0 | 891.7 | 67329 | 83.05 |
| 3 | 2367.0 | 1.7 | 0 | 0.00 | 68 | 2399.5 | 899.1 | 68798 | 84.86 |
| 4 | 2367.5 | 94.5 | 87 | 0.11 | 69 | 2400.0 | 906.7 | 70279 | 86.69 |
| 5 | 2368.0 | 167.7 | 294 | 0.36 | 70 | 2400.5 | 914.4 | 71773 | 88.53 |
| 6 | 2368.5 | 231.0 | 624 | 0.77 | 71 | 2401.0 | 922.3 | 73279 | 90.39 |
| 7 | 2369.0 | 309.4 | 1065 | 1.31 | 72 | 2401.5 | 930.3 | 74799 | 92.26 |
| 8 | 2369.5 | 371.2 | 1626 | 2.01 | 73 | 2402.0 | 938.3 | 76331 | 94.15 |
| 9 | 2370.0 | 399.7 | 2261 | 2.79 | 74 | 2402.5 | 945.8 | 77877 | 96.06 |
| 10 | 2370.5 | 419.0 | 2933 | 3.62 | 75 | 2403.0 | 953.3 | 79435 | 97.98 |
| 11 | 2371.0 | 431.9 | 3631 | 4.48 | 76 | 2403.5 | 960.8 | 81005 | 99.92 |
| 12 | 2371.5 | 447.0 | 4351 | 5.37 | 77 | 2404.0 | 968.3 | 82587 | 101.87 |
| 13 | 2372.0 | 472.6 | 5103 | 6.30 | 78 | 2404.5 | 976.0 | 84181 | 103.84 |
| 14 | 2372.5 | 495.0 | 5898 | 7.28 | 79 | 2405.0 | 984.3 | 85789 | 105.82 |
| 15 | 2373.0 | 512.1 | 6725 | 8.30 | 80 | 2405.5 | 992.3 | 87410 | 107.82 |
| 16 | 2373.5 | 524.8 | 7576 | 9.34 | 81 | 2406.0 | 1000.4 | 89045 | 109.84 |
| 17 | 2374.0 | 535.7 | 8446 | 10.42 | 82 | 2406.5 | 1008.3 | 90693 | 111.87 |
| 18 | 2374.5 | 545.1 | 9332 | 11.51 | 83 | 2407.0 | 1016.6 | 92353 | 113.92 |
| 19 | 2375.0 | 554.2 | 10234 | 12.62 | 84 | 2407.5 | 1030.4 | 94031 | 115.99 |
| 20 | 2375.5 | 563.3 | 11151 | 13.75 | 85 | 2408.0 | 1051.4 | 95734 | 118.09 |
| 21 | 2376.0 | 571.9 | 12082 | 14.90 | 86 | 2408.5 | 1071.1 | 97478 | 120.24 |
| 22 | 2376.5 | 580.4 | 13027 | 16.07 | 87 | 2409.0 | 1088.7 | 99249 | 122.42 |
| 23 | 2377.0 | 588.8 | 13986 | 17.25 | 88 | 2409.5 | 1104.3 | 101048 | 124.64 |
| 24 | 2377.5 | 596.8 | 14959 | 18.45 | 89 | 2410.0 | 1120.1 | 102872 | 126.89 |
| 25 | 2378.0 | 604.3 | 15944 | 19.67 | 90 | 2410.5 | 1149.9 | 104733 | 129.19 |
| 26 | 2378.5 | 611.5 | 16941 | 20.90 | 91 | 2411.0 | 1182.0 | 106644 | 131.54 |
| 27 | 2379.0 | 618.6 | 17950 | 22.14 | 92 | 2411.5 | 1216.3 | 108612 | 133.97 |
| 28 | 2379.5 | 625.8 | 18971 | 23.40 | 93 | 2412.0 | 1251.6 | 110635 | 136.47 |
| 29 | 2380.0 | 632.7 | 20003 | 24.67 | 94 | 2412.5 | 1285.5 | 112716 | 139.03 |
| 30 | 2380.5 | 639.2 | 21046 | 25.96 | 95 | 2413.0 | 1323.4 | 114856 | 141.67 |
| 31 | 2381.0 | 645.5 | 22100 | 27.26 | 96 | 2413.5 | 1355.8 | 117055 | 144.39 |
| 32 | 2381.5 | 651.7 | 23164 | 28.57 | 97 | 2414.0 | 1383.6 | 119302 | 147.16 |
| 33 | 2382.0 | 657.9 | 24238 | 29.90 | 98 | 2414.5 | 1409.4 | 121593 | 149.98 |
| 34 | 2382.5 | 664.2 | 25323 | 31.23 | 99 | 2415.0 | 1430.8 | 123924 | 152.86 |
| 35 | 2383.0 | 670.4 | 26417 | 32.59 | 100 | 2415.5 | 1446.4 | 126284 | 155.77 |
| 36 | 2383.5 | 676.6 | 27522 | 33.95 | 101 | 2416.0 | 1462.3 | 128670 | 158.71 |
| 37 | 2384.0 | 682.8 | 28637 | 35.32 | 102 | 2416.5 | 1475.9 | 131080 | 161.68 |
| 38 | 2384.5 | 689.0 | 29762 | 36.71 | 103 | 2417.0 | 1488.5 | 133511 | 164.68 |
| 39 | 2385.0 | 695.4 | 30898 | 38.11 | 104 | 2417.5 | 1500.9 | 135963 | 167.71 |
| 40 | 2385.5 | 701.9 | 32044 | 39.53 | 105 | 2418.0 | 1513.0 | 138435 | 170.76 |
| 41 | 2386.0 | 708.5 | 33200 | 40.95 | 106 | 2418.5 | 1524.6 | 140927 | 173.83 |
| 42 | 2386.5 | 715.2 | 34368 | 42.39 | 107 | 2419.0 | 1535.7 | 143437 | 176.93 |
| 43 | 2387.0 | 722.0 | 35547 | 43.85 | 108 | 2419.5 | 1546.4 | 145965 | 180.05 |
| 44 | 2387.5 | 729.0 | 36737 | 45.31 | 109 | 2420.0 | 1556.8 | 148511 | 183.18 |



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| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 45 | 2388.0 | 736.6 | 37939 | 46.80 | 110 | 2420.5 | 1566.9 | 151073 | 186.35 |
| 46 | 2388.5 | 744.5 | 39154 | 48.30 | 111 | 2421.0 | 1576.9 | 153651 | 189.53 |
| 47 | 2389.0 | 752.0 | 40382 | 49.81 | 112 | 2421.5 | 1586.8 | 156246 | 192.73 |
| 48 | 2389.5 | 759.1 | 41621 | 51.34 | 113 | 2422.0 | 1596.7 | 158857 | 195.95 |
| 49 | 2390.0 | 766.3 | 42872 | 52.88 | 114 | 2422.5 | 1606.6 | 161485 | 199.19 |
| 50 | 2390.5 | 773.4 | 44135 | 54.44 | 115 | 2423.0 | 1616.4 | 164128 | 202.45 |
| 51 | 2391.0 | 780.3 | 45409 | 56.01 | 116 | 2423.5 | 1626.1 | 166788 | 205.73 |
| 52 | 2391.5 | 787.2 | 46695 | 57.60 | 117 | 2424.0 | 1635.7 | 169463 | 209.03 |
| 53 | 2392.0 | 793.9 | 47992 | 59.20 | 118 | 2424.5 | 1645.1 | 172154 | 212.35 |
| 54 | 2392.5 | 800.6 | 49300 | 60.81 | 119 | 2425.0 | 1654.3 | 174860 | 215.69 |
| 55 | 2393.0 | 807.4 | 50619 | 62.44 | 120 | 2425.5 | 1663.3 | 177581 | 219.04 |
| 56 | 2393.5 | 814.5 | 51949 | 64.08 | 121 | 2426.0 | 1672.0 | 180317 | 222.42 |
| 57 | 2394.0 | 821.2 | 53291 | 65.73 | 122 | 2426.5 | 1680.6 | 183067 | 225.81 |
| 58 | 2394.5 | 827.9 | 54643 | 67.40 | 123 | 2427.0 | 1689.0 | 185831 | 229.22 |
| 59 | 2395.0 | 834.6 | 56007 | 69.08 | 124 | 2427.5 | 1697.2 | 188608 | 232.64 |
| 60 | 2395.5 | 841.4 | 57382 | 70.78 | 125 | 2428.0 | 1705.3 | 191399 | 236.09 |
| 61 | 2396.0 | 848.3 | 58767 | 72.49 | 126 | 2428.5 | 1713.2 | 194203 | 239.55 |
| 62 | 2396.5 | 855.3 | 60165 | 74.21 | 127 | 2429.0 | 1720.9 | 197019 | 243.02 |
| 63 | 2397.0 | 862.5 | 61574 | 75.95 | 128 | 2429.5 | 1728.4 | 199849 | 246.51 |
| 64 | 2397.5 | 869.8 | 62995 | 77.70 | 129 | 2430.0 | 1735.7 | 202690 | 250.01 |
| 65 | 2398.0 | 877.1 | 64427 | 79.47 | | | | | |

## 8.4 WATER AVAILABILITY AT RESERVOIR

Mean annual flows are calculated for the period 1966-2015. Average value for mean annual flow has been calculated as 208.36 $m^3/s$. Flows are generally maximum in July and August almost touching 700 $m^3/s$. Whereas, flows are low from December to April each year when snow falls in the catchment. The graph shows that design discharge of 60 $m^3/s$ is available for about half year (almost 6 months). Graph also shows that flows are exceeding the design discharge from June to mid-December which shows the potential of hydropower generation

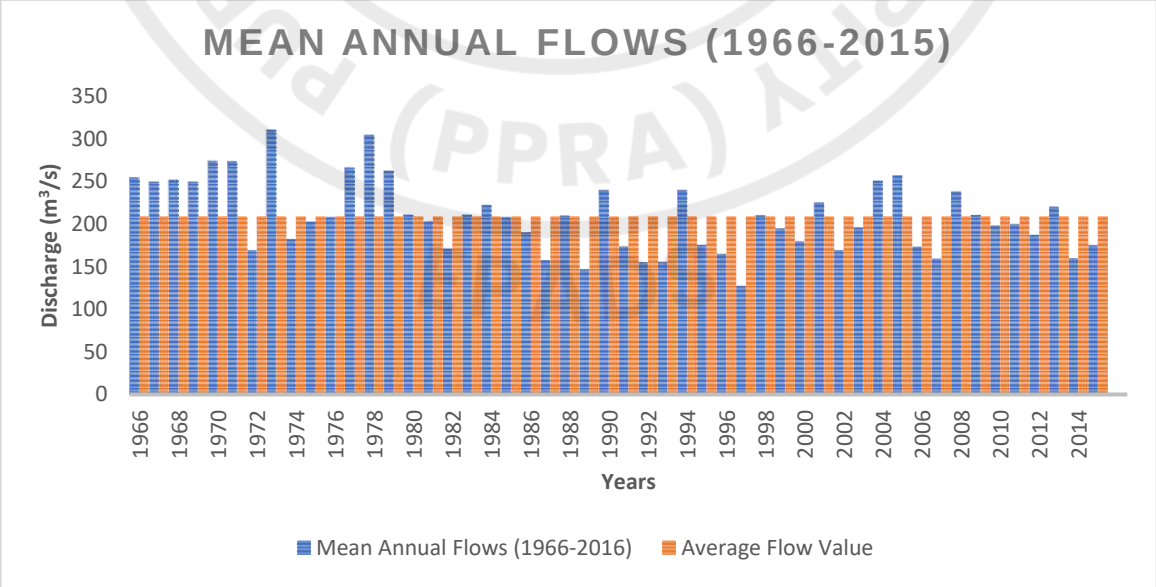


**Figure 8-2 Mean Annual Flows**



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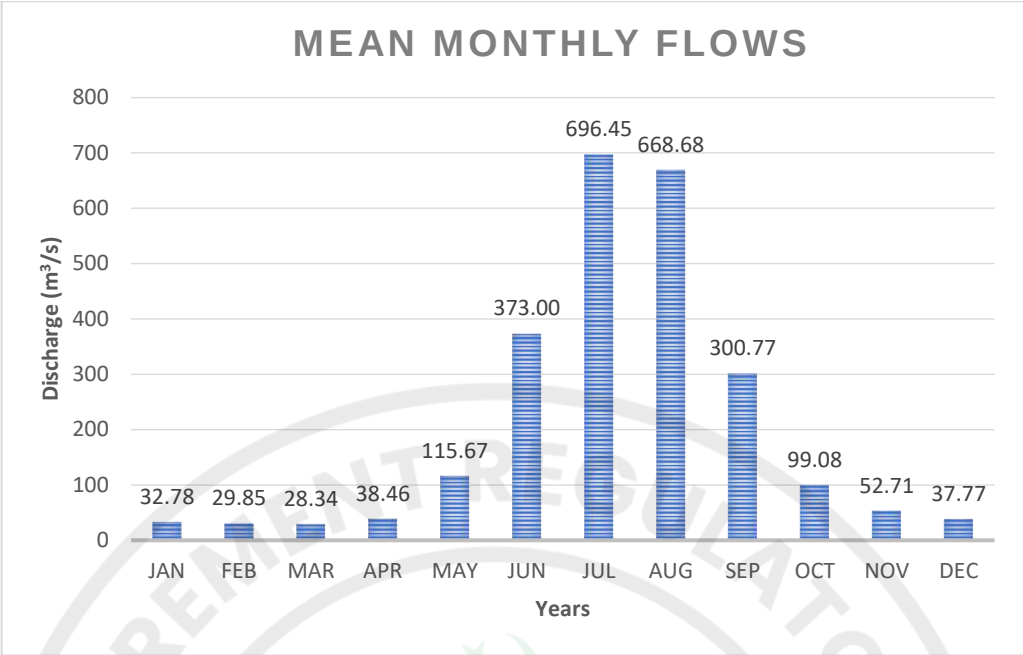


**Figure 8-3 Mean Monthly Flows**

Maximum, Mean and Minimum daily flows for the period 1966-2015 are also plotted in the Figure below to depict the flow pattern at Attabad Lake site.

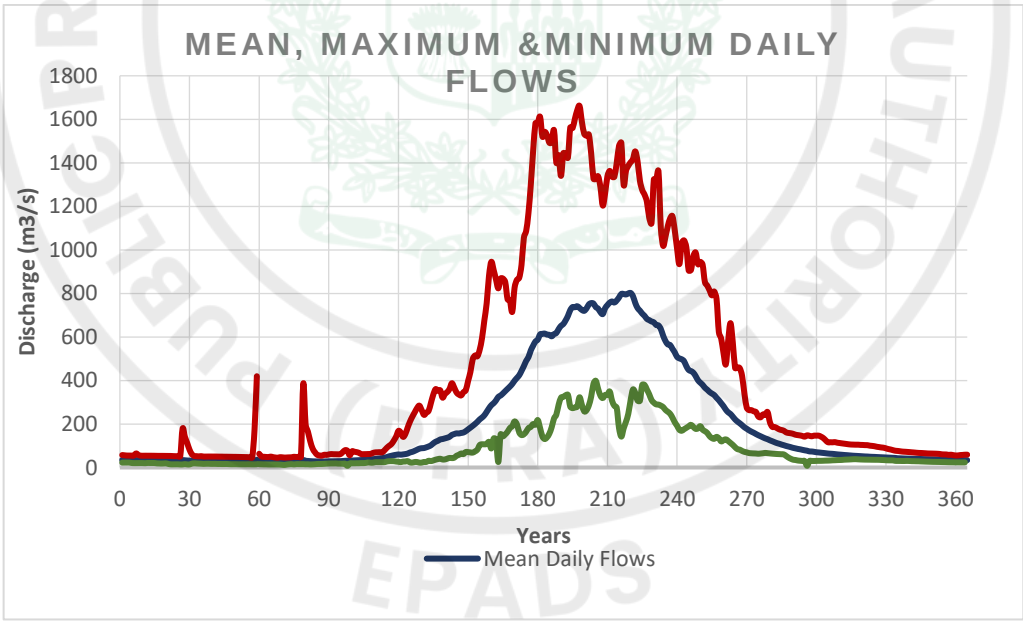


**Figure 8-4 Mean, Maximum & Minimum Daily Flows**

### 8.4.1 Flow Duration Curve (FDC)

Flow Duration Curve (FDC) for Attabad Lake HPPLHPP is plotted on the basis of almost 51 years (1966-2016). From FDC it is evident that design discharge of 60 $m^3/s$ is available for almost 50% of the time. Therefore, design discharge of 60 $m^3/s$ is justified for the generation of 54 MW power.



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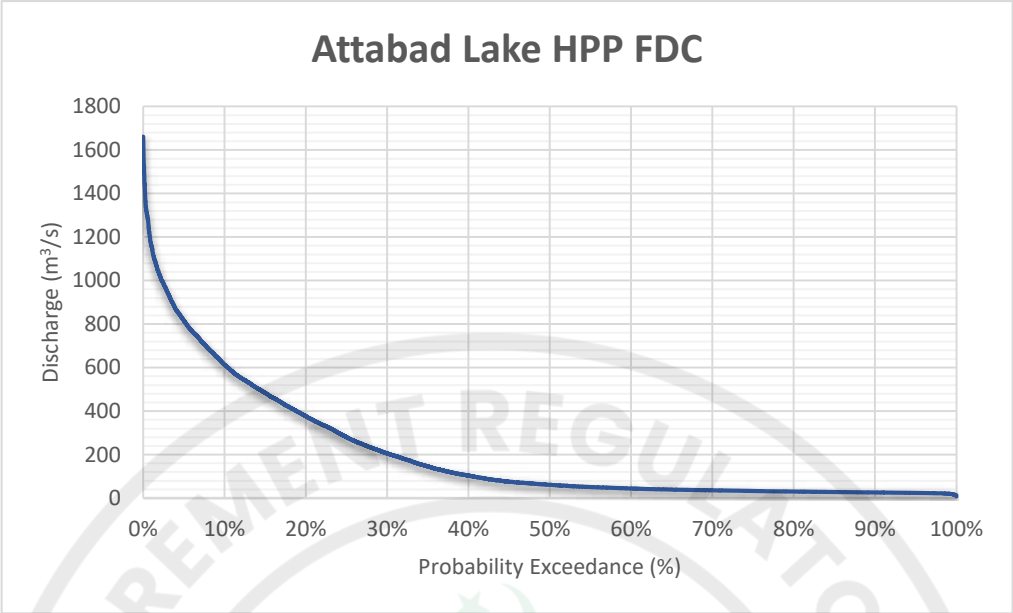


**Figure 8-5 Attabad Lake Flow Duration Curve (FDC)**

**Table 8-2 Flow Duration Curve Results**

| Probability Exceedance (%) | Flow ($m^3/s$) | Probability Exceedance (%) | Flow ($m^3/s$) |
|---|---|---|---|
| 10 | 613.4 | 60 | 44.3 |
| 20 | 376.6 | 70 | 36 |
| 30 | 205 | 80 | 30.3 |
| 40 | 103.3 | 90 | 26.2 |
| 50 | 61.3 | 99 | 20.5 |

## 8.5 WATER LEVELS

The available head for power generation has been determined from normal operative level and the water level where tailrace channel joins Hunza River.

### 8.5.1 Upstream Water Levels

Upstream water levels have been determined keeping in view the operation of the Attabad Lake. For power and energy estimates, the normal operative level varies from 2,412 m.a.s.l to 2,414 m.a.s.l.

### 8.5.2 Downstream Water Levels

The tail-water rating curve for downstream of the powerhouse at Hunza River is obtained using the water levels, historic discharges and cross section of Hunza River. Calculations are tabulated at Table 8-3 and the tailwater rating curve is plotted at Figure 8-6. The downstream tail water rating has been adopted for stage estimation downstream of power house. The head losses expected to occur in the power scheme have been calculated to determine the net head available for power generation.



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**Table 8-3 Tailwater Curve Analysis**

| Water Surface Elevation | Discharge (m³/s) | Velocity (m/s) | Flow Area (m²) | Wetted Perimeter (m) | Top Width (m) |
|---|---|---|---|---|---|
| 2300.10 | 29.50 | 1.29 | 22.80 | 51.31 | 51.18 |
| 2300.35 | 98.27 | 1.87 | 52.53 | 68.02 | 67.77 |
| 2300.75 | 215.19 | 2.38 | 90.39 | 81.51 | 81.11 |
| 2301.35 | 394.73 | 3.00 | 131.40 | 83.59 | 82.93 |
| 2301.95 | 616.04 | 3.55 | 173.32 | 85.68 | 84.76 |
| 2302.55 | 876.00 | 4.05 | 216.15 | 87.76 | 86.58 |
| 2303.12 | 1172.50 | 4.51 | 259.90 | 89.85 | 88.40 |
| 2303.62 | 1503.99 | 4.94 | 304.55 | 91.93 | 90.23 |
| 2304.06 | 1869.31 | 5.34 | 350.12 | 94.02 | 92.05 |
| 2304.47 | 2267.56 | 5.72 | 396.61 | 96.10 | 93.88 |
| 2304.92 | 2698.06 | 6.08 | 444.00 | 98.19 | 95.70 |
| 2305.40 | 3049.87 | 6.17 | 494.07 | 106.72 | 104.05 |
| 2305.95 | 3525.16 | 6.44 | 547.06 | 110.79 | 107.93 |

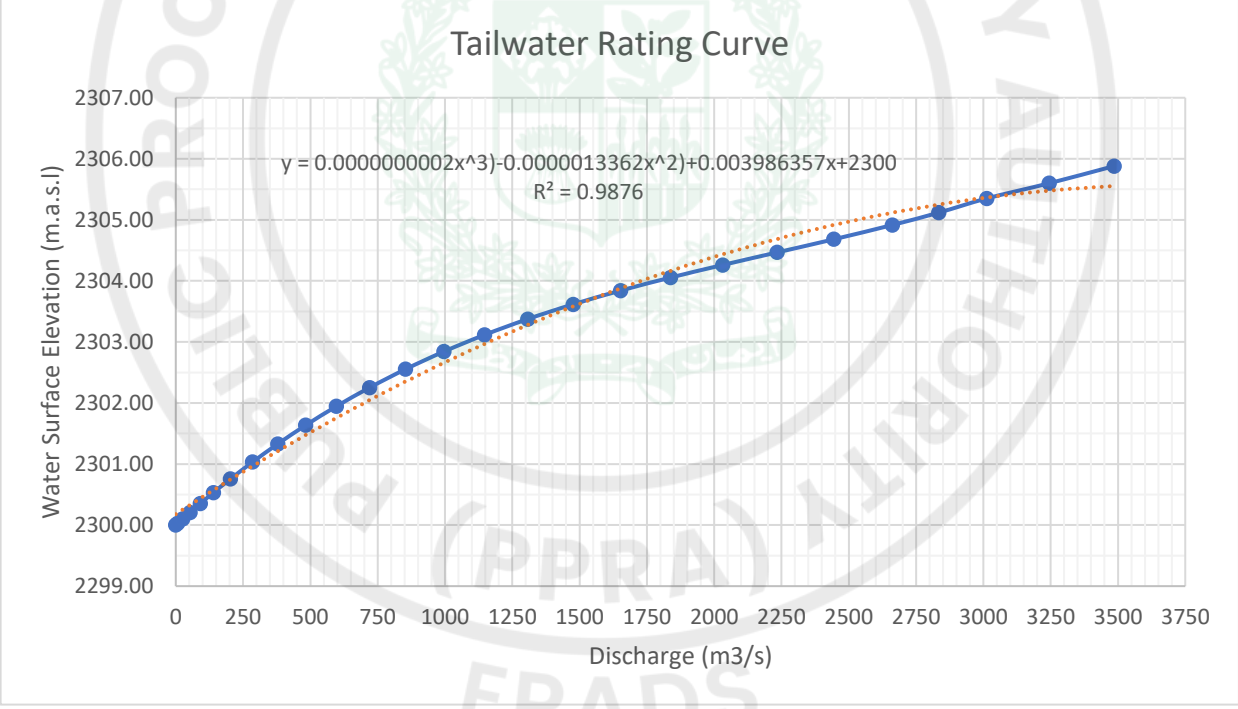


**Figure 8-6 Tailwater Rating Curve**

## 8.6 POWER AND ENERGY STUDIES

### 8.6.1 Power and Energy Potential

Power and energy potential at the site have been estimated on average 10-daily basis using time series data from 1966 to 2015. Available head across the hydropower facility has been computed keeping in view the minimum and maximum operation water levels i.e. 2,012 to 2,014 m.a.s.l. Tailwater rating curve has been used for estimating the tailwater levels on the downstream side for determining the head available for power generation.



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The power estimates have been computed by using the following formula:

$$P = \frac{\gamma \times n \times g \times H \times Q}{1000}$$

where,

| | | |
|---|---|---|
| P | = | Power output, 54 MW |
| ρ | = | Density of water, 1,000 kg /m3 |
| g | = | Gravity acceleration, 9.81 m/s2 |
| η | = | Overall efficiency of the hydroelectric plant 88.32% |
| Q | = | Design discharge, 60m3/s |
| H | = | Net Head varies between 105 m to 107.5 m depending head wa ter levels |

**Table 8-4 Efficiency Coefficients of Various Power Plant Components**

| **Component** | **Efficiency** |
|---|---|
| Turbine & Speed Increaser | 91.5% |
| Generator | 97.5% |
| Transformer | 99% |
| **Overall** | 88.32% |

The average daily energy has been calculated as follows:

$$E = \frac{P \times h \times d}{1000}$$

where,

| | | |
|---|---|---|
| E | = | Energy output (GWh) |
| P | = | Power output (MW) |
| h | = | Hours in a day |
| d | = | Number of days in each time step |

### 8.6.2 Optimization of Power and Energy

In previous studies, 32.5 MW capacity plant had been proposed for this project, however, keeping in view the potential of the lake and availability of head, the power and energy optimization have been carried out to size the plant. Upstream water levels and tail water rating along with the average flow data for the period 1966 to 2015 have been used for calculating the power, energy and plant factor. Comparison of power and energy potential of this study with the previous study has been tabulated below:



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**Table 8-5 Summary of Power & Energy Potential**

| Power and Energy Parameters | As in Previous Studies Conducted through Consultants | As in this Study Conducted by WAPDA |
|---|---|---|
| Design Discharge ($m^3/s$) | 40 | 60 |
| Gross Head (m) | 106 | 112 |
| Power Capacity (MW) | 32.5 | 54 |
| Mean Annual Energy (GWh) | 256.66 | 373.69 |
| Plant Factor (%) | 92.70 | 79 |

### 8.6.3 Plant Factor

The Plant Factor is the unit-less ratio of an actual electrical energy output over a given period of time to the maximum possible electrical energy output over that period.

The plant factor which provides the basis for the installed capacity of the project is calculated as follows:

***pf = (E/(P*8.760))*100***

Where as

pf = Plant factor (%)

E = Mean annual energy (GWh/annum)

P = Installed Capacity (MW)

**Hydraulic Losses**

The hydraulic losses have been calculated using Darcy' Weisbach equation for pipes and hydraulic losses for different discharges keeping all other parameters same given in Table 8-6.

$$h_L = \frac{fLV^2}{2gD}$$

Where

$h_L$ = Friction head losses in meters (m)

f = Moody's Friction Factor

D = Diameter of conduit in meters (m)

G = Gravitational acceleration ($m^2/s$)

L = Length of conduit in meters (m)



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The summary of head losses is given in the following table

**Table 8-6 Total Hydraulic Loss at Different Discharges**

| Discharge ($m^3$/sec) | Total Loss (m) | Discharge ($m^3$/sec) | Total Loss (m) |
|---|---|---|---|
| 10 | 0.22 | **60** | **6.04** |
| 20 | 0.71 | 80 | 10.69 |
| 40 | 2.71 | 100 | 16.67 |

**Net Head**

After establishing the gross head, it is important to allow for the losses arising from laying of conveyance system. The gross head minus the sum of all loses through conveyance of flow for entrance to exist equals the net head. The range of net head varies between 105 to 107.5 m.

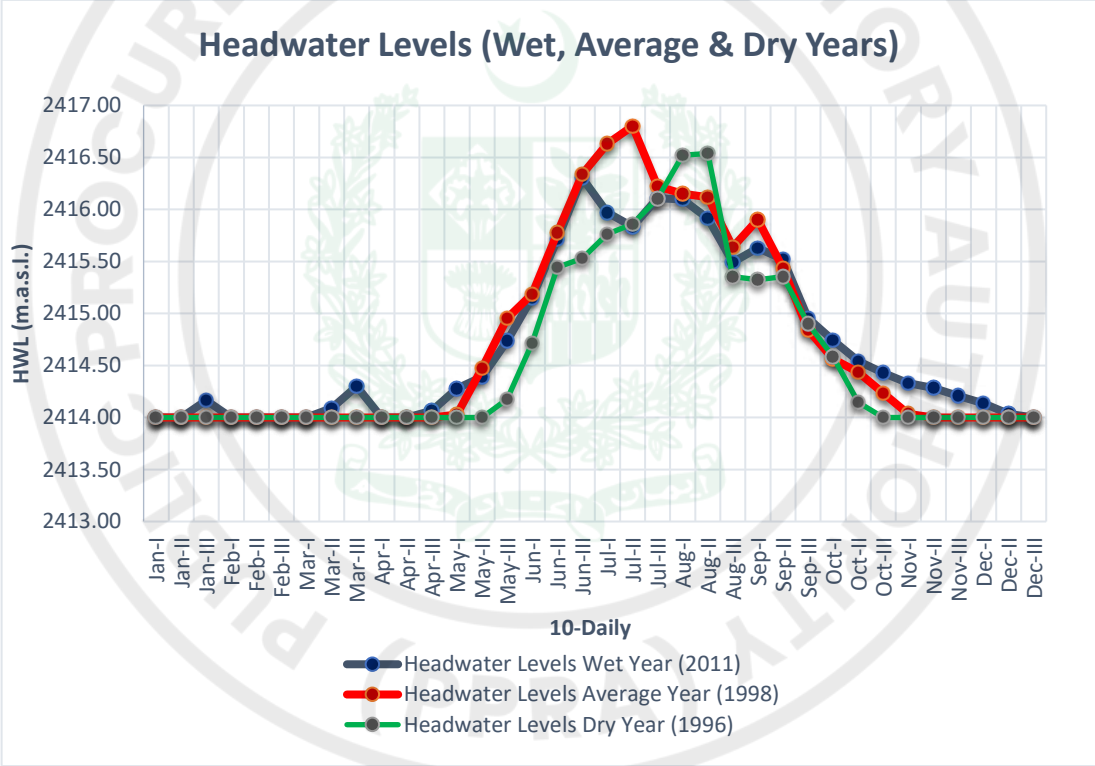


**Figure 8-7 Headwater Level Variations (Wet, Average & Dry Years)**



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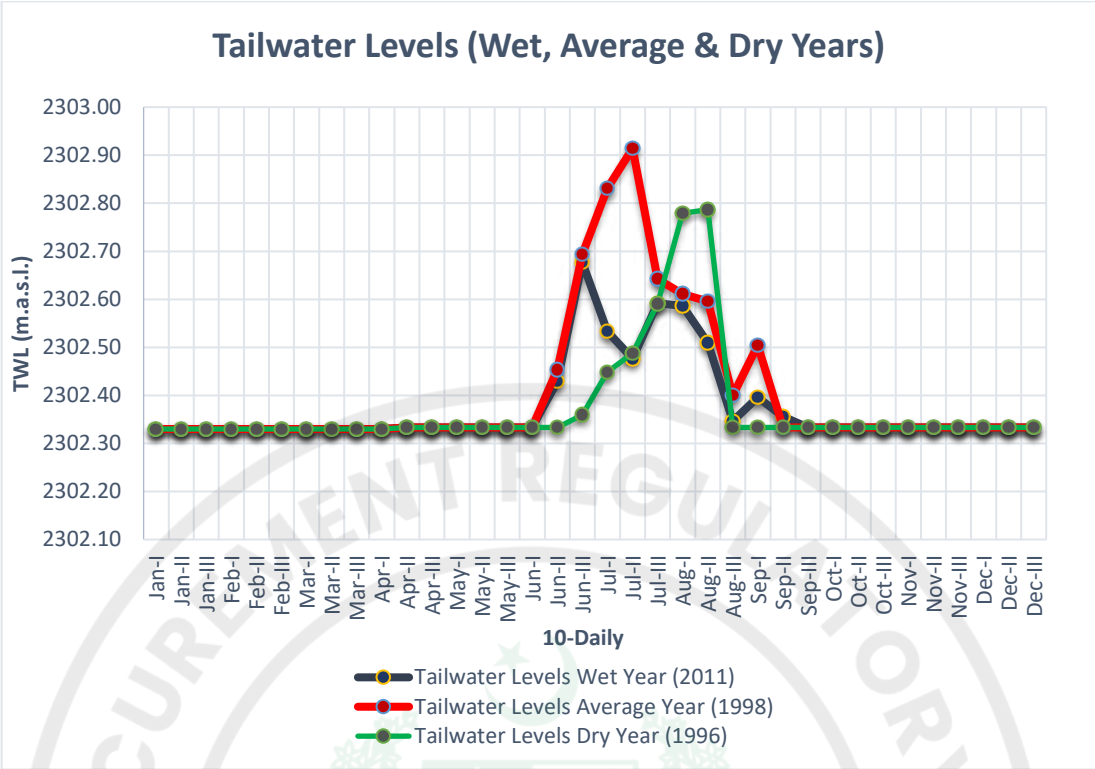


**Figure 8-8 Tailwater Level Variations (Wet, Average & Dry Years)**

Basic Assumptions in Calculations

The following basic assumptions have been made in estimating power and energy of the identified schemes.

- The residual water has been maintained in that 2 km reach i.e. weir to powerhouse site for ecological purposes and for calculations of power and energy.

- The variations in the efficiencies of generating units due to change of net heads have not been considered. For design discharges available to powerhouse, an efficiency of 91.5%, 97.5% and 99% have been used for the turbine, generator and transformers, respectively.

## 8.7 ESTIMATED POWER AND ENERGY

Keeping in view all the aspects, selected optimized design discharge is 60 $m^3/s$, the power and energy have been estimated on the basis of 10 day flows for all years from 1966 to 2015. For 10-Daily Power Curves, the optimum installed capacity would be 54.0 MW with environmental flow of 3 $m^3/s$ having mean annual energy of 373.69 GWh. The plant factor will be taken as 79%.

The calculated annual energy, for years 1998 (average year), 2011 (wet year) and 1996 (dry year), is 375.75, 449.49 and 333.87 GWh respectively. The energy calculated based on 10 daily flows for 50 year ranges between 333.87 GWh to 449.49 GWh.A mean value of 373.69 GWh has been taken as mean annual energy. The 10 daily power and energy for average, wet and dryyears are presented in Table 8-7, 8 and 9 respectively, whereas power curves for these three scenarios are shown in Figure 8-9, Figure 8-10 and Figure 8-11 respectively.



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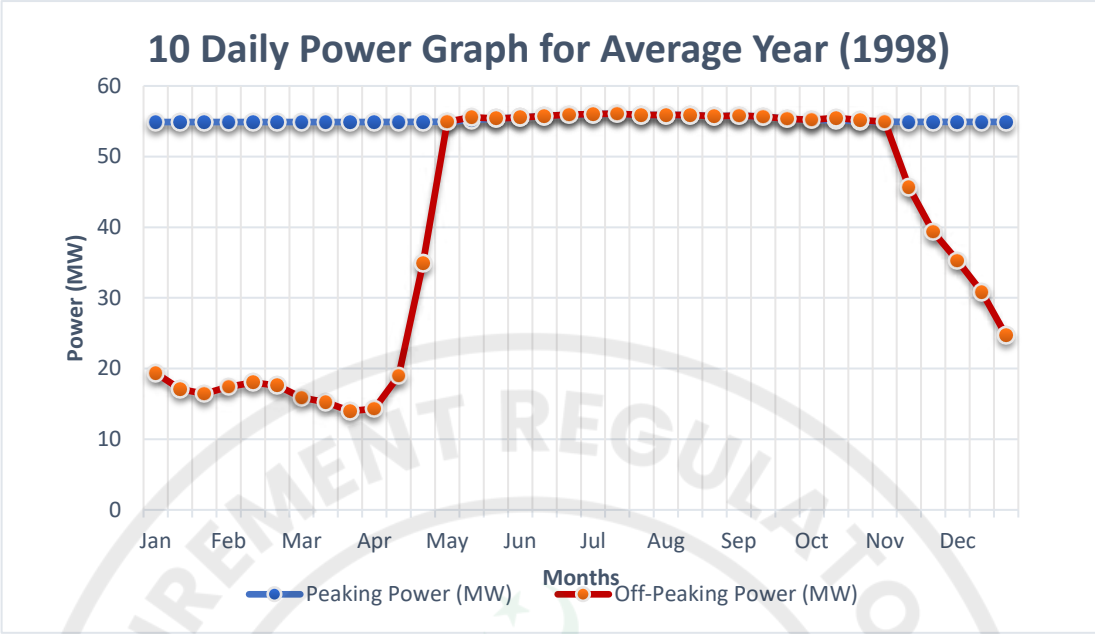


**Figure 8-9 10-Daily Power Graph for Average Year (1998)**

As in average year, the installed power of 54 MW would be available for 24 hours from May to October. Peaking power (4 hours) will be available throughout the year, however, off-peak power (20 hours) will vary from 14 MW to 54 MW and will remain full from May to October. When flow reduces due to winter in November, the power generation would also reduce, however, enough flows remain available to run one turbine unit during lowest flow period as indicated in Figure 8-9.

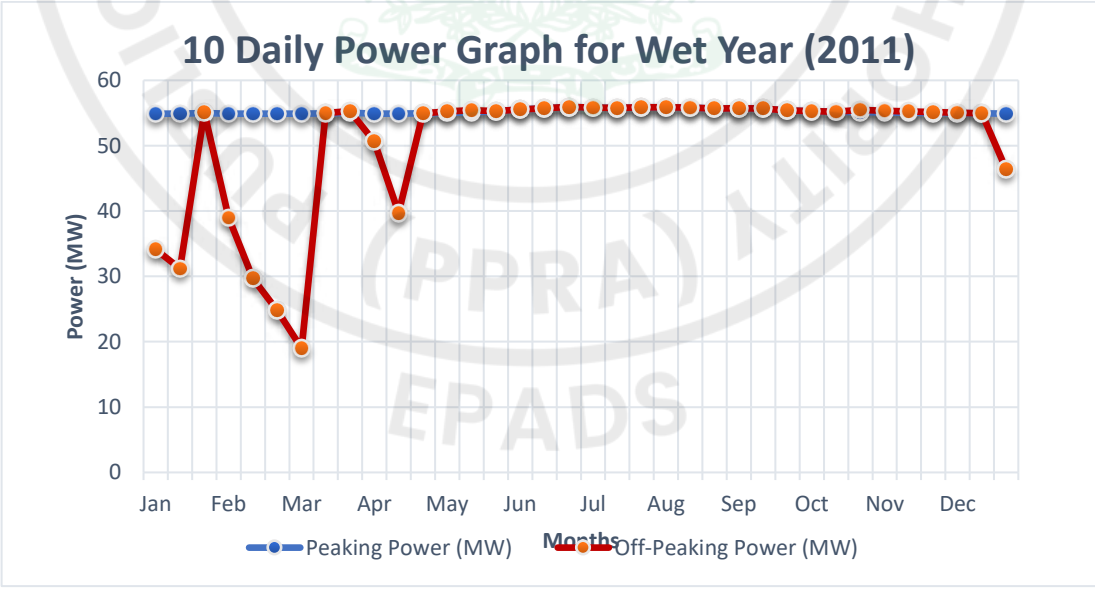


**Figure 8-10 10-Daily Power Graph for Wet Year (2011)**

In wet year, installed power of 54 MW would be available from May to mid-December. Power may reach to full capacity during high flows of wet year even in February and March. In low flow period, the minimum power is estimated to remain at 20 MW as indicated in Figure 8-10.



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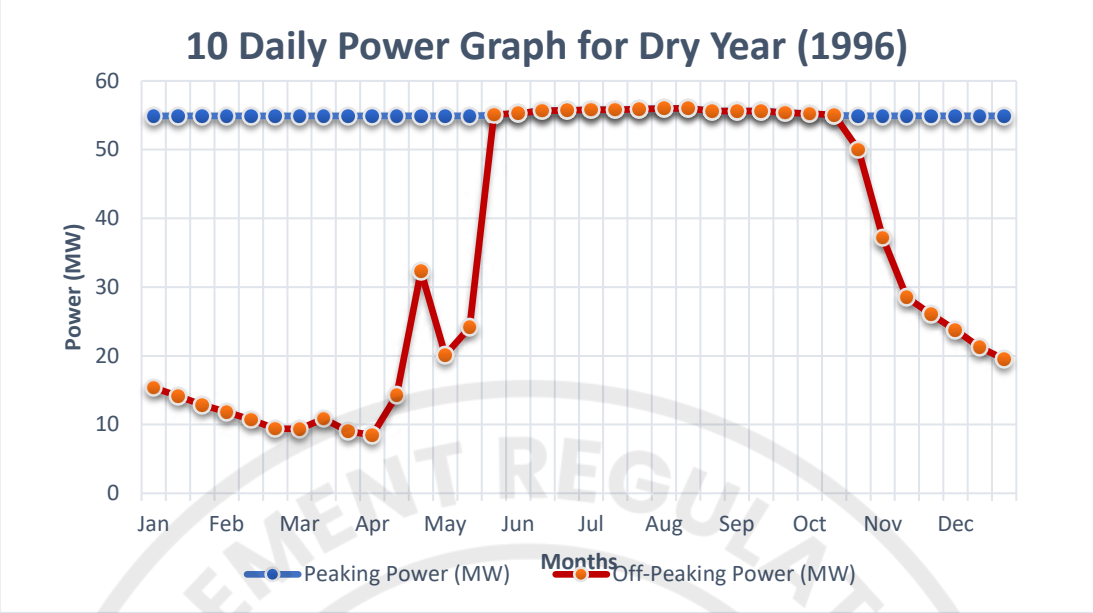


**Figure 8-11 10-Daily Power Graph for Dry Year (1996)**

In dry year, installed power of 54 MW will be available from June to mid-October and reduces as low as 9 MW when less flows are available. For dry year 1996, the power variation over the year is indicated in Figure 8-11.

The mean annual energy for the recorded period from 1966 to 2015 has been estimated and it is graphically presented in Figure 8-12. The graph indicates that the estimated annual energy over a period of 50 years doesn't vary much and remain quite consistent with little variation. It varies from 333.87 GWh to 449.49 GWh with mean value as 373.69 GWh. The plant factor for 54 MW power plant would be 79%. The low variation in mean annual energy and high plant factor indicate the reliability of hydropower from the lake.



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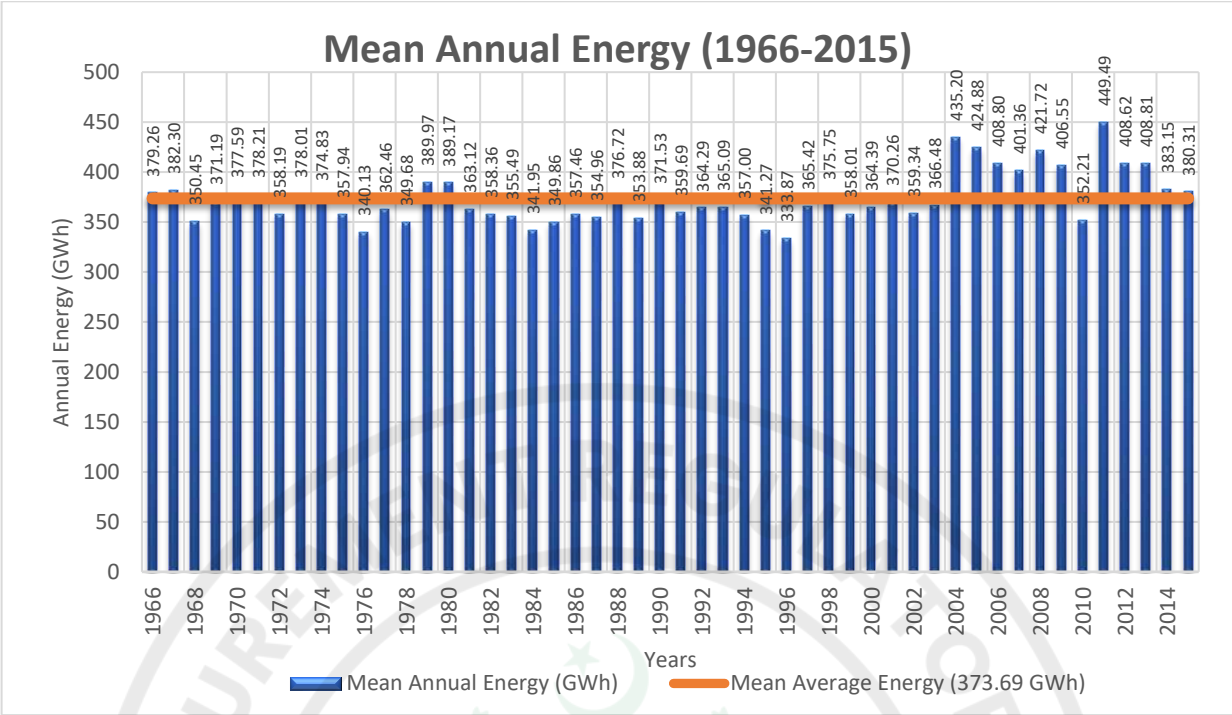


**Figure 8-12 Mean Annual Energy Graph from 1966 to 2015**

A comparison has also been plotted between monthly energy generations for Wet, Average and Dry years. Mean Annual Energy Curves indicate the trend of variations of monthly energies in GWh. The graph is shown at Figure 8-14.

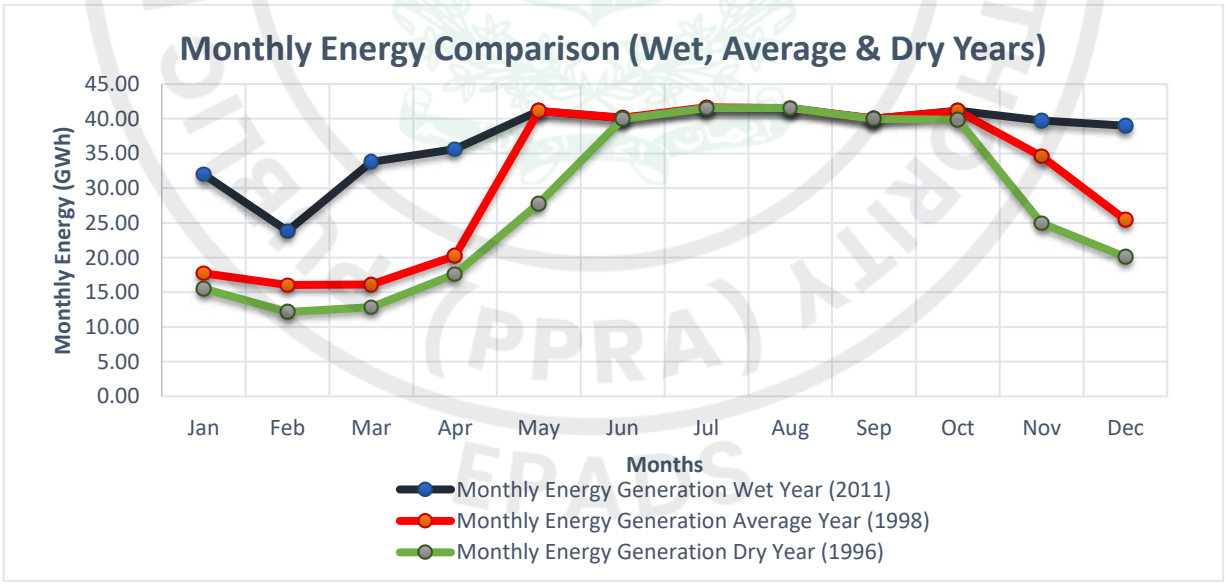


**Figure 8-13 Monthly Energy Comparison (Wet, Average & Dry Years)**

Power and energy calculations for Average, Wet and Dry years have been calculated and tabulated at Table 8-7, Table 8-8 & Table 8-9 respectively



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**Table 8-7 Power and Energy Calculations for Average Year (1998)**

| Month | Days | River Discharge ($m^3/s$) | $Q_{pk}$ ($m^3/s$) | $Q_{op}$ ($m^3/s$) | HWL m.a.s.l | TWL m.a.s.l | $P_{pk}$ (MW) | $P_{op}$ (MW) | Energy (GWh) |
|---|---|---|---|---|---|---|---|---|---|
| Jan | 10 | 30.72 | 60.00 | 21.27 | 2414.00 | 2302.33 | 54.91 | 19.38 | 6.07 |
| | 10 | 28.65 | 60.00 | 18.78 | 2414.00 | 2302.33 | 54.91 | 17.11 | 5.62 |
| | 11 | 28.04 | 60.00 | 18.05 | 2414.00 | 2302.33 | 54.91 | 16.44 | 6.03 |
| Feb | 10 | 28.94 | 60.00 | 19.13 | 2414.00 | 2302.33 | 54.91 | 17.42 | 5.68 |
| | 10 | 29.47 | 60.00 | 19.76 | 2414.00 | 2302.33 | 54.91 | 18.00 | 5.80 |
| | 8 | 29.10 | 60.00 | 19.32 | 2414.00 | 2302.33 | 54.91 | 17.60 | 4.57 |
| Mar | 10 | 27.55 | 60.00 | 17.46 | 2414.00 | 2302.33 | 54.91 | 15.90 | 5.38 |
| | 10 | 26.95 | 60.00 | 16.74 | 2414.00 | 2302.33 | 54.91 | 15.25 | 5.25 |
| | 11 | 25.81 | 60.00 | 15.37 | 2414.00 | 2302.33 | 54.91 | 13.99 | 5.49 |
| Apr | 10 | 26.09 | 60.00 | 15.71 | 2414.00 | 2302.33 | 54.91 | 14.31 | 5.06 |
| | 10 | 30.33 | 60.00 | 20.80 | 2414.00 | 2302.33 | 54.91 | 18.95 | 5.99 |
| | 10 | 44.82 | 60.00 | 38.19 | 2414.00 | 2302.33 | 54.91 | 34.86 | 9.17 |
| May | 10 | 63.84 | 60.00 | 60.00 | 2414.03 | 2302.33 | 54.93 | 54.93 | 13.18 |
| | 10 | 116.70 | 60.00 | 60.00 | 2414.47 | 2302.33 | 55.16 | 55.56 | 13.32 |
| | 11 | 216.28 | 60.00 | 60.00 | 2414.96 | 2302.33 | 55.41 | 55.41 | 14.63 |
| Jun | 10 | 274.75 | 60.00 | 60.00 | 2415.19 | 2302.33 | 55.53 | 55.53 | 13.33 |
| | 10 | 451.22 | 60.00 | 60.00 | 2415.78 | 2302.45 | 55.77 | 55.77 | 13.39 |
| | 10 | 649.46 | 60.00 | 60.00 | 2416.34 | 2302.69 | 55.94 | 55.94 | 13.43 |
| Jul | 10 | 763.42 | 60.00 | 60.00 | 2416.63 | 2302.83 | 56.02 | 56.02 | 13.44 |
| | 10 | 832.02 | 60.00 | 60.00 | 2416.80 | 2302.91 | 56.06 | 56.06 | 13.46 |
| | 11 | 607.13 | 60.00 | 60.00 | 2416.22 | 2302.64 | 55.91 | 55.91 | 14.76 |
| Aug | 10 | 581.22 | 60.00 | 60.00 | 2416.15 | 2302.61 | 55.89 | 55.89 | 13.41 |
| | 10 | 568.59 | 60.00 | 60.00 | 2416.12 | 2302.60 | 55.87 | 55.87 | 13.41 |
| | 11 | 406.63 | 60.00 | 60.00 | 2415.64 | 2302.40 | 55.73 | 55.73 | 14.71 |
| Sep | 10 | 493.48 | 60.00 | 60.00 | 2415.90 | 2302.50 | 55.81 | 55.81 | 13.39 |
| | 10 | 345.06 | 60.00 | 60.00 | 2415.44 | 2302.33 | 55.66 | 55.66 | 13.36 |
| | 10 | 190.28 | 60.00 | 60.00 | 2414.84 | 2302.33 | 55.35 | 55.35 | 13.28 |
| Oct | 10 | 132.75 | 60.00 | 60.00 | 2414.57 | 2302.33 | 55.20 | 55.20 | 13.25 |
| | 10 | 110.03 | 60.00 | 60.00 | 2414.43 | 2302.33 | 55.14 | 55.49 | 13.30 |
| | 11 | 81.49 | 60.00 | 60.00 | 2414.23 | 2302.33 | 55.03 | 55.17 | 14.56 |
| Nov | 10 | 64.03 | 60.00 | 60.00 | 2414.03 | 2302.33 | 54.93 | 54.94 | 13.18 |
| | 10 | 54.65 | 60.00 | 49.98 | 2414.00 | 2302.33 | 54.91 | 45.69 | 11.33 |
| | 10 | 48.89 | 60.00 | 43.06 | 2414.00 | 2302.33 | 54.91 | 39.33 | 10.06 |
| Dec | 10 | 45.18 | 60.00 | 38.62 | 2414.00 | 2302.33 | 54.91 | 35.26 | 9.25 |
| | 10 | 41.18 | 60.00 | 33.81 | 2414.00 | 2302.33 | 54.91 | 30.85 | 8.37 |
| | 11 | 35.54 | 60.00 | 27.04 | 2414.00 | 2302.33 | 54.91 | 24.66 | 7.84 |
| **Average Year Annual Energy (1998) GWh** | | | | | | | | | **375.75** |



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## Table 8-8 Power and Energy Calculations for Wet Year (2011)

| Month | Days | River Discharge ($m^3/s$) | $Q_{pk}$ ($m^3/s$) | $Q_{op}$ ($m^3/s$) | HWL m.a.s.l | TWL m.a.s.l | $P_{pk}$ (MW) | $P_{op}$ (MW) | Energy (GWh) |
|---|---|---|---|---|---|---|---|---|---|
| Jan | 10 | 44.17 | 60.00 | 37.40 | 2414.00 | 2302.33 | 54.91 | 34.14 | 9.02 |
| | 10 | 41.46 | 60.00 | 34.15 | 2414.00 | 2302.33 | 54.91 | 31.17 | 8.43 |
| | 11 | 73.86 | 60.00 | 60.00 | 2414.16 | 2302.33 | 55.00 | 55.08 | 14.54 |
| Feb | 10 | 48.54 | 60.00 | 42.65 | 2414.00 | 2302.33 | 54.91 | 38.95 | 9.99 |
| | 10 | 40.09 | 60.00 | 32.51 | 2414.00 | 2302.33 | 54.91 | 29.66 | 8.13 |
| | 8 | 35.63 | 60.00 | 27.15 | 2414.00 | 2302.33 | 54.91 | 24.76 | 5.72 |
| Mar | 10 | 30.37 | 60.00 | 20.84 | 2414.00 | 2302.33 | 54.91 | 18.99 | 5.99 |
| | 10 | 67.54 | 60.00 | 60.00 | 2414.09 | 2302.33 | 54.96 | 54.99 | 13.20 |
| | 11 | 89.69 | 60.00 | 60.00 | 2414.30 | 2302.33 | 55.07 | 55.27 | 14.58 |
| Apr | 10 | 59.14 | 60.00 | 55.36 | 2414.00 | 2302.33 | 54.91 | 50.64 | 12.33 |
| | 10 | 49.22 | 60.00 | 43.46 | 2414.00 | 2302.33 | 54.91 | 39.70 | 10.14 |
| | 10 | 65.66 | 60.00 | 60.00 | 2414.06 | 2302.33 | 54.94 | 54.96 | 13.19 |
| May | 10 | 86.83 | 60.00 | 60.00 | 2414.28 | 2302.33 | 55.05 | 55.23 | 13.25 |
| | 10 | 103.14 | 60.00 | 60.00 | 2414.39 | 2302.33 | 55.11 | 55.41 | 13.29 |
| | 11 | 166.85 | 60.00 | 60.00 | 2414.74 | 2302.33 | 55.29 | 55.29 | 14.60 |
| Jun | 10 | 266.03 | 60.00 | 60.00 | 2415.15 | 2302.33 | 55.51 | 55.51 | 13.32 |
| | 10 | 431.15 | 60.00 | 60.00 | 2415.71 | 2302.43 | 55.75 | 55.75 | 13.38 |
| | 10 | 635.93 | 60.00 | 60.00 | 2416.30 | 2302.68 | 55.93 | 55.93 | 13.42 |
| Jul | 10 | 517.05 | 60.00 | 60.00 | 2415.97 | 2302.53 | 55.83 | 55.83 | 13.40 |
| | 10 | 470.43 | 60.00 | 60.00 | 2415.83 | 2302.48 | 55.79 | 55.79 | 13.39 |
| | 11 | 565.29 | 60.00 | 60.00 | 2416.11 | 2302.59 | 55.87 | 55.87 | 14.75 |
| Aug | 10 | 560.97 | 60.00 | 60.00 | 2416.10 | 2302.59 | 55.87 | 55.87 | 13.41 |
| | 10 | 497.46 | 60.00 | 60.00 | 2415.91 | 2302.51 | 55.81 | 55.81 | 13.40 |
| | 11 | 362.62 | 60.00 | 60.00 | 2415.49 | 2302.35 | 55.68 | 55.68 | 14.70 |
| Sep | 10 | 403.53 | 60.00 | 60.00 | 2415.63 | 2302.40 | 55.72 | 55.72 | 13.37 |
| | 10 | 370.33 | 60.00 | 60.00 | 2415.52 | 2302.36 | 55.69 | 55.69 | 13.37 |
| | 10 | 216.16 | 60.00 | 60.00 | 2414.96 | 2302.33 | 55.41 | 55.41 | 13.30 |
| Oct | 10 | 168.18 | 60.00 | 60.00 | 2414.74 | 2302.33 | 55.30 | 55.30 | 13.27 |
| | 10 | 128.43 | 60.00 | 60.00 | 2414.54 | 2302.33 | 55.19 | 55.19 | 13.25 |
| | 11 | 108.97 | 60.00 | 60.00 | 2414.43 | 2302.33 | 55.13 | 55.48 | 14.63 |
| Nov | 10 | 94.08 | 60.00 | 60.00 | 2414.33 | 2302.33 | 55.08 | 55.31 | 13.27 |
| | 10 | 87.67 | 60.00 | 60.00 | 2414.28 | 2302.33 | 55.06 | 55.24 | 13.25 |
| | 10 | 78.32 | 60.00 | 60.00 | 2414.21 | 2302.33 | 55.02 | 55.13 | 13.23 |
| Dec | 10 | 71.31 | 60.00 | 60.00 | 2414.14 | 2302.33 | 54.98 | 55.04 | 13.21 |
| | 10 | 64.06 | 60.00 | 60.00 | 2414.03 | 2302.33 | 54.93 | 54.94 | 13.18 |
| | 11 | 55.28 | 60.00 | 50.74 | 2414.00 | 2302.33 | 54.91 | 46.39 | 12.62 |
| **Wet Year Annual Energy (2011) GWh** | | | | | | | | | **449.49** |



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## Table 8-9 Power and Energy Calculations for Dry Year (1996)

| Month | Days | River Discharge ($m^3/s$) | $Q_{pk}$ ($m^3/s$) | $Q_{op}$ ($m^3/s$) | HWL m.a.s.l | TWL m.a.s.l | $P_{pk}$ (MW) | $P_{op}$ (MW) | Energy (GWh) |
|---|---|---|---|---|---|---|---|---|---|
| Jan | 10 | 27.06 | 60.00 | 16.87 | 2414.00 | 2302.33 | 54.91 | 15.36 | 5.27 |
| | 10 | 25.96 | 60.00 | 15.56 | 2414.00 | 2302.33 | 54.91 | 14.16 | 5.03 |
| | 11 | 24.77 | 60.00 | 14.12 | 2414.00 | 2302.33 | 54.91 | 12.85 | 5.24 |
| Feb | 10 | 23.83 | 60.00 | 13.00 | 2414.00 | 2302.33 | 54.91 | 11.83 | 4.56 |
| | 10 | 22.80 | 60.00 | 11.76 | 2414.00 | 2302.33 | 54.91 | 10.70 | 4.34 |
| | 8 | 21.61 | 60.00 | 10.33 | 2414.00 | 2302.33 | 54.91 | 9.40 | 3.26 |
| Mar | 10 | 21.56 | 60.00 | 10.27 | 2414.00 | 2302.33 | 54.91 | 9.34 | 4.07 |
| | 10 | 22.93 | 60.00 | 11.92 | 2414.00 | 2302.33 | 54.91 | 10.85 | 4.37 |
| | 11 | 21.27 | 60.00 | 9.93 | 2414.00 | 2302.33 | 54.91 | 9.03 | 4.40 |
| Apr | 10 | 20.75 | 60.00 | 9.30 | 2414.00 | 2302.33 | 54.91 | 8.46 | 3.89 |
| | 10 | 26.03 | 60.00 | 15.64 | 2414.00 | 2302.33 | 54.91 | 14.24 | 5.04 |
| | 10 | 42.51 | 60.00 | 35.41 | 2414.00 | 2302.33 | 54.91 | 32.32 | 8.66 |
| May | 10 | 31.39 | 60.00 | 22.07 | 2414.00 | 2302.33 | 54.91 | 20.11 | 6.22 |
| | 10 | 35.07 | 60.00 | 26.48 | 2414.00 | 2302.33 | 54.91 | 24.14 | 7.02 |
| | 11 | 75.25 | 60.00 | 60.00 | 2414.18 | 2302.33 | 55.00 | 55.09 | 14.54 |
| Jun | 10 | 162.25 | 60.00 | 60.00 | 2414.72 | 2302.33 | 55.28 | 55.28 | 13.27 |
| | 10 | 347.31 | 60.00 | 60.00 | 2415.44 | 2302.33 | 55.66 | 55.66 | 13.36 |
| | 10 | 373.33 | 60.00 | 60.00 | 2415.53 | 2302.36 | 55.69 | 55.69 | 13.37 |
| Jul | 10 | 446.88 | 60.00 | 60.00 | 2415.76 | 2302.45 | 55.77 | 55.77 | 13.38 |
| | 10 | 479.44 | 60.00 | 60.00 | 2415.86 | 2302.49 | 55.80 | 55.80 | 13.39 |
| | 11 | 564.28 | 60.00 | 60.00 | 2416.11 | 2302.59 | 55.87 | 55.87 | 14.75 |
| Aug | 10 | 720.09 | 60.00 | 60.00 | 2416.52 | 2302.78 | 55.99 | 55.99 | 13.44 |
| | 10 | 726.57 | 60.00 | 60.00 | 2416.54 | 2302.79 | 55.99 | 55.99 | 13.44 |
| | 11 | 322.03 | 60.00 | 60.00 | 2415.36 | 2302.33 | 55.62 | 55.62 | 14.68 |
| Sep | 10 | 313.09 | 60.00 | 60.00 | 2415.32 | 2302.33 | 55.60 | 55.60 | 13.34 |
| | 10 | 321.96 | 60.00 | 60.00 | 2415.36 | 2302.33 | 55.62 | 55.62 | 13.35 |
| | 10 | 203.88 | 60.00 | 60.00 | 2414.90 | 2302.33 | 55.38 | 55.38 | 13.29 |
| Oct | 10 | 136.56 | 60.00 | 60.00 | 2414.59 | 2302.33 | 55.22 | 55.21 | 13.25 |
| | 10 | 72.07 | 60.00 | 60.00 | 2414.15 | 2302.33 | 54.99 | 55.05 | 13.21 |
| | 11 | 58.52 | 60.00 | 54.63 | 2414.00 | 2302.33 | 54.91 | 49.96 | 13.41 |
| Nov | 10 | 46.90 | 60.00 | 40.68 | 2414.00 | 2302.33 | 54.91 | 37.15 | 9.63 |
| | 10 | 39.05 | 60.00 | 31.26 | 2414.00 | 2302.33 | 54.91 | 28.51 | 7.90 |
| | 10 | 36.80 | 60.00 | 28.57 | 2414.00 | 2302.33 | 54.91 | 26.05 | 7.41 |
| Dec | 10 | 34.72 | 60.00 | 26.07 | 2414.00 | 2302.33 | 54.91 | 23.76 | 6.95 |
| | 10 | 32.41 | 60.00 | 23.29 | 2414.00 | 2302.33 | 54.91 | 21.22 | 6.44 |
| | 11 | 30.83 | 60.00 | 21.40 | 2414.00 | 2302.33 | 54.91 | 19.50 | 6.71 |
| **Dry Year Annual Energy (1996) GWh** | | | | | | | | | **333.87** |



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# 9 DESIGN OF STRUCTURES

## 9.1 INTRODUCTION

Attabad Lake Hydropower Project (ALHPP) is a Runoff River peaking scheme on Hunza River in Hunza Region. The Project is planned to develop the reach of river 2.5 km downstream of Attabad Lake to generate 54 MW power by proposing the following Civil Engineering Structures:

Natural dam of 45 m height from river bed to act as diversion structure with low level outlet and an overflow ungated spillway.

Power Intake structure is proposed on the left bank of river to take the design discharge of 60.0 $m^3/s$.

- Low pressure headrace tunnel having diameter of 5.5 m with total length of 2320 m.
- Vertical surge shaft of 10 m diameter with height of 49 m.
- Concrete lined pressure shaft of 3.6 m diameter having a length of 80 m.
- Steel penstock having a length of 470 m length and diameter of 3.5 m.
- Surface powerhouse with three (03) Francis units with an installed capacity of 54 MW and open switchyard.
- Tailrace channel of 18 m length.

The overflow weir/ungated spillway on existing dam created due to landslide at right side of Hunza River has been proposed with its crest level at elevation 2414.0 m.a.s.l. The structure has been designed to safely pass 1:10,000-year return period flood and Operating Basis Earthquake (OBE) and Safety Evaluation Earthquake (SEE) without damage. The overflow weir/spillway is ungated structure for flood discharge. The discharge to downstream stilling basin of overflow weir/spillway for energy dissipation before being released into channelized section of Hunza River in slide area. The care has been taken to provide protective design of the structures. Detail Drawings of over flow weir/ spillway are shown in AFS-WR-409 to AFS-411 Vol. 2 Drawings.

Three low level sediment flushing outlets serving the dual purpose of diversion during construction as well as sediment flushing have been provided on the left bank of overflow weir/ungated spillway. Considerable sediment inflow is expected into the reservoir during the glacier/snow melt runoff and also during rains. In order to maintain the power intakes free of sediment build up, it is located 2 m above the invert level of flushing outlets. The concrete spillway section and the three low level outlets will be used to flush the sediments from the reservoir.

Due to the high river bed gradient, it is expected that intensive sediment load would be entering in the reservoir. To prevent this occurring, provision has also been made to build a low “flow-through” rockfill boulder trap on Shimshal River upstream of the reservoir to trap any moving boulders or bed material.

Two boulder traps will be constructed on Shimshal River which is main sources of sediment load in Hunza River at Attabad. Each boulder trap will be 20 m high an estimated boulder/debris/sediment volume of 1.4 Million $m^3$. The diversion of Hunza River will be accomplished by the construction of upstream and downstream cofferdams with impervious cut off provided by intersecting columns of jet grouting.



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Conventional ring cofferdams with sufficient space provision for construction activities and access will be used for construction of the diversion intakes and tunnels and the power intakes. The headrace commences at the twin intakes on the left bank connecting to the low pressure tunnel.

At the downstream end of the low pressure tunnel a surge shaft is provided to limit pressure rise in the waterway system and allow flexibility in power plant operation. From surge tank, first horizontal tunnel and the embedded penstock lead to three vertical shaft Francis Turbines arranged in on-ground powerhouse. Transformers are arranged in a GIS open switchyard. The switchyard is above ground located near the powerhouse. A 18m long tailrace releases generation flows back to the Hunza River about 2.5 km downstream of overflow weir. Feasibility Drawings are provided in Vol. 2 – Drawings of the Feasibility Report.

## 9.2 HYDRAULIC MODELLING OF RESERVOIR

The primary tools for simulating the flow phenomena in water resources structures are hydraulic/hydrodynamic models that describe the fluid motion and the dynamics of the flood wave by solving mathematical equations, which are based on the principles of the conservation of mass and momentum.

Hydraulic Model, the Hydrologic Engineering Center's River Analysis System (HEC-RAS 5.0.7) is used to assess the impact of design flood on the proposed weir, downstream as well as backwater effect at the upstream side of the lake. The software is developed by the US Army Corps of Engineers and it is widely used for performing 1D steady and unsteady flow, 2D unsteady flow river hydraulics calculations, sediment transport modeling, and water quality analysis.

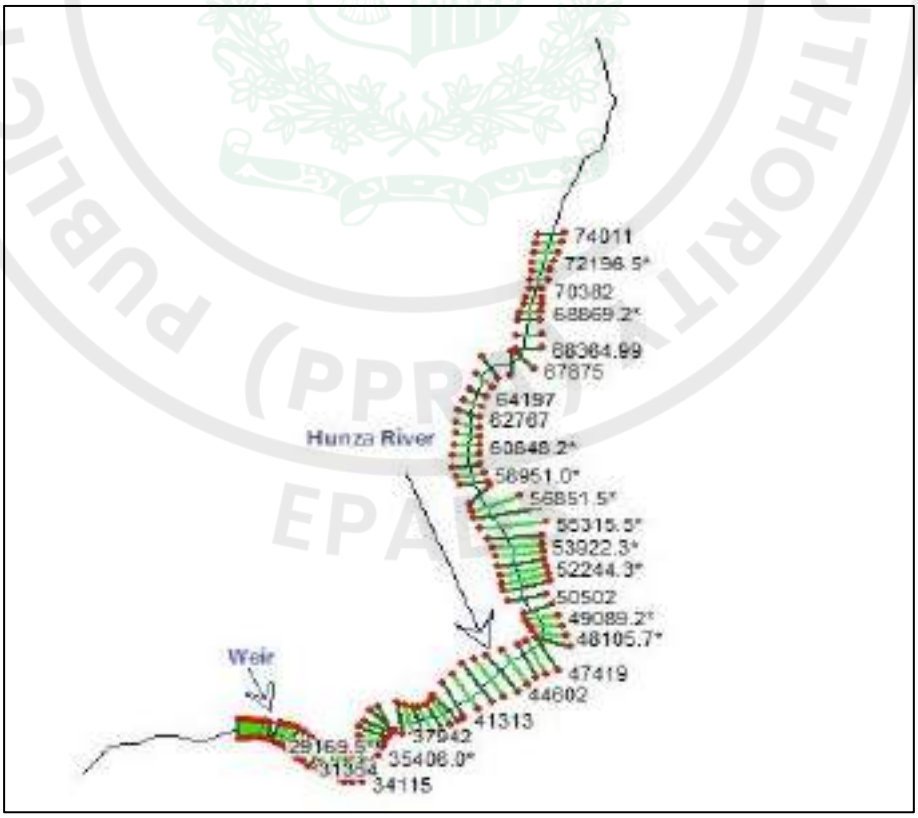




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**Figure 9-1 Reservoir Area showing River Cross Sections and Location of Weir**

### 9.2.1 Input Data

Hydraulic Model is prepared to analyze the impact of flood of 3,250 $m^3/s$, 10,000 year return period flood, at upstream side of the project with proposed weir. A 1D-Unsteady numerical modeling approach is used in the analysis to study the impact of proposed weir having crest elevation of 2,014 m.a.s.l.



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River cross section data has been taken from the hydrographic survey conducted for the project by ISRIP in Sep/Oct 2020. Forty Cross Sections in about 14 km reach has been used to prepare an input file for HEC-RAS. These surveyed cross sections are further used for interpolation of cross sections where required for true representation and model stability. A proposed 60 m long ungated ogee weir and about 400 m downstream reach covering stilling basin and stone apron have also been drawn. In most upstream part of the reach, Manning's 'n' value has been taken as 0.040, value changes just before the weir structure and at weir crest it has been taken as 0.013 and accordingly downstream, Coefficient of Discharge (Cd) is taken as 0.8. Further, boundary conditions are set as flood hydrograph for 3,250 $m^3/s$ peak and normal depth at downstream.

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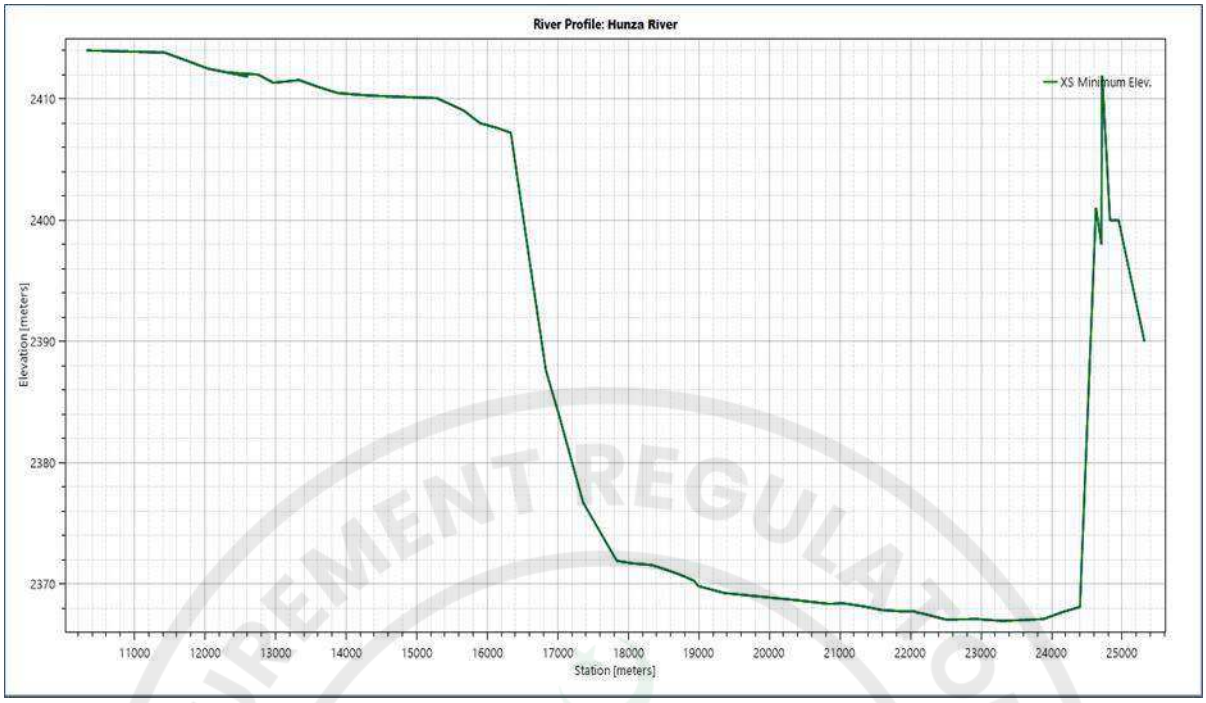


**Figure 9-2 Hunza River Profile in Reservoir Area**

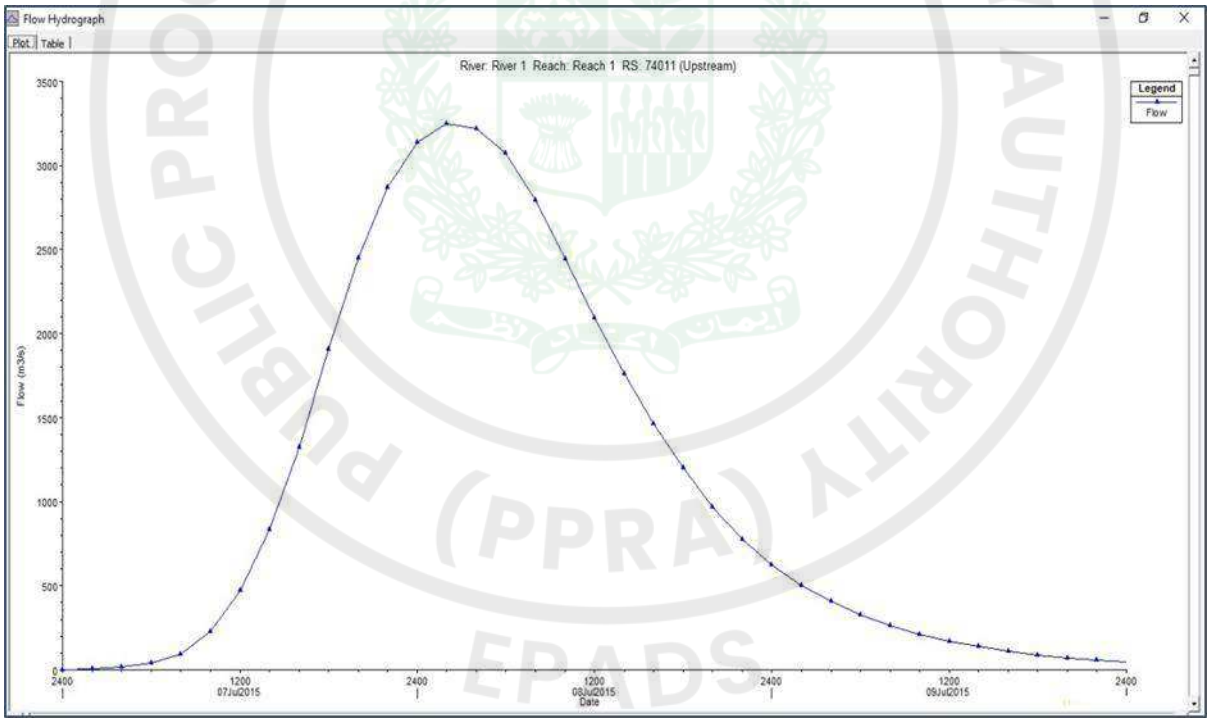


**Figure 9-3 Extrapolated Flow Hydrograph**



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### 9.2.2 Analysis and Conclusions

The model has been run keeping a lesser time step for computations and accordingly results are computed. It can be viewed from the results that maximum Water Surface Elevation (WSE) at overflow Weir is 2,421.43 m.a.s.l. and about 14 km upstream it is 2,422.61 m.a.s.l. against design flood. This shows the impact of flood wave at upstream of the lake with 60 m long ungated weir having crest at 2,414 m.a.s.l. Flood mapping is drawn using RAS Mapper tool in HEC-RAS which shows the extent of maximum water surface elevation against the design flood. Rating Curve is also drawn at the weir. The model is calibrated using the flows measurements at Ganish Bridge and water surface level measurements at the lake during hydrographic survey.

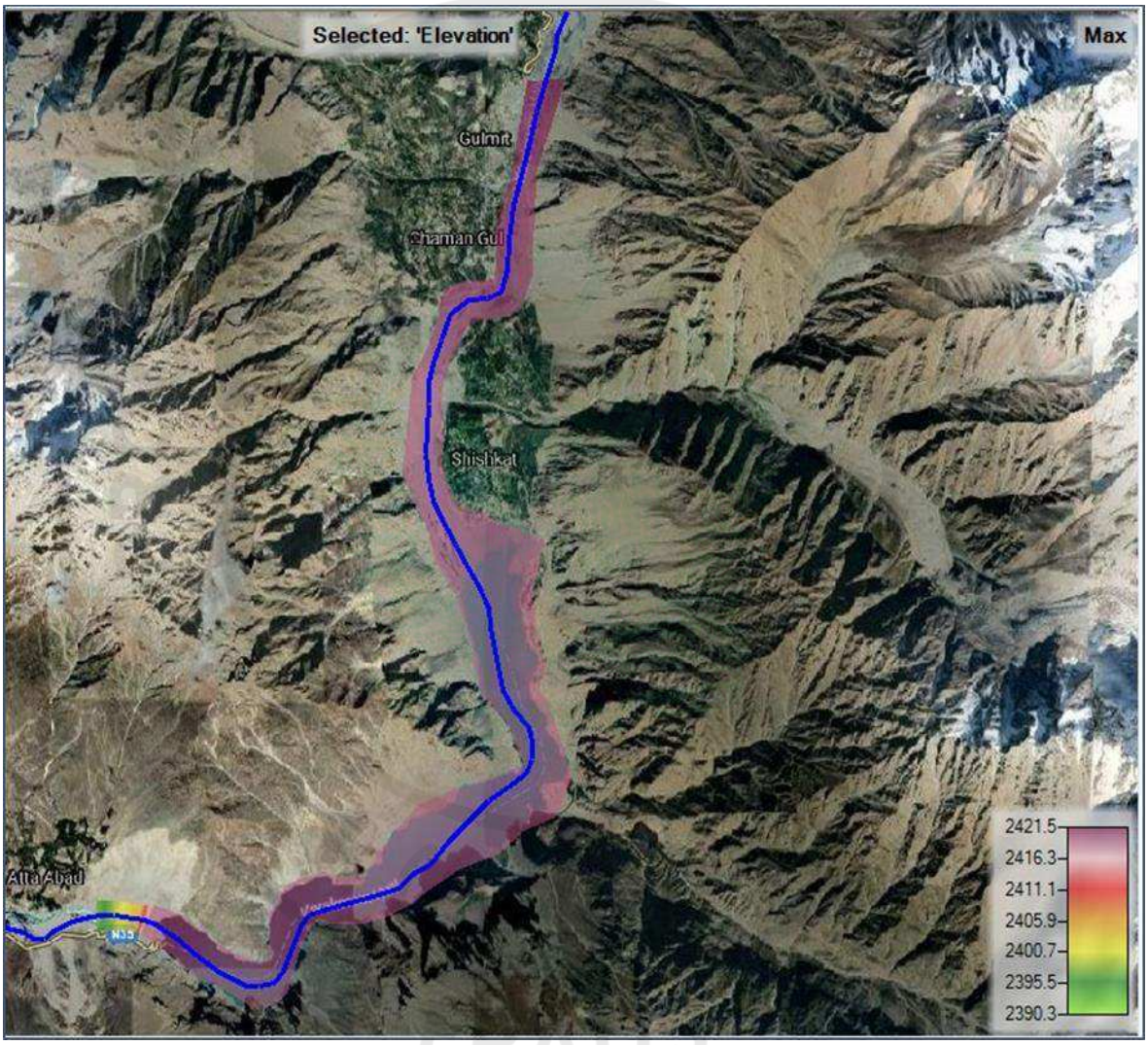


**Figure 9-4 Maximum Water Surface Elevation (WSE) against Design Flood**



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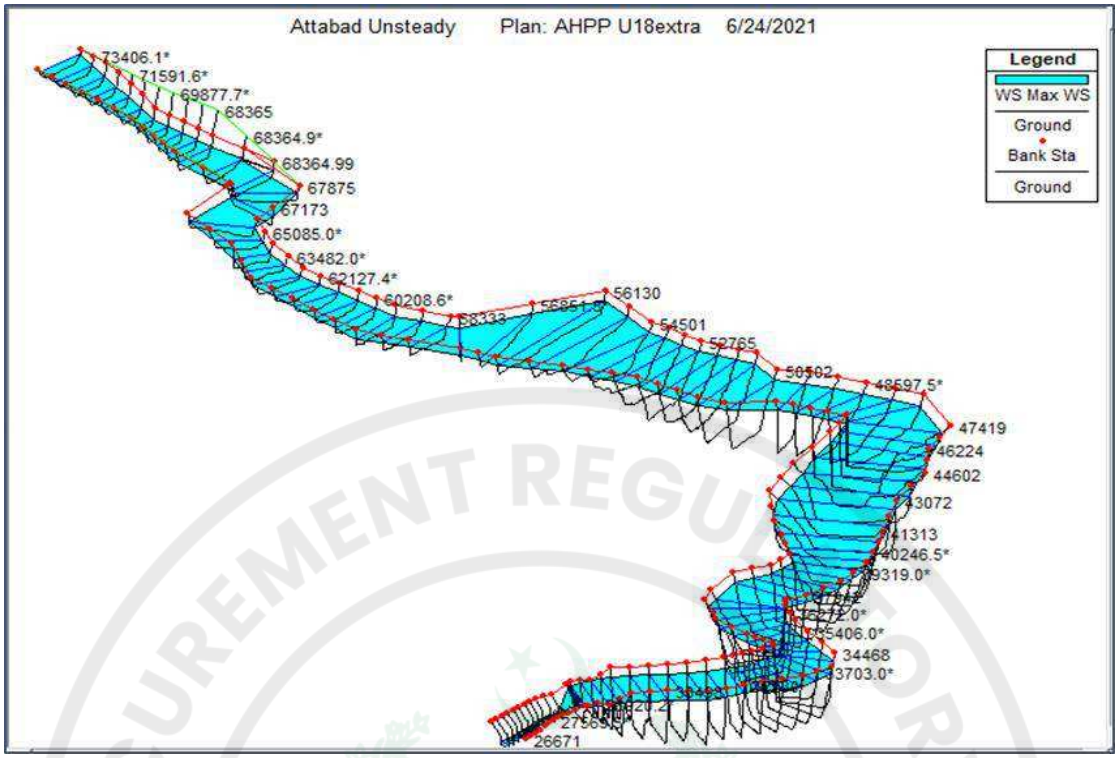


**Figure 9-5 3D Perspective Plot against Max WSE**

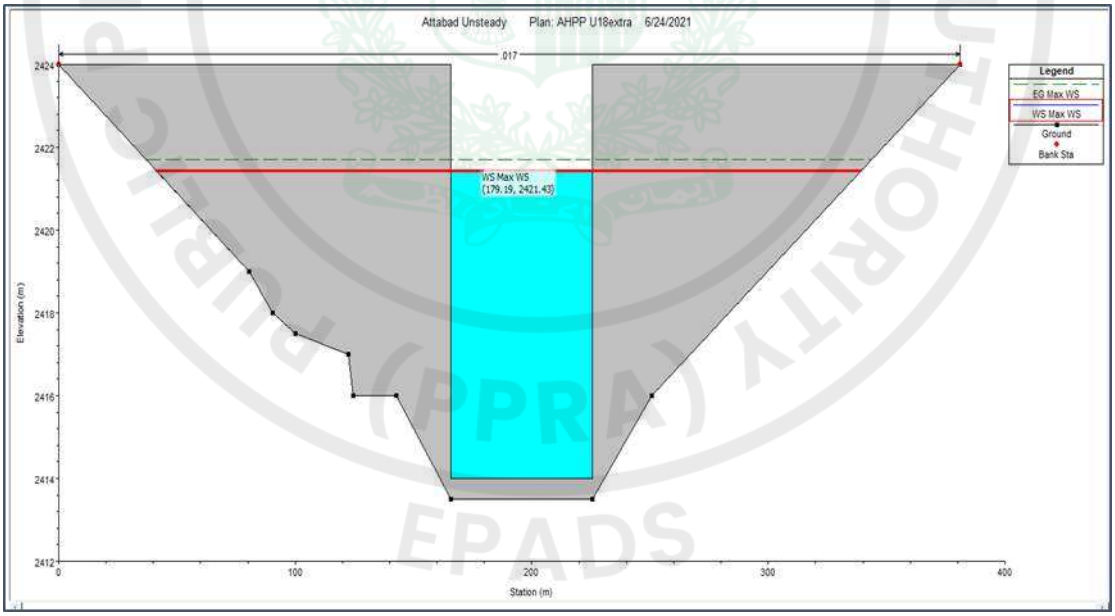


**Figure 9-6 Weir Section with Maximum Water Surface Elevation**

Detailed output table is tabulated below showing discharges, minimum river elevation, water surface elevation, energy grade line elevation, velocity, flow area and top width of each cross section from about 14 km upstream of the overflow weir / ungated spillway to about 500 m downstream. In conclusion, this shows that there would be no major impact on upstream settlements due to the overflow weir at 2,414 m.a.s.l and flood would remain within the river system.



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## Table 9-1 Maximum Water Surface Elevation at each Surveyed Cross Section

| Sr. No. | River Station | Distance from Weir | Q Total | Min XS El. | W.S. El. | E.G. El. | Velocity | Flow Area | Top Width |
|---|---|---|---|---|---|---|---|---|---|
| | (u/s to d/s) | (m) | ($m^3/s$ | (m) | (m) | (m) | (m/s) | ($m^2$) | (m) |
| 1 | 74011 | 13,886 | 3169. | 2414.00 | 2422.6 | 2422.6 | 1.05 | 3017.17 | 399.81 |
| 2 | 70382 | 12,780 | 3116. | 2413.82 | 2421.9 | 2422.3 | 2.59 | 1200.87 | 170.55 |
| 3 | 68365 | 12,165 | 3119. | 2412.50 | 2422.0 | 2422.1 | 1.06 | 2934.84 | 332.25 |
| 4 | 68365 | 12,165 | 3118. | 2411.84 | 2422.0 | 2422.0 | 0.95 | 3291.69 | 413.04 |
| 5 | 67875 | 12,016 | 3118. | 2412.01 | 2422.0 | 2422.0 | 0.82 | 3808.64 | 429.72 |
| 6 | 67173 | 11,802 | 3112. | 2411.33 | 2421.9 | 2422.0 | 0.86 | 3603.62 | 428.07 |
| 7 | 65973 | 11,436 | 3113. | 2411.55 | 2421.9 | 2421.9 | 0.88 | 3552.69 | 447.56 |
| 8 | 64197 | 10,895 | 3106. | 2410.49 | 2421.8 | 2421.9 | 1.33 | 2334.18 | 246.01 |
| 9 | 62767 | 10,459 | 3095. | 2410.28 | 2421.6 | 2421.8 | 2.02 | 1533.76 | 221.29 |
| 10 | 59569 | 9,485 | 3094. | 2410.06 | 2421.6 | 2421.6 | 0.71 | 4383.47 | 452.61 |
| 11 | 58333 | 9,108 | 3091. | 2409.06 | 2421.6 | 2421.6 | 0.70 | 4398.80 | 408.15 |
| 12 | 57573 | 8,876 | 3094. | 2408.00 | 2421.6 | 2421.6 | 0.74 | 4171.30 | 420.15 |
| 13 | 56130 | 8,436 | 3092. | 2407.20 | 2421.6 | 2421.6 | 0.21 | 15073.7 | 1252.65 |
| 14 | 54501 | 7,940 | 3092. | 2387.60 | 2421.6 | 2421.6 | 0.17 | 18005.9 | 847.82 |
| 15 | 52765 | 7,411 | 3093. | 2376.70 | 2421.6 | 2421.6 | 0.14 | 22744.4 | 698.40 |
| 16 | 51203 | 6,935 | 3093. | 2371.90 | 2421.6 | 2421.6 | 0.11 | 28707.9 | 769.19 |
| 17 | 50502 | 6,721 | 3093. | 2371.70 | 2421.6 | 2421.6 | 0.14 | 21636.6 | 573.80 |
| 18 | 49581 | 6,440 | 3094. | 2371.56 | 2421.6 | 2421.6 | 0.18 | 17209.1 | 460.98 |
| 19 | 47614 | 5,841 | 3092. | 2370.26 | 2421.6 | 2421.6 | 0.15 | 20547.6 | 553.60 |
| 20 | 47419 | 5,781 | 3092. | 2369.82 | 2421.6 | 2421.6 | 0.14 | 21934.0 | 660.34 |
| 21 | 46224 | 5,417 | 3093. | 2369.26 | 2421.6 | 2421.6 | 0.12 | 24782.0 | 703.79 |
| 22 | 44602 | 4,923 | 3092. | 2368.97 | 2421.6 | 2421.6 | 0.10 | 31098.3 | 786.87 |
| 23 | 43072 | 4,457 | 3092. | 2368.70 | 2421.6 | 2421.6 | 0.09 | 34793.8 | 814.98 |
| 24 | 41313 | 3,920 | 3092. | 2368.35 | 2421.6 | 2421.6 | 0.11 | 28512.3 | 719.01 |
| 25 | 40714 | 3,738 | 3092. | 2368.41 | 2421.6 | 2421.6 | 0.12 | 26649.7 | 603.33 |
| 26 | 39779 | 3,453 | 3092. | 2368.16 | 2421.6 | 2421.6 | 0.14 | 22493.7 | 494.28 |
| 27 | 38859 | 3,173 | 3091. | 2367.84 | 2421.6 | 2421.6 | 0.14 | 21662.4 | 470.46 |
| 28 | 37942 | 2,893 | 3091. | 2367.73 | 2421.6 | 2421.6 | 0.12 | 25907.7 | 555.37 |
| 29 | 37328 | 2,706 | 3091. | 2367.75 | 2421.6 | 2421.6 | 0.14 | 21329.6 | 491.89 |
| 30 | 37243 | 2,680 | 3091. | 2367.63 | 2421.6 | 2421.6 | 0.14 | 22001.6 | 527.13 |
| 31 | 37079 | 2,630 | 3091. | 2367.59 | 2421.6 | 2421.6 | 0.13 | 23213.2 | 496.64 |
| 32 | 36669 | 2,505 | 3091. | 2367.41 | 2421.6 | 2421.6 | 0.13 | 23108.0 | 481.39 |
| 33 | 35875 | 2,263 | 3091. | 2367.05 | 2421.6 | 2421.6 | 0.17 | 18406.1 | 374.54 |
| 34 | 34468 | 1,834 | 3091. | 2367.11 | 2421.6 | 2421.6 | 0.15 | 20584.5 | 430.94 |
| 35 | 34115 | 1,727 | 3091. | 2367.05 | 2421.6 | 2421.6 | 0.13 | 24623.9 | 503.81 |
| 36 | 33291 | 1,475 | 3091. | 2366.95 | 2421.6 | 2421.6 | 0.13 | 23690.5 | 495.10 |
| 37 | 32230 | 1,152 | 3091. | 2367.03 | 2421.6 | 2421.6 | 0.17 | 17716.2 | 398.85 |
| 38 | 31354 | 885 | 3091. | 2367.11 | 2421.6 | 2421.6 | 0.14 | 22496.2 | 463.89 |
| 39 | 30498 | 624 | 3091. | 2367.66 | 2421.6 | 2421.6 | 0.15 | 21319.7 | 436.76 |
| 40 | 29668 | 371 | 3091. | 2368.10 | 2421.6 | 2421.6 | 0.20 | 15587.6 | 432.53 |
| 41 | 28671 | 67 | 3091. | 2398.00 | 2421.5 | 2421.6 | 0.51 | 6086.59 | 363.33 |
| 42 | 28635 | 56 | 3091. | 2413.50 | 2421.4 | 2421.7 | 2.29 | 1350.51 | 297.71 |
| 43 | 28450 | 0 | **Weir** | | | | | | |
| 44 | 28269 | (55) | 3091. | 2400.00 | 2404.0 | 2412.1 | 12.60 | 245.28 | 60.00 |
| 45 | 27869 | (177) | 3091. | 2400.00 | 2402.6 | 2422.0 | 19.51 | 158.43 | 60.00 |
| 46 | 26671 | (542) | 3091. | 2390.00 | 2392.7 | 2410.8 | 18.83 | 164.19 | 60.00 |



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## 9.3 NATURAL DAMMING ON HUNZA RIVER

On January 4, 2010, a huge mass from the right bank of Hunza river slided down near Attabad village and blocked Hunza River for about 2 km. The inflow filled upstream valley created a 22 km long till reservoir the end of May 2010. The estimated lake initial storage was about 310 million $m^3$.

The deposited mass as a result of land slide is mainly composed of non-cohesive rock flour (fine dust, silt, silt gravels and cobbles) at the toe of the failed slope. Large boulders of granodioritic rocks with intrusions of granite, pegmatite and apatite were deposited close to the left bank of Hunza River. The deposit on the downstream side is composed of black clay with high plasticity and organic content. The upstream shoulder of the natural dam has mild slope and downstream slope is quite steep. With 2 km long dam, there is rare chance of piping failure.

A Dam brake study was conducted by NESPAK for National Disaster Mitigation Authority (NDMA) in March, 2010. For drainage of impounded flows through slided area, the excavation of material was proposed as 24 m deep and 45 m wide to form as spillway. The excavation works for the spillway was completed in the mid of May and the overflow began on May 29, 2010. The pattern of outflows was observed at downstream Ganish Bridge. The flows in summer 2010 were as a result of snow melt, no abrupt change in flows observed.

The recent deposits are the most widely spread soil units overlies the bed rocks. The slopes are covered with overburden having variable thickness. Terrace deposits comprise of mixtures of clay, sandy silt, boulders and gravel in various proportions. These units include Angular Boulder Gravel with Fines (ABGM), Rounded Boulder Gravel with Fines(RBGM), Terrace deposit and Moranic deposits. An overtopping concrete weir founded on slided mass is proposed after foundation treatment. Geological rock units with which weir has to be abut, includes Granodiorite, intruded by pegmatite veins at right side. On left side weir has to be abut with ABGM formed by slided mass.

The present bed level of Hunza River at start of narrow section downstream of reservoir is 2412 m.a.s.l. The river width is about 50 to 55 m in summer month. The water depth varies from 2 to 6 m depending upon the outflows. The existing water way would be remodeled to act as ungated spillway to pass the design flood. The river diversion during construction would be made through a low level open channel which would be used as sediment flushing channel during operation phase.

On the left bank of Hunza River, upstream of the weir, the river flows will be diverted at twin intakes into the power waterways system leading via desanders to the low pressure tunnel, surge tank, pressure pipe upto the power station from where the water ultimately discharges into the Hunza River. The roadway network exists at all important locations of proposed structures: weir, power intake, surge tank and powerhouse.

The maximum and minimum operating levels of the Attabad Lake Reservoir has been set by optimization and intake submergence requirements at 2414.0 m.a.s.l. and 2412.0 m.a.s.l. With normal poundage at 2414.0 m a s l, the length of reservoir is about 12 km and it has a gross capacity of 123 million $m^3$. The live storage with 2 m regulation from 2412 to 2414 m.a.s.l is 11 Million $m^3$.

The existing river course downstream of lake would be remodeled into channelized section. In the initial portion, a concrete structure of overflow weir / ungated spillway and stilling basin is proposed as control section for flood passage. Downstream of weir/spillway structure, trapezoidal section 50 m bed width. The overflow ungated weir/spillway crest is at 2414.0 m.a.s.l. On the left bank of main weir, a deep cut channel would be excavated to divert the river flows during construction for a discharge of 1750 $m^3/s$. The diversion channel later on would be used for sediment flushing. The width of flushing channel has been proposed as 25 m. Three



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low level bottom outlets 5 m x 5 m are proposed to be equipped with hydraulically operated radial gates. Taking account freeboard above maximum flood level and gate operating of low level outlets and clearance requirements to pass flood, plate form level has been set at 2424.0 m.a.s.l.

A deep cut channel has been proposed on the left bank for diversion during construction which later on can be used for sediment flushing. The low level outlets can be used to supplement spillway discharge for additional measure of safety. The spillway discharges onto a stilling basin on the downstream for energy dissipation to be released into Hunza River. Considerable sediment inflow is expected into the reservoir during the glacier/snow melt runoff and also during rains. In order to maintain the power intakes free of sediment build up these are placed 2 m below the power intake. During the high flow season, the spillway will also be operated to pass any suspended sediment.

## 9.4 HYDRAULIC DESIGN

### 9.4.1 Hydraulic Design of Weir/Spillway and Stilling Basin

The weir/spillway overflow structure provided on the ALHPP is located on the left abutment of the embankment dam and is designed to safely pass the 1:10,000 year returned period flood of 3250$m^3$/s. The weir/spillway will be supplemented by the capacity of the three low level diversion cum flushing outlets in case of mal-operation of one gate and in case of emergencies.

| | |
|---|---|
| Maximum reservoir level | 2414.0 m.a.s.l. |
| Spillway crest elevation | 2414.0 m.a.s.l. |

#### 9.4.1.1 Weir/Spillway Discharge Capacity Overflow Ungated Structure:

The weir/spillway structure was designed with a crest elevation of 2414.0 m a s l and a design head of 12.0 m. The spillway discharge capacity is calculated for various design discharges. The effect of piers and abutments on the effective crest width as well as the variation of the discharge coefficient with head are considered in the calculation of the spillway discharge capacity. For the relevant design floods the calculation of the discharge capacity has been performed and the corresponding results are given in the tables and graphs below.



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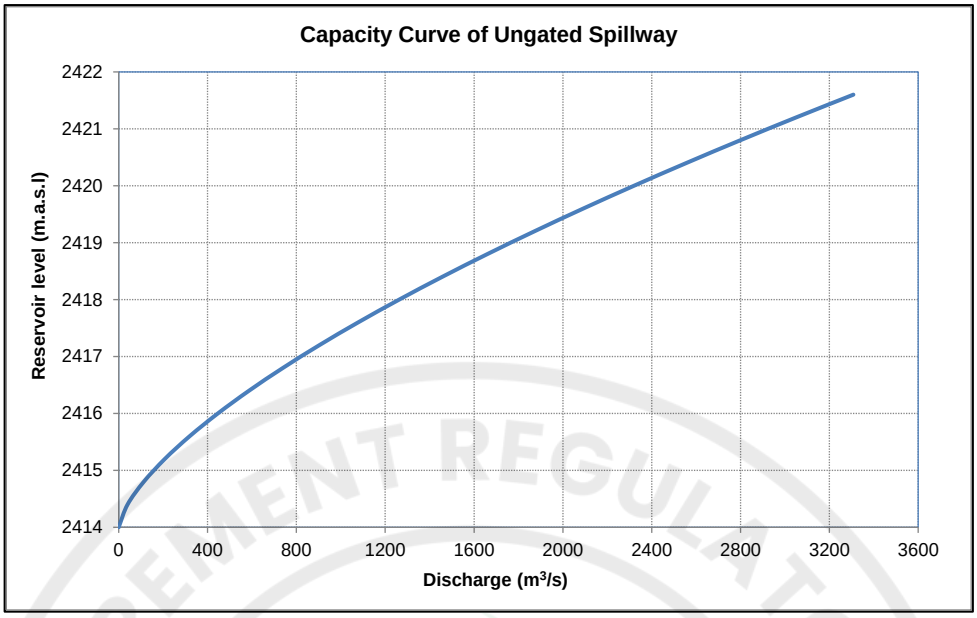


**Figure 9-7 Discharge Capacity of Overflow Spillways**

It is seen that the spillway discharge at elevation 2421.4 m a s l is 3,250 $m^3/s$. Along with overflow spillway, two low level flushing outlets would be in operation to discharge 600 $m^3/s$. The total discharge through overflow weir / ungated spillway is 3,250 $m^3/s$, which is 10,000 year return period. The spillway can therefore safely pass the PMF discharge with sufficient free board.

It is seen that the overflow weir/ungated spillway discharge capacity even at elevation 2414 m.a.s.l. is zero and spillage through power intake and sediment flushing outlet is possible which is only about 660 $m^3/s$ when out of three, two under sluices are in operation. The discharge rating is shown in Figure 9-7 and indicates that the 1: 10,000 returned period flood can be passed safely in an emergency at an elevation of 2421.4 m.a.s.l.

### 9.4.1.2 Design of Spillway Stilling Basin

The riverbed downstream of the spillway consists of sandy gravels and boulders and would erode if the spillway discharges were released directly on to the bed. As such a stilling basin needs to be provided for energy dissipation.

The stilling basin is designed for the design flood of 1:10,000, (HQ 10,000 = 3,250 $m^3/s$). Proper functioning of the stilling basin is reconfirmed in addition for floods covering return periods from 1:10 to 1: 10,000 years AEP.

$HQ_{10}$ = 2,040 $m^3/s$

$HQ_{100}$ =2,910$m^3/s$

$HQ_{10,000}$ =3,250 $m^3/s$

The approach to hydraulic design of the stilling basin is as follows:

I. Determine the energy head at the spillway crest for the selected spillway design at maximum operation level of 2414.0 m.a.s.l.

II. Determine the hydraulic conditions along the ogee, in particular at the transition from ogee to stilling basin.



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III. Calculate the conjugated depth h2 of the hydraulic jump and the required length of the stilling basin.

IV. Determine the relevant tailwater level and calculate the required elevation of the stilling basin floor.

The relation between conjugate depths for a hydraulic jump on a stilling basin is given by,

$$\frac{h_2}{h_1} = \frac{1}{2}\sqrt{1 + 8F_1^2} - 1$$

Where,

h1 and h2 are the depths before and after the jump.

F1 is the Froude number at the start of the jump.

Tailwater levels has been checked for the various design discharges using the tailwater rating curve developed for the river cross-cross section 50 m downstream of the weir.

The hydraulic conditions from spillway crest to the stilling basin has been determined for discharges between $HQ_{10}$ and $HQ_{1000}$ i.e. 2040 to 3250 $m^3/s$. As a result, a stilling basin with the following dimensions have been selected:

| | |
|---|---|
| Invert of stilling basin | 2397.0 m.a.s.l. |
| Width of stilling basin | 60.0 m. |
| Elevation of river bed d/s | 2400.0 m.a.s.l. |
| Length of stilling basin | 55.0 m. |



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# Attabad Hydropower Project
# Design Calculations for Weir

## 1. Weir Dimensions

| | | | |
|---|---|---|---|
| Discharge (estimated design flood) | Q = | **3130** | $m^3/s$ |
| Crest Width (as per site conditions) | B = | **60.0** | m |
| | B1 = | **60.0** | m |
| Gravity | g = | 9.81 | $m/s^2$ |
| Crest Coefficient | $\mu$ = | 0.9 | |

Water height over weir has been calculated from the formula as :

$$Q = 2/3 \mu B (2g)^{0.5} h^{1.5}$$

| | | | |
|---|---|---|---|
| Height of Water above crest (from formula | h = | **7.33** | m |
| Upstream Bed Level (as per site condition) | | 2412 | m |
| Weir Crest Level (assumed to pass flood) | | 2414.0 | m |
| Water level at Flood (crest Elev.+h) | | 2421.3 | m |
| Side Wall Level | | 2422.0 | m |

## 2. Design of Stilling Basin

| | | | | |
|---|---|---|---|---|
| Assumed Stilling Basin Level | | 2397 | | |
| Upstream water depth | $h_o$ | 9.33 | m | |
| Inflow velocity | $v_o$ | 5.59 | m/s | |
| Total energy at stilling Basin | $E_o$ | 25.91 | m | |
| Height of weir | w | 2.00 | m | |
| Depth of water at toe (assume) | $h_1$ | 2.555 | m | |
| Depth of water at toe (Calculated) | $h_1$ | **2.539** | m | $h_1 = E_o - \frac{1.10 \times (Q^2)}{(h_1)^2 \times (B)^2 \times 2g}$ |
| Velocity | v1 | 20.55 | m/s | |
| Froud's number | F1 | 4.12 | | |
| Sequent Depth | $h_u$ | 6.40 | m | |
| Velocity | $V_u$ | 8.15 | m/s | |
| Depth of water after Jump | $h_2$ | 13.57 | m | |
| Length of Stilling Basin | $5x(h_2-h_1)$ | 55.15 | m | |
| Downstream water depth | $h_d$ | 6.00 | m | |
| Level difference (e) | $h_2-h_d$ | 7.57 | m | |



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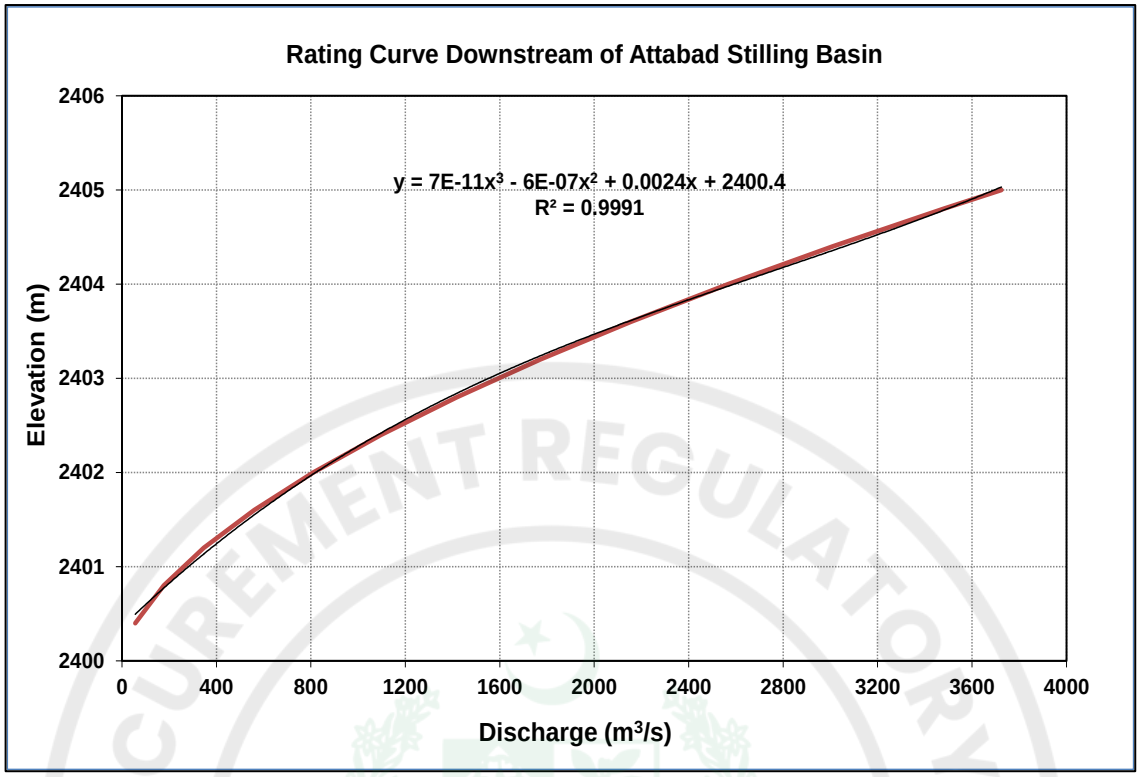


**Figure 9-8 Tail Water Rating Curve Downstream of Stilling Basin**

For the entire range of discharges considered in the present analysis, the criterion that the downstream water level exceeds the conjugated depth $h_2$ is maintained including a safety margin of 5 %.

**Table 9-2 Variation of Stilling Basin Length with Flood Discharge**

| Discharge $m^3/s$ | Flood | Energ Head m | Depth $h_1$ m | Froude number | Conjugate depth $h_2$ m | Tailwater level m.a.s.l | Stilling Floor m.a.s.l | Basin Length m |
|---|---|---|---|---|---|---|---|---|
| 2040 | HQ10 | 22.83 | 1.496 | 5.06 | 9.98 | 2403.5 | 2397 | 42.44 |
| 2650 | HQ50 | 24.25 | 1.965 | 4.54 | 11.67 | 2404.1 | 2397 | 48.54 |
| 2910 | HQ100 | 24.82 | 2.165 | 4.36 | 12.31 | 2404.3 | 2397 | 50.72 |
| 3730 | HQ1000 | 25.91 | 2.539 | 4.12 | 13.57 | 2405.0 | 2397 | 55.15 |

### 9.4.2 Flushing Outlets

Three low level sediment flushing cum diversion outlets have been provided on the left bank upstream of the embankment dam to enable flushing of sediment in front of the power intakes. Each flushing outlet is equipped with a hydraulically operated slide gate as the service gate. Provision has been also made for installation of stoplogs both at the upstream and downstream ends of the tunnels for use both during maintenance and repair.

The flushing outlets will be utilized for the following:



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- Sediment flushing to keep the area upstream of the power intakes sediment free
- Reservoir (sediment) flushing in combination with reservoir draw down. The operational procedures for this need to be verified by physical model tests and also consider effects on reservoir periphery slope stability.
- For drawdown of the reservoir for maintenance and repair of structures as necessary.
- For use as an optional release facility for flood passage in the event of spillway gate problems.

The inverts of the flushing conduits have been set at riverbed level. The slide gates are located as upstream as possible in the conduits taking into consideration structural and operational requirements. Relatively high flow velocities will prevail and will prevent sediment load from depositing within the conduits. The design discharge capacity available at full reservoir supply level of 2414.0 m.a.s.l is 900 $m^3/s$ with flushing outlets operating.

The flushing outlets are designed to be capable of removing fine and medium fractions of sediments (sand and gravel) that should not be allowed to accumulate in front of the power intake. During the high flow season 60 $m^3/s$ will be diverted through the power intakes located upstream of the weir. The balance inflow may be released over the spillway and through the sediment flushing channel / undersluice, the latter being utilized to clear any sediment deposition in front of the intakes. This will ensure that coarse sediment fractions will not be drawn into the power intake at times of high river flow at normal operating level. No continuous flushing of the reservoir is envisaged. Discharge capacity of the two low level outlets which are also used as diversion tunnels during pre-commissioning stage for river diversion is provided in the details given under the sub-section on river diversion.



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## DESIGN OF UNDERSLUICES

## ATTABAD HYDROPOWER PROJECT

| | | |
|---|---|---|
| Maximum upstream Water Level | 2421.4 | m.a.s.l. |
| Maximum downstream Water Level | 2405.0 | m.a.s.l. |
| Upstream Bed Level | 2400.0 | m.a.s.l. |
| Downstream Bed Level | 2400.0 | m.a.s.l. |
| Design Discharge | 720 | $m^3/s$ |
| Width of Undersluice | 5.0 | m |
| Height of Undersluice | 5.0 | m |
| Gravitational Acceleration | 9.81 | $m/s^2$ |
| Cross sectional Area | 25 | |
| Wetted Perimeter | 20 | |
| Hydraulic Radius | 1.25 | |
| (U/S water level) - (D/S water level) = h | 16.40 | m |

**CAPACITY OF UNDER SLUICE**

$X = (1/1+f_i+f_o+f_c+f_{fr})^{1/2}$

where

| | | |
|---|---|---|
| Coefficient for intake losses ($f_i$) | 0.06 | |
| Coefficient for outlet losses ($f_o$) | 1 | |
| Coefficient for change in cross sec. ($f_c$) | 0.04 | |
| Coefficient for friction losses ($f_{fr}$) | | |
| Stickler's coefficient (k) | 70 | |
| $f_{fr}$ = | 0.13 | |
| X = | 0.67 | |
| X | | |
| V = (2gh)^0.5 | 12.00 | m/s |
| Q = One Under Sluice | **300.0** | $m^3/s$ |
| Discharge through three Undersluices | **900.1** | $m^3/s$ |



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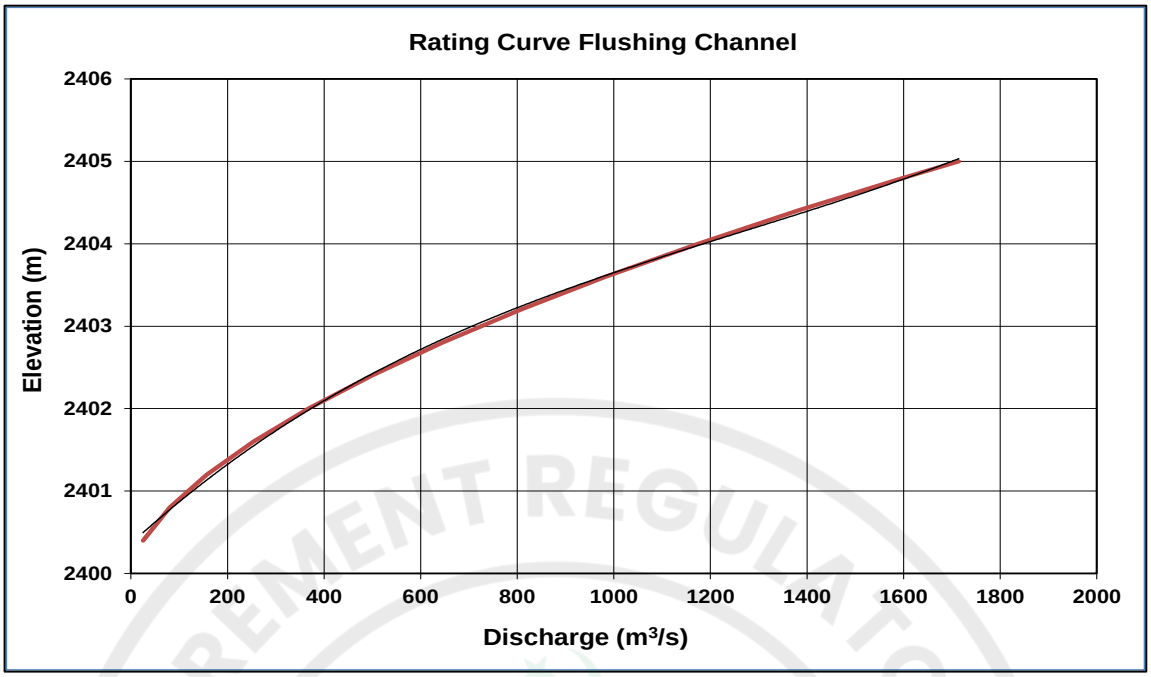


**Figure 9-9 Tail Water Rating Curve at Flushing Channel**

Reservoir drawdown can be achieved as when required through spillway and the low level outlets. However, it is necessary to ensure that the reservoir is not drawn down rapidly so as to provoke instability of the embankment dam or destabilize the reservoir periphery slopes. It is recommended that the hydraulic performance of the low level outlets be confirmed in combination with the spillway and power intake by hydraulic model tests at design stage.

### 9.4.3 Freeboard Calculations

Freeboard is provided on all dams to ensure that overtopping of the dam will not result from wind setup, wave action, uncertainties in analytical procedures and in operation in combination with high reservoir pool elevations.

Freeboard is the vertical distance between the crest of the dam and the reservoir water surface. Freeboard is further categorized into “normal freeboard” and “minimum freeboard”. Normal freeboard is the allowance between the crest of the dam and normal reservoir level as fixed by design. The normal freeboard should satisfy the dam safety needs for long term storage and must be adequate to prevent overtopping in case of abnormal and severe wind action of low probability that may result from unusual sustained winds of high velocity from a critical direction. Minimum freeboard is the difference in elevation between the crest of the dam and the maximum reservoir level that would result from the inflow design flood with normal spillway operation.

#### 9.4.3.1 Wind Speed:

Wind speed at reservoir sites is best estimated from local measurements, although even these usually need to be carefully interpreted because of localized influences of surrounding topography. However, wind data was not available in the case of Attabad Lake weir stie. Therefore, in the absence of data, the per hour wind velocity over land has been assumed as per the recommendation of ACER Technical Memorandum No 2 (1992) which is 100 km/hr with all speed correction factors applied, for calculating minimum freeboard.



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#### 9.4.3.2 Design Wave Height and Duration

The wave heights and periods are associated with the fetch. Wind duration and adjusted wind speed are determined from the ACER Technical Memorandum referred to above. Taking fetch length = 0.25 miles and wind velocity as 100 miles / hr. the wave height is 4 ft. (1.21m) for 4.5 seconds wave period. The duration of wind is 5 hours

Wave Height by Molitor – Stevenson Formula:

$$H_s = 0.76+0.032 (VF)^{0.5} -0.26 F^{0.25}$$

Where:

| | |
|---|---|
| V = Wind velocity (km/h) | 160 |
| F = Fetch (km) | 0.4 |
| $H_s$ | 0.81 m |

The maximum value of Hs = 1.21 m is adopted for design.

## 9.5 DESIGN OF RIVER DIVERSION WORKS

The riverbed at the weir site is about 60 m wide. On either bank, there is alluvium due to landslide and at rock is not found upto 68 m depth. The river diversion has been proposed in two stages. The river will flow through main weir section for constructing the left bank deep diversion channel regulated by gates after constructing a coffer dam in stage-I (shown in Dwg AFS-WE-412 in Vol.2) which will later used for sediment flushing channel. Afterwards a coffer dam has been constructed in stage-2 (detils shown in in Dwg AFS-WE-413 in Vol.2) and the river flow will be managed through diversion channel to construct the overflow weir/ spillway.

## 9.6 DISCHARGE CAPACITY OF RIVER DIVERSION WORKS

The magnitude of the construction flood is normally limited to flood return period of 1:20 to 1:50. However in the case of Attabad Lake, the diversion structures are designed for the average year flood of return period of 1:20 which is a flood of 1750 $m^3/s$ magnitude. The risk of overtopping will be managed by strengthening of the coffer dam to tolerate overtopping during the construction period while the main embankment is still at lower levels.

The height of the upstream cofferdam has been estimated related to the discharge capacity of the diversion channel. The adopted crest elevation of the cofferdam is fixed at 2420.0 m.a.s.l. The channel will discharge in free flow condition.



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**Table 9-3 Diversion Channel Discharge Rating**

| Geometrical Input Data | | | Calculation of Downstream Rating Curve | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Length of Canal : | 475.00 | m | Wat. Dep. | Area | Wett.Par. | Hydr.Rad. | Discharge | Velocity | Froude No. |
| Slope Water Side : 1: | 1.00 | - | m | $m^2$ | m | m | $m^3/s$ | m/s | - |
| Hydraulic Bed Width : | **25.00** | m | 0.00 | 0.00 | 25.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Strickler Value (M) | 45.00 | - | 0.40 | 10.16 | 26.13 | 0.39 | 27.37 | 2.69 | 1.36 |
| Slope of Energy Line (S) | 6 /475 | - | 0.80 | 20.64 | 27.26 | 0.76 | 86.71 | 4.20 | 1.50 |
| | | | 1.20 | 31.44 | 28.39 | 1.11 | 170.19 | 5.41 | 1.58 |
| Water Depth : (Input) | 5.00 | m | 1.60 | 42.56 | 29.53 | 1.44 | 274.67 | 6.45 | 1.63 |
| Depth : (From rating curve) | **5.00** | **m** | 2.00 | 54.00 | 30.66 | 1.76 | 398.33 | 7.38 | 1.67 |
| **$Q = MxR^{0.667}xS^{0.5}xA$** | | | 2.40 | 65.76 | 31.79 | 2.07 | 539.97 | 8.21 | 1.69 |
| Discharge | **1857.79** | **$m^3/s$** | 2.80 | 77.84 | 32.92 | 2.36 | 698.73 | 8.98 | 1.71 |
| | | | 3.20 | 90.24 | 34.05 | 2.65 | 874.02 | 9.69 | 1.73 |
| WL Canal Start : | 2403.00 | m.a.s.l. | 3.60 | 102.96 | 35.18 | 2.93 | 1065.38 | 10.35 | 1.74 |
| WL Canal End : | **2397.00** | **m.a.s.l.** | 4.00 | 116.00 | 36.31 | 3.19 | 1272.50 | 10.97 | 1.75 |
| | | | 4.40 | 129.36 | 37.45 | 3.45 | 1495.13 | 11.56 | 1.76 |
| BL Canal Start : | 2398.00 | **m.a.s.l.** | 4.80 | 143.04 | 38.58 | 3.71 | 1733.09 | 12.12 | 1.77 |
| BL Canal End : | **2392.00** | **m.a.s.l.** | 5.00 | 150.00 | 39.14 | 3.83 | 1857.79 | 12.39 | 1.77 |

The crest level of the coffer dam was set at elevation 2421.0 m.a.s.l. allowing about 2.0 m freeboard. The above results show that the adopted scale of the river diversion works accommodates reasonable risk from flooding during construction of the overflow weir / ungated spillway structure.

## 9.7 POWER INTAKE STRUCTURE

### 9.7.1 General

Twin intakes have been provided for intake of water into the power waterway system. The intakes are designed to be operated in such a manner as to ensure that the required turbine flow shall be conveyed within acceptable limit of head losses in accordance with the capacity requirements of the water conveyance systems and the power station in a safe and dynamically acceptable manner. The intakes will be capable of discharging the total design discharge for the generating units plus 20% of the design discharge for flushing the de-silting basin. The total design discharge of intakes is 60.0 $m^3/s$, that is, each intake will discharge 30.0 $m^3/s$. details of intake structure are shown in AFS-PI-424 to 426 in Vol.2.

On each structure, a trashrack has been provided at the entrance to prevent entry of debris into the power waterway system. The control gate in the gate passage is rectangular 4.5 m high by 3.6 m wide and is upstream sealing. This allows air passage downstream of the gate and does away with the need for special provision of an air vent. Provision has also been made for installation of stoplogs upstream of the control gates for maintenance and inspection. A



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trashrack cleaning machine has been provided for removal of debris from the trashracks. A gantry has been provided for placement and removal of the stoplogs.

#### 9.7.1.1 Siting and Orientation

The intakes have been sited on the left bank as close as possible to the embankment dam for mitigation of blockage by sedimentation, maximization of submergence and ease of flushing of sediment at the entrances by the low level flushing outlets cum diversion channel located just upstream of the embankment dam. The intake is oriented so as to minimize tendency for flow separation which can render a portion of the intake ineffective. Higher intake flow rates are more conducive to flow separation than lower rates and as such velocities of entry have been kept low.

The invert of the intake is placed at elevation 2412.0 m.a.s.l. based on sediment control and submergence considerations. Deck and other operating levels have been set at 2422.0 m.a.s.l.so that the intake can perform over a range of operating water levels in the reservoir including maximum flood water levels.

#### 9.7.1.2 Intake Geometry

ALHPP intakes are low head, horizontal intakes. To minimize head losses and the potential for flow separation, the configuration of the entrance area of the intake is such that the flow accelerates more or less uniformly from the trashrack to the gate area and downstream.

Boundaries of flow approximate those of flow issuing from an orifice to minimize the effects of the surfaces on flow and thus minimize head losses. The boundary curvature upstream of the gates including roof, floor and sidewalls and those downstream of the gates including transition shapes and lengths are defined in accordance with the above considerations.

The entrance shapes are designed in accordance with guidelines given in U.S. Army Corps of Engineers EM 1110-2-1620 and the U.S. Army Corps of Engineers, Waterways Experiment Station (WES) Hydraulic Design Charts, HDC 221-2 or HDC 211-1 as suited to site lateral space availability.

### 9.7.2 Hydraulic Design

#### 9.7.2.1 Criteria for Design

The following basic criteria shall be complied with in the hydraulic design of the intakes:

- The hydraulic performance of the intakes shall be sustained so that the net flow area on the intakes is not reduced by adverse sediment build up.
- The intakes shall be designed for hydraulically efficient flow with bell mouthed intakes and entrance losses shall be accounted for in the design.
- The intake shall have sufficient water cover under MDDL conditions and no vortices shall form. The design shall be tested by hydraulic model study and modified as necessary to prevent formation of vortices at detailed design stage.



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- Head losses in the waterway system shall be evaluated for hydraulic purposes and accounted for in design for all normal operating conditions.

- There shall be no settlement of sediment in the tunnel. Velocity in the tunnel shall be greater than the non-silting velocity at the design discharge of the tunnel.

- The water conductor system shall be designed to be emptied only by gravity.

- The intake gates shall operate only either in the fully open or fully closed position only. The gates shall be able to receive the command/signal from instruments and operate accordingly for this purpose.

- Provision will be made at the intake for instruments to collect and transfer information on gate positions, reservoir levels immediately upstream of the intakes, tunnel flows etc. for optimum operation of the Project.

#### 9.7.2.2 Intake Submergence

Vortices can affect intake efficiency and also present a safety hazard. The intensity of the circulation phenomena set up around an intake is a function of the geometry. Design guidance provided by Gordon and others shall be used in preventing formation of undesirable vortices. Gordon's curve for unsymmetrical flow is used for design.

Gordon's relationship for asymmetrical flow is given by:

$$S_{min} = 2.3\, DF_r$$

where

Fr = Froude number =V/$\sqrt{}$gD

V = velocity of flow in the conduit (m/s)

D = diameter or height of conduit (m)

$S_{min}$ = required submergence from the opening soffit (m)

The power intakes should have sufficient submergence to prevent air entrainment by vortex formation. For the selected intakes each connecting tunnel design discharge is 60.0 m³/s.



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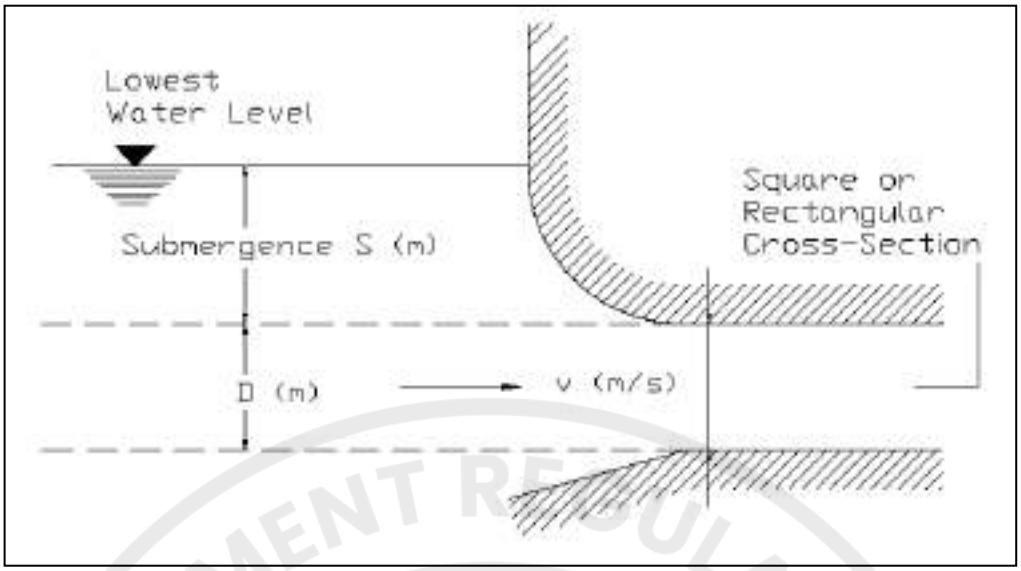


D = 4.5 m

V = 2.41 m/s

$S_{min}$ = 2.3 x 4.5 x 0.36

$S_{min}$ = 3.75 m

Take,

$S_{min}$ = 3.75 m

### 9.7.3 Power Intake Settings

| | |
|---|---|
| Maximum Operation Level | 2414.0 m.a.s.l. |
| Minimum Operation Level | 2412.0 m.a.s.l. |
| Required submergence | 2.0 m |
| Intake waterway height | 4.5 m |
| Required Invert level | 2404.0 m.a.s.l. |

The intake invert has been set at 2404.0 m.a.s.l.

Since vortex formation is dependent on many factors including orientation of the intake to flow and not only on submergence, hydraulic model studies are recommended at detailed design stage to confirm that vortices do not form at the intake.

### 9.7.4 Trashrack Cross-sectional Area

The gross cross-sectional area of the trashrack shall be selected for a flow velocity not exceeding 1.0 m/s. For the design discharge of 60 $m^3/s$, the required minimum trashrack area is determined as:

$A_{min}$ required > Q / 1.0 m/s, giving Amin>60 $m^2$

Necessary trashrack area has been selected to comply with the above requirement with allowance for trashrack bar thicknesses etc.



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## 9.8 LOW PRESSURE TUNNEL

### 9.8.1 Criteria for design

The hydraulic design criteria followed for tunnels were as follows:

**(i) Head Loss Considerations**

For discharge calculation conservative values of loss coefficients have been taken in accordance with intake geometry and geometry of the tunnel. The approaches and flow boundaries are designed for hydraulically efficient flow minimize head losses.

**(ii) Boundary Pressures**

Pressure gradients are developed for the headrace tunnels to show local average pressure changes resulting from velocity changes. These are examined in terms of conduit back pressures for the entire operating range.

**(iii) Air Relief**

Air that occupies a partially filled tunnel can become trapped and can lead to operational difficulties such as head loss, unsteady flow, transients and blowouts. Air can enter the tunnel system at the intakes and at hydraulic jumps. It can also form when pressure and temperature conditions cause dissolved air to be released. Engineering measures are taken to reduce air entrainment which includes elimination of hydraulic jumps and dissipation of flow vortices at intakes. Vents to the ground surface are also given.

**(iv) Flow Velocity**

Flow velocities are restricted so that turbulent conditions and the possibility of damage to the structures are limited. Velocities for shorcrete lining shall in general be less than 3 m/s. For velocities greater than 3 m/s the risk of cavitation increases and special precautions like provision of concrete lining may need to be taken.

**(v) Energy Losses**

Energy losses within conduits fall into two general classifications: (a) surface resistance (friction) caused by shear between the confining boundaries and the fluid and (b) form resistance resulting from boundary alignment changes

**(vi) Surface Resistance (Friction)**

Three basic equations are generally being used for computing energy losses in pressurized systems. The Manning equation which has been used extensively for both free surface and pressure flow is adopted in this analysis.



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**Use of Manning's Formula**

The Manning's Formula is expressed as:

$$V = \frac{S^{1/2} R^{2/3}}{n}$$

Where

R = A/P = Area of flow / Wetted perimeter

n = Manning's coefficient

$S_o$ = Energy gradient Bed slope in uniform flow

**(vii) Design Roughness Values**

U.S. Army Corps of Engineers (EM 1110-2-2901) recommends the following values of Manning's n roughness values for different types of excavation and lining of tunnels:

USACE Recommended Manning's k Values

| Type of Excavation or Lining | Recommended Manning's k Value |
|---|---|
| Drill and blast excavation, unhand | 0.038 |
| Tunnel boring machine excavation, unlined | 0.018 |
| Lined with pre-cast concrete segments | 0.016 |
| Lined with cast-in-place concrete | 0.013 |
| Lined with steel with mortar coat | 0.014 |
| Lined with steel (dia> 3 m) | 0.013 |
| Lined with steel (dia< 3 m (10 ft.)) | 0.012 |

However, the water conduit system was designed for Manning's k value of 0.016

**(viii) Form Resistance**

**General**

Energy losses caused by entrances, bends, gates, valves, piers, etc., are conventionally called "local losses". In many situations they are more important than the losses due to conduit friction. A convenient way of expressing the local losses in flow is,

$$h_l = K\,(V^2/2g)$$

Where

$h_l$ = head loss in m

K = dimensionless coefficient

V = designated reference velocity m/s

g = acceleration due to gravity $m/s^2$



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The reference velocity in the energy loss equations corresponds to a local reference section of the conduit at or near the point where the loss occurs.

**Sudden Expansion**

In almost all cases the loss coefficient K is determined by experiment. However, one exception is the head loss for a sudden expansion. Designating the smaller upstream section as section one and the larger downstream conduit section as section two, the head loss equation may be written as:

$$h_l = (1 - A_1/A_2)^2 (V_1^2/2g) = K (V_1^2/2g)$$

In which

$$K = (1 - A_1/A_2)^2$$

Where A1 and A2 are the respective upstream and downstream conduit cross-sectional areas and the reference velocity is the upstream velocity $V_1$.

**Sudden Contraction**

The head loss h, due to a sudden contraction is subject to the same analysis as the sudden expansion, provided the amount of contraction of the jet is known. Using the downstream conduit velocity $V_2$ as the reference velocity, the head loss equation may be written as:

$$h_l = (1/C_c - 1)^2 (V_2^2/2g) = K (V_2^2/2g)$$

In which

$$K= (1/C_c - 1)^2$$

Where $C_c$ is the contraction coefficient

**(ix) Transitions**

Head losses in transitions shall be calculated using the equation:

$$hl = K (V^2/2g)$$

where the value of the transition loss coefficient K must be obtained from published experimental literature or references.

**(x) Bends**

The bend loss, excluding friction loss, for a conduit is a function of the bend radius, conduit size and shape, and deflection angle of the bend. Bend loss coefficients K must be obtained from published experimental literature or references.

### 9.8.2 Low Pressure Headrace Tunnel

**(i) Alignment of Headrace tunnel**

Low pressure tunnel from intake to surge tank would be excavated in the left bank rock formation parallel and at lower elevation to existing Highway tunnel. The length of headrace tunnel is estimated about 2320 m.



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### (ii) Dimensioning of Headrace Tunnel

Headrace tunnel was optimized by considering different diameters for design discharge of 60 $m^3/s$ with following parameters:

- Manning- Strickler coefficient 60
- Tunnel slope 0.4 %
- Shotcrete lining thickness 0.10 – 0.3 m (as per conditions)
- Length of headrace tunnel 2300 m
- Diameter of concrete lined section 5.5 m
- Concrete Lining 0.3 m

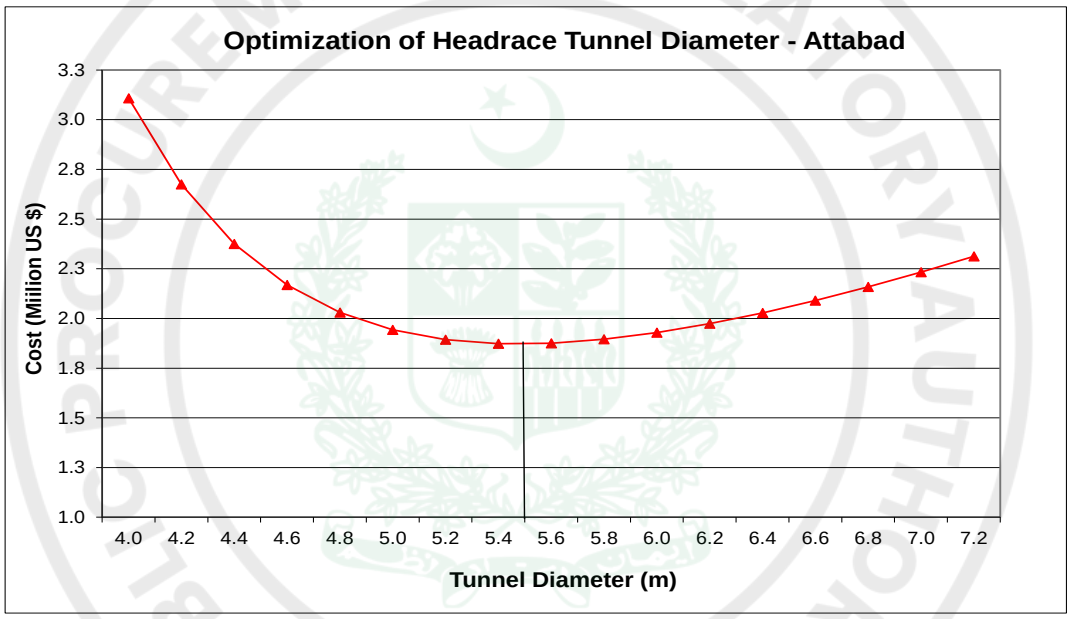


**Figure 9-10 Optimization of Headrace Tunnel Diameter**

The optimized diameter of low pressure headrace tunnel is 5.6 m and its length 2320 m. The alignment, layout and cross-sections drawings of low pressure headrace tunnel are given in AFS-WR-404 to 407 Vol. 2 Drawings.

## 9.9 SURGE TANK

The configuration of the waterway system has been generally given above and consists of two intakes with each intake connected to the low pressure headrace tunnel with an internal diameter of 5.5 m. The Surge tank is provided just before the start of pressure shaft. Downstream of the surge tank the headrace tunnel transitions from 5.5 m to 3.6 m diameter concrete lined section leading to embedded penstock. The penstock commences downstream of the surge tank with internal diameter of 3.5 m in the steel lined section.



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### 9.9.1 Hydraulic Design of Surge Tank

The principal surge tank designs considered Throttled cylindrical surge tank. At the junction of the headrace tunnel and surge tank a throttle with a cross-section area of not less than 50 % of the pressure shaft is arranged in accordance with standard design practice to damp pressure fluctuations. In view of the expected high flow velocities at the throttle it will be steel lined.

In accordance with standard design practice and the hydraulic design criteria, the cross sectional area of the cylindrical surge tank is selected with a factor of safety of 2.5 times larger than the Thoma-Criterion to ensure adequate stability of plant operation. Based on the characteristics of the upstream waterways and the design water levels, the minimum surge tank dimensions have been determined as shown in Table 9-4.

**Table 9-4 Surge Tank Dimensions**

| **Minimum Cross Section for Surge Tank at Headrace Tunnel** | | | |
|---|---|---|---|
| Total headrace discharge | Q | 60 | $m^3/s$ |
| Length of headrace tunnel | L | 2320 | m |
| Diameter of Tunnel | D | 5.50 | m |
| Cross section area | A | 24.62 | $m^2$ |
| Head loss | h | 2.6 | m |
| Velocity in tunnel | v | 2.46 | m/s |
| Velocity head | $v^2/2g$ | 0.31 | m |
| Minimum reservoir level | $W_L$ | 2412.0 | m.a.s.l |
| Minimum tailwater level | $W_L$ | 2302.0 | m.a.s.l |
| Head difference | $H_o$ | 110.0 | m |
| Net head | $H_n$ | 105.2 | m |
| | $A_S$ | 63.16 | $m^2$ |
| | 1.5 $A_S$ | 90.08 | |
| | $D_{Srequired}$ | 10.7 | m |
| | $D_{Sselected}$ | 10.0 | m |

For load acceptance of the turbine units and subsequent full load rejection the following scenarios are assumed.



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LC-UP 1) Load acceptance from partial load, not exceeding 50 % total load increase; subsequent full load rejection;

LC-UP 2) Load acceptance of two units after synchronization; subsequent full load rejection;

LC-DN 1) Full load acceptance of two turbines followed by another turbine after a certain time interval

LC-DN 2) Load reduction by 50 per cent and subsequent complete load acceptance.

### 9.9.2 Load Case Maximum Upsurge

The load case is defined assuming that full load rejection occurs in the most unfavorable moment, i.e. when flow in the headrace tunnel is at its maximum (flow velocity) as the result of preceding partial load acceptance.

For the maximum upsurge analysis, the following assumptions are made:

| | |
|---|---|
| Turbine load acceptance after synchronization | 5.0 seconds (10 to100%) |
| Wicket gate closure at turbine load rejection : | 5.0 seconds (100 to 0 %) |
| Maximum Reservoir Level : | 2414.0 m.a.s.l. |
| Minimum tunnel roughness : | 0.3 mm |

The relevant load cases are defined assuming partial load acceptance following load rejection in the most unfavorable moment, i.e. when the flow in the headrace tunnel is at its maximum (reverse flow velocity) after full load rejection. A conservative approach is taken in the present feasibility design, full load acceptance of two units connected to the headrace tunnel will be assumed as extraordinary load case for which the surge tank design shall guarantee the specified minimum freeboard margins.

For the minimum down surge analysis the following assumptions are made:

| | |
|---|---|
| Turbine load acceptance after synchronization | 50 sec (10-100%) |
| Wicket gate closure at turbine load rejection | 5.0 sec (100-0%) |
| Minimum reservoir water level | 2412.0 m.a.s.l. |
| Maximum turbine discharge | 20 $m^3/s$ |
| Maximum tunnel roughness | 0.3 mm |

Minimum down surge was calculated for following scenarios:



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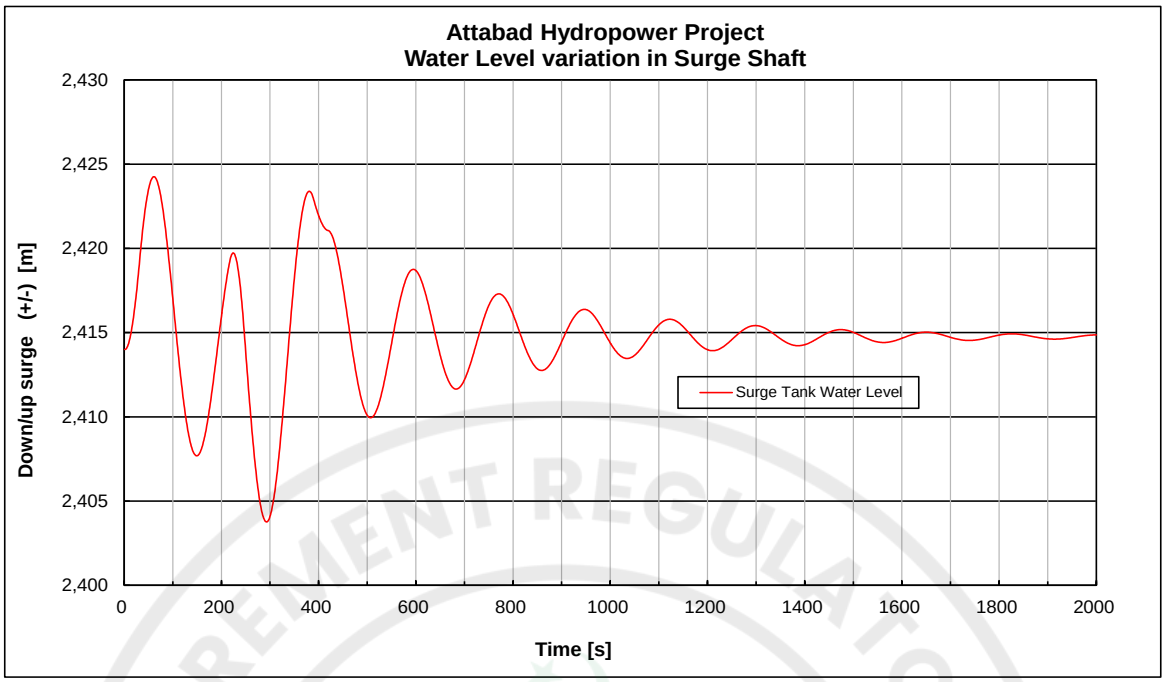


**Figure 9-11 Surge Tank: Combined Load Case Maximum Upsurge**

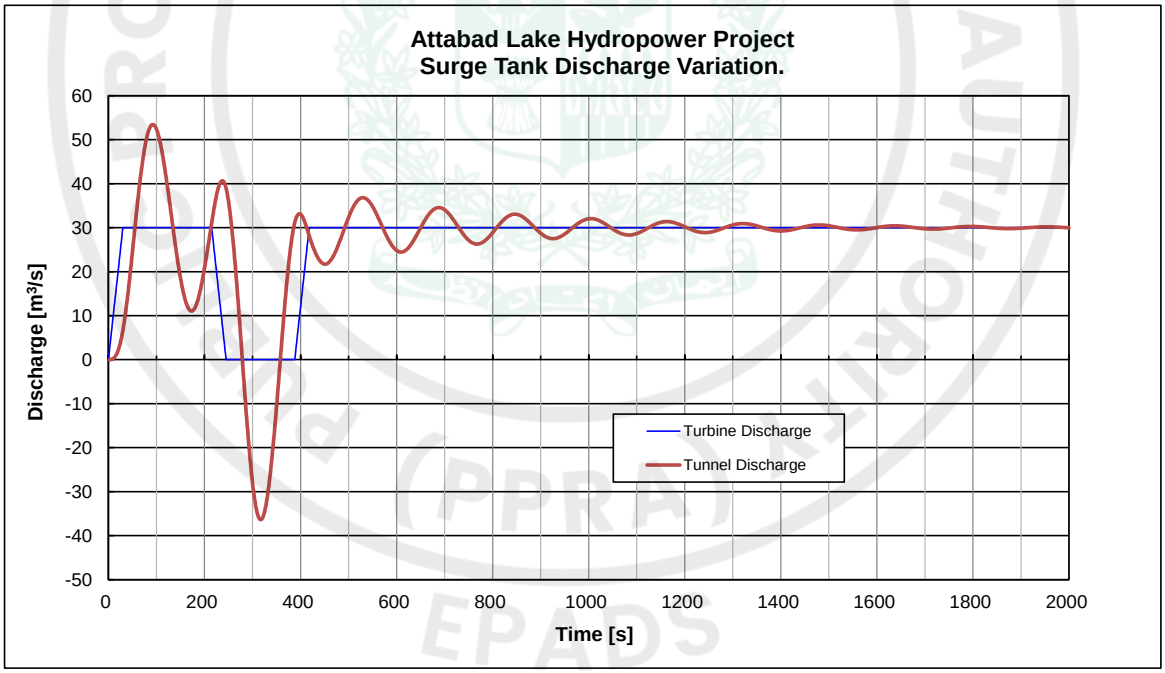


**Figure 9-12 Surge Tank: Combined Load Maximum Upsurge and Downsurge**

### 9.9.3 Results of Surge Tank Simulation

For the most critical load cases surge tank water level, flow into and out of surge tank and turbine discharge with time are shown in Figure 9-12.

For the load case resulting in the maximum down surge the corresponding variation of surge tank water level, is shown in Figure 9-13. The extreme surge tank water levels are given in Table 9-5 for all relevant load cases.



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**Table 9-5 Extreme Water Levels in Surge Tank**

| | Water Level |
|---|---|
| Upsurge | 2424.2 |
| Down surge | 2403.8 |

## 9.10 WATER HAMMER ANALYSIS IN PENSTOCKS

For the calculation of pressure rise in the penstocks of Attabad Hydropower project water hammer analysis was carried out by applying the standard procedure based upon the following conditions:

| | |
|---|---|
| Reservoir Level | 2414.0 m.a.s.l. |
| Turbines centre line level | 2300.0 m.a.s.l. |
| Operation Mode | Full Load Rejection within 5 seconds |
| QT for single unit | 20.0 $m^3/s$ |

### 9.10.1 Water hammer calculations for single Penstock

In Attabad Hydropower Project the power house has three turbine units. Each turbine unit is connecting with one penstock. To calculate water hammer pressure in the penstocks the longest penstock is considered because it will give the maximum rise in pressure when valve of turbine closed suddenly. The longest penstock is 35m long.

| | | |
|---|---|---|
| Total discharge for 3 units | Q | = 60.0 $m^3/s$ |
| Discharge for single turbine | QT | = 20.0 $m^3/s$ |
| Diameter of penstock | D | = 2.07 m |
| Velocity in the penstock | V | = 5.89 m/s |
| Length of penstock | L | = 35 m |
| Maximum Operation Level | | = 2414.0 m.a.s.l. |
| Minimum Tail Water Level | | = 2300.0 m.a.s.l. |
| Maximum Head | | = 114 m |
| Steel liner Thickness | t | = 25 mm |
| D/t | | = 82.8 |

### 9.10.2 Pressure wave velocity

Engineering analysis of water hammer required the term a which is the velocity of pressure wave. According to Parmakian (1955) the velocity of pressure wave is given by the following formula:

$$a = \sqrt{\frac{1}{\rho(\frac{1}{K} + \frac{DC_1}{Et})}}$$

Where

E = Elastic modulus for steel = $1x10^9$ $N/m^2$



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K = Volume modulus of water = $2.1 \times 10^{11}$ N/m$^2$

$\rho$ = Mass of water = 1000 kg/m$^3$

$C_1 = 1-u^2$

u = Poisson's ratio for steel = 0.3

a = 140 m/s

### 9.10.3 Water hammer Pressure (Allievi chart)

Neglecting hydraulic losses in the Penstock,

Pipe-line constant, $\rho = \frac{aV}{2gH_o} = 0.2267$

For closure time t = 5sec

Time constant, $\theta = \frac{aT}{2L} = 10$

From Allievi Chart,

Max. Pressure rise ratio, $Z = \frac{H_o + h_{\max}}{H_o} = 1.025$

$H_O + h_{max} = 1.025 H_o = 107.6$ m

Hence pressure rise in penstocks for sudden closure of value (5s) the pressure rise in 35 m long penstock is 33.02 m.

## 9.11 POWER COMPLEX

### 9.11.1 General

At the powerhouse site mildly sloping terrace with good geological conditions is available to place a surface power complex. Hence a surface power complex is selected. The power complex comprises of mainly surface powerhouse, transformers bay and Gas Insulated Switchgears (GIS) building.

The powerhouse building houses three (03) Francis turbine units each comprising main inlet valve. The vertical axis Francis turbine is coupled directly to a generator, their auxiliary plant, the generator circuit breakers, isolators and unit transformers. The powerhouse also accommodates the main drainage sump, battery rooms, mechanical and electrical workshops.

The transformer bay houses 10 transformers (three each for a unit) and one spare transformer, a rail is provided beside the transformers for gantry crane to move along 6 m. wide roadway. The general arrangement of the power complex structures are shown in Dwgs. No. AFS-PH-431 to 436 in Vol. 2 Drawings



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### 9.11.2 Sizing of Powerhouse

The powerhouse building was sized considering the turbine axis setting level and space required to house the electrical equipment, transformers and mechanical plant with adequate allowance for installation, operation and maintenance.

Floor levels in the machine hall are dictated by the level of the turbine centerline which is set at elevation 2308.0 m.a.s.l. The water after passing through Francis pressure turbine goes into elbow shaped draft tube and carried out to tail bay from where the open free flow tailrace channel starts. The outlet of the draft tube will always remain submerged to avoid suction. The submergence height with reference to turbine centreline is calculated as 4.5 m by Thoma criteria. With the submergence height the minimum tailwater level is fixed at elevation 2300.0 m.a.s.l. and the maximum Tailwater is at elevation 2307.0 m.a.s.l. A draft tube gate is provided at its outlet which is to be operated by a gantry crane to be placed at elevation 2308.2 m.a.s.l.

The turbine, electrical equipment, generator and operating floor levels are determined chiefly by the headroom required to access the turbine pit with the top cover suspended, the headroom to accommodate auxiliary equipment such as the generator circuit breakers, the structural depth of concrete to carry the bottom bracket, and the height of the generator.

Placing the crane rail level, the underside of the crane bridge beam and the main hook height around 5.80m from the operating floor which at elevation 2306.2m.a.s.l. should allow cranes in tandem, utilizing a lifting beam about 2m deep, to lift either the rotor or the stator to a height safely above the generator exciter housings, usually standing about 1 m above the floor. A sloping trussed roof is proposed to cater for the snow accumulation problem over the roof. Minimum of 2.5 m clear height is provided over the top of crane bridge beam which at the centre is 6.0 m which is sufficient for movement of operating and maintenance staff.

All levels will be confirmed or revised if necessary when turbine and generator manufacturer's data is received during detailed design. Manifold will be constructed for the trifurcating the 4.2 m dia. steel lined high pressure tunnel into three 1.85 m dia, penstock pipes that will be connected with spherical valve and further leading to turbine.

The surface powerhouse building is 63 m long, 20 m wide and 35 m high from the foundation level. At the draft tube end a draft tube gate is provided which will be lifted by a gantry crane moving on 3.2 m extended cantilevered deck along each unit bay.

### 9.11.3 Powerhouse Building

The powerhouse building comprises of the four main floors which are:

- Machine Hall floor at Elevation. 2306.2 m a s l
- Generator floor at Elevation. 2303.0 m a s l
- Turbine floor at Elevation. 2298.0 m a s l
- Valve floor at Elevation. 2300.0 m a s l



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In addition to these floors the following are full width but shorter floors provided at different levels such as:

- Administration Floor at Elevation. 2306.2 m a s l
- Services and HVAC floor at Elevation. 2309.2 m a s l

Machine hall floor is divided into three sections i.e. Erection bay, Unit bays and powerhouse Operation bay. Erection bay is provided between the main access and the machine bay. The length of this bay is 11 m that will allow the assembly, erection and dismantling of one complete machine, providing adequate floor space for assembling the bottom cover, runner, top cover, shaft, bottom bracket, rotor and top bracket. The unit bays length is 10.0 m and it comprises of three units. The control room, store, lift, stairs and amenities are located in powerhouse operation bay. From machine hall floor three cable ways from generators lead to transformers bay which is of the same level of machine hall i.e. 2009.0 m. From transformers cable galley carries cables to GIS switchyard for further transmission.

On Generator floor, in addition to three generators, mechanical, electrical workshops, welding room and store are provided under the erection bay. Beyond the unit bays battery and charger rooms are placed along with lift and stairs. Turbine floor houses three turbine units and on one side there are compressor room with lift and stairs. On Valve floor spherical valves are placed on pedestals. The length of this floor is approx. 48 m. Stairs are terminated at this floor. Below this floor there are drainage and cooling water pits. The drainage sumps have emergency pumps.

On Administration floor meeting room, prayer room, offices, stairs and lift are provided. Services and HVAC floor contains potable water, service water, HVAC plant room with treatment, etc. Two overhead cranes run in the powerhouse building at Elevation. 2012.0 m. The powerhouse building floor plans and cross sections are given in Dwg. No. AFS-PH-431 to 436 in **Vol. 2 Drawings.**

## 9.12 TAILRACE CHANNEL

From each turbine the water will be carried through elbow shaped draft tube that will outflow into a tailrace bay from where the tailrace channel starts. The design parameters of the tailrace channel are as follows:

| | |
|---|---|
| Type | Concrete lined |
| Manning Stickler’s coefficient | 60 |
| Total Length | 18.0 m |
| Cross section type | Rectangular |
| Width | 45.0 m |
| Height | 13.0 m to 10.0 m |



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# 10 GEOTECHNICAL & STRUCTURAL STABILITY ANALYSIS

## 10.1 GENERAL

The overflow weir/ungated spillway and sediment flushing channel/undersluice of the Attabad Lake Hydropower Project (ALHPP) are in between sloping surfaces on both the left and right banks of existing spilling channel of Attabad Lake. Major focus of geotechnical and structural stability is carried out for an overflow weir/ungated spillway and sediment flushing channel/under sluices located on or near sloping ground, and thus are potentially subject to various kinds of slope instability such as slides, flows and falls. Slope failures can produce extensive damage to the structure. Therefore, it is necessary to evaluate the proposed slopes to assess their stability.

Slope geometry is an important factor which affects the slope stability. The basic geometrical slope design parameters are bench height, overall slope angle, and surface area Stability of slope decreases with the increase in its height and slope angle. In case of the ALHPP, for the sake of stability the slope is cut and is proceeded from top towards the edges of the structures in bench formation.

The cross sections showing benched slope stability options are shown from AFS-WR-414 to 423 Vol.2 Drawings. The cross section selected for analysis is the critical section at Chainage 0+50, where the main structure of the Project is placed in between the two slopes; the left slope will be benched from El 2490 to 2400 m.a.s.l, which needs analysis for its safety.

## 10.2 PROJECT NARRATIVE FOR USE OF GEOTECHNICAL SOFTWARE (SLOPE-W; GEOSTUDIO)

Manual procedures available for slope stability analysis are very laborious. These have limited application and based upon various assumptions. Quite often, the manual procedures for slope stability are very complex and less precise.

Over the last five decades, a lot of research has been carried out in the world for developing new techniques for planning, analysis and design. In this regard, various techniques have been developed to produce better quality of analysis in civil engineering projects. Besides, these techniques are being supplemented by computer software which save a lot of time and effort and thus provide better quality and cost effective design by incorporating actual conditions at the site. Use of computer software have made it possible to incorporate those analysis conditions which were limited in the past owing to tedious manual methods of analysis.

SLOPE/W provides less tedious and user-friendly operation and also reflects the existing conditions at the Project Site and operates in Windows Environment.

The analysis on geotechnical software is intended to provide guidance for the proper procedure and incorporation of modern techniques for stability analysis for sound design, saving the efforts involved in conventional analysis. The cross section showing slope under analysis is shown in **Figure 10.1.**



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**Figure 10-1: Cross Section at Chainage 0+50**

## 10.3 GEOLOGY OF THE SLOPES

Slided mass covers huge volume and consisted of mixed boulders and gravels near the slope surface and beneath the proposed area of overflow weir/ungated spillway and sediment flushing channel/undersluice. One of the difficult and critical task is to stabilize the both side slopes along the weir and sediment flushing channel. Benching is one of the best solution for such type of slope to stabilize. At some place, mashing or gabion maybe helpful for slope stabilization.

## 10.4 SCOPE OF THE ANALYSIS

The intended scope of the design has been to analyze the critical slopes near ALHPP structures, using conventional (computer aided) methods of analysis. The comparison of results obtained by different analysis methods is presented in factors of safety.

## 10.5 DESCRIPTION OF THE SLOPE STABILITY ANALYSIS

The conventional methods of slope stability analysis used are based on limit design. In these methods a trial surface of sliding is assumed and a quantitative estimate of the factor of safety is obtained by considering the overall equilibrium of the sliding mass and comparing the strength necessary to maintain limit equilibrium with the available shear strength of the embankment material. Stability computations are performed along a number of sliding surfaces to obtain the minimum factor of safety. The sliding surface, along which the minimum factor of safety is obtained, is known as the critical sliding or slip surface.

The basic premise of all limit equilibrium methods of stability analysis is that the slope mass acts as a rigid body and the shear strength of the materials will be fully developed at all points simultaneously along a surface of incipient failure. Deformations of the slope mass and the relationships of the strain to the developed strength of the material are not accounted for in the analysis as customarily performed. Such assumptions are significant departures from reality and the magnitude of the error involved will depend on the stress-strain relationships of the materials involved. However, limit equilibrium methods are used because of their simplicity and



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the fact that experience has shown that if the factor of safety exceeds the recommended value, the slopes would be safe against shear failure and would not suffer excessive deformations.

The shape of sliding surface depends on the geometry of the problem and may be circular or non-circular. A shear failure in a steep slope of homogeneous soil will usually develop along circular surfaces; however, if weak layers or seams are present in the soil profile, the failure surface will have a tendency to follow these planes, insofar as kinematically possible, and adopt a non-circular shape. In most cases the sliding surfaces can be approximated by circular slip surfaces even for non-homogeneous (zoned) sections with moderate differences in the shear strength of constituent materials.

These methods are described in detail in the following sections:

### 10.5.1 Ordinary Method of Slices

In all the limit-equilibrium methods of stability analysis the factor of safety is determined by considering equilibrium of the potential sliding mass along assumed slip surfaces and locating by trial the slip surface that gives the lowest factor of safety. The method of analysis should be such as to accommodate conditions wherein the slip surface is curbed and the soil properties and pore pressures vary with location through the slope. For this reason, most of the equilibrium methods divide the free-body bound by the slip surface into a number of vertical slices. This procedure is known as the method of slices and is adaptable to any type of slip surface, circular or curbed. The method was pioneered by Fellenius and Taylor and has since been developed to improve its reliability and accuracy.

**Equilibrium Requirements**

In this method the potential sliding mass is subdivided into a number of vertical elements or slices. These slices need not be equal in width, e.g., slice widths may be selected in such a way that, as far as possible, the base of each slice falls within one type of soil in a non-homogeneous slope. The inclination of the base of each slice, the slice weight, the material properties and the pore pressures at the base of each slice should be known before an analysis can be carried out.

**Figure 10.2** shows a potential sliding mass along a trial slip surface through an embankment slope. The sliding mass is subdivided into a number of imaginary vertical slices. Usually six to nine slices are adequate for all practical purposes. The ratio between slice height and slice width should usually be 1 to 2.5, or maximum 3.

Each slice is acted upon by its own weight W and by the boundary interslice or side forces, both of which have tangential or shear components X and normal components E. The forces acting on the base of the slice are the shear resistance S and the normal force P. A rigorous solution to the problem of stability involving the soil mass would require that:

- The forces on each slice must satisfy the conditions of equilibrium, and
- The forces acting on the sliding mass as a whole must satisfy conditions of equilibrium.



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The following static equilibrium conditions should be satisfied:

- Sum of all vertical forces, $\sum F_V = 0$
- Sum of all horizontal forces, $\sum F_H = 0$
- Sum of moments of all forces about any point, $\sum M = 0$

These conditions should be satisfied both for the individual slices as well as for the overall equilibrium of the slope.

In addition, to enable computation of the factor of safety, the following equation relating the equilibrium shear stress to the shear strength of the material is introduced. A state of limiting equilibrium is said to exist when the equilibrium shear stress is express as:

$$\tau = \frac{\tau_f}{F}$$

Where,

F = Factor of safety;

$\tau_f$ =Shear strength at failure

$\tau$ = Equilibrium shear stress along the shear surface



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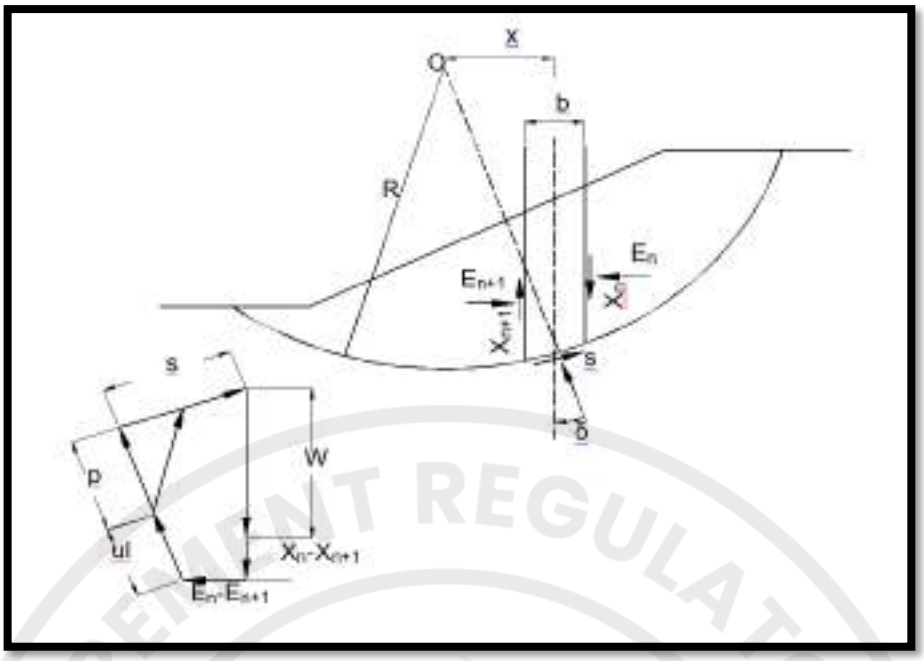


**Figure 10-2: Sliding Mass – ordinary method of Slices**

The shear strength of soils is usually expressed by Coulomb's equation:

$$\tau_f = c' + \sigma'_n \tan\phi'$$

Combining eqns. above,

$$\tau_f = \frac{c'}{F} + \frac{\sigma'_n \phi'}{F}$$

$$\tau = c_e + \sigma'_n \tan\phi_e$$

Where 'c' and 'phi' are the mobilized or developed values of shear parameters corresponding to equilibrium shear stress acting along the shear surface.

Limit equilibrium analysis is based on the assumption of ideal plastic behavior wherein stress-strain relationships do not exist (as for brittle soils) and the shear stress is defined by eqn. 2.3, the term 1/F giving the degree of mobilization. Implicit in the analysis is a constant value of F along the entire shear surface. Most soils lie somewhere between the ideal brittle and plastic materials.

By using the factor of safety to define the limit equilibrium, one can easily discriminate between the failure shear surface ($F_{min}$ = 1) and the critical shear surface at equilibrium ($F_{min}$ > 1).

**Limitations of this method**

The number of unknowns (interslice forces, normal and tangential forces, and F) are more than the number of equations. No explicit solution is therefore possible for the factor of safety, and it is necessary to make further simplifying assumptions to arrive at a solution. The various



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procedures of stability analysis differ principally in the equilibrium requirements they satisfy and the manner in which they handle the interslice forces.

### 10.5.2 Bishop method of Slices

The Simplified Bishop Method satisfies the following two equilibrium conditions:

XI. Overall moment equilibrium about the centre of the slip surface;

$$F = \frac{1}{\sum W \sin\alpha} \sum [c'l + (P - ul)\tan\phi']$$

XII. Vertical equilibrium for each slice; thus resolving the forces acting on a typical slice vertically (Figure 10.2).

$$W + X_n - X_{n+1} = P\cos\alpha + S\sin\alpha$$

The factor of safety in this method is computed by the equation:

$$F = \frac{1}{\sum W \sin\alpha} \sum [c'b + \tan\phi'(W - bu + X_n - X_{n+1})] \frac{1}{m_\alpha}$$

It is assumed in the Simplified Bishop Method that the interslice forces are adequately defined by their horizontal components and their vertical components can be neglected. With this assumption, the final factor of safety equation will be:

$$F = \frac{1}{\sum W \sin\alpha} \left[ \frac{c'b + \tan\phi'(W - bu)}{m_a} \right]$$

**Limitations of this method**

The main limitations of the Simplified Bishop Method are that it neglects the vertical component of the interslice forces and does not satisfy the horizontal force equilibrium. In practice, the Simplified Bishop Method has proved an accurate method for circular slip surfaces, including flat slopes with high pore pressures, and has gained wide acceptance. The justification for using the Simplified Bishop Method is largely empirical.

### 10.5.3 Spencer method

Keeping in view the limitations of the above methods used, spencer method is also used which produces accurate values of FOS keeping by considering also the following:

- Considers both shear and normal interslice forces,
- Satisfies both moment and force equilibrium, and
- Assumes a constant interslice force function.

The force-equilibrium factor of safety $F_t$ can be obtained by the following:



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$$F_t = \frac{\sum\left[\{c'b + \tan\phi'(W - bu + X_n - X_{n+1})\}\frac{1}{m_\alpha}\sec\alpha\right]}{\sum[W + X_n - X_{n+1}]\tan\alpha}$$

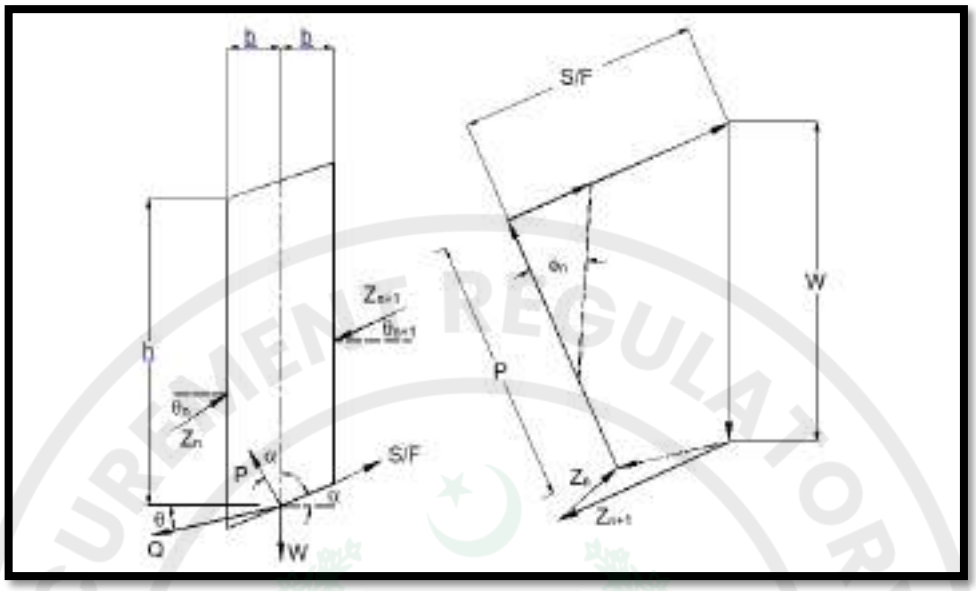


**Figure 10-3: Slice Orientation – Spencer Method**

When using Spencer's Method for analyzing slope stability for a non-circular sliding surface, the moment-equilibrium equation can be established by taking moments of the forces acting on the slices about some arbitrary center of rotation. The rest of the procedure remains unchanged.

### 10.5.4 Janbu Method

Janbu's Method of stability analysis, also known as the Generalised Procedure of Slices (GPS), can be used for solving stability problems involving a shear surface of any shape, circular or curved. Janbu considered the force and moment equilibrium of an individual slice as well as the equilibrium of the sliding mass as a whole. In view of the difficulty of obtaining a moment-equilibrium equation for the sliding mass as a whole for a non-circular sliding surface.

### 10.5.5 Morgenstern-Price method

Morgenstern and Price (1965) developed a method similar to the Spencer method, but they allowed for various user-specified interslice force functions. The interslice functions available in SLOPE/W for use with the Morgenstern-Price (M-P) method are:

- Constant
- Half-sine
- Clipped-sine
- Trapezoidal
- Data-point specified

Selecting the Constant function makes the M-P method identical to the Spencer method.



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## 10.6 PROS AND CONS OF SLOPE STABILITY METHODS-SUMMARY

Many different solution techniques for the method of slices have been developed over the years. Basically, all are very similar. The differences between the methods are depending on: what equations of statics are included and satisfied and which interslice forces are included and what is the assumed relationship between the interslice shear and normal forces?

In the beginning, Ordinary, or Fellenius method was first developed. The method ignored all interslice forces and satisfied only moment equilibrium. These simplified assumptions made it possible to compute a factor of safety using hand calculations, which was important since there were no computers available.

Later Bishop (1955) devised a scheme that included interslice normal forces, but ignored the interslice shear forces. Again, Bishop's Simplified method satisfies only moment equilibrium. Of interest and significance with this method is the fact that by including the normal interslice forces, the factor of safety equation became nonlinear and an iterative procedure was required to calculate the factor of safety.

The Janbu's Simplified method is similar to the Bishop's Simplified method. It includes the normal interslice forces and ignores the interslice shear forces. The difference between the Bishop's Simplified and Janbu's Simplified methods is that the Janbu's Simplified method satisfies only horizontal force equilibrium, as opposed to moment equilibrium.

Later, computers made it possible to more readily handle the iterative procedures inherent in the limit equilibrium method, and this lead to mathematically more rigorous formulations which include all interslice forces and satisfy all equations of statics. Two such methods are the Morgenstern-Price and Spencer.

## 10.7 SLOPE STABILITY INPUT PARAMETERS

The parameters are used are as follows:

Above below Water Surface:

- c 100 KPa
- Phi 20
- Unit Weight 21 KN/$m^3$

Above Water Surface:

- c 120 KPa
- Phi 25
- Unit Weight 18 KN/$m^3$

Youngs Modulus of Elasticity is 1.29 e +4 and poisons ratio used is 0.15



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## 10.8 METHODOLOGY ADOPTED FOR SLOPE STABILITY SLOPE/ W ANALYSIS

Slope stability analysis of critical slope at ALHPP is done by using aforementioned methods for the following two different slip surface arrangements within the Slope/ W software:

- Grid and radius Arrangement of Slip Surfaces
- Entry and Exit Slip Circle arrangement.

The Factor of Safety (FOS) has been calculated by introducing 2000 iterations and a Critical Slip Circle (the slip circle whose FOS is the minimum) has been found by analysis.

The shear strength & Normal Strengths and Interslice forces are drawn for each of the slice.

The Analysis are shown in **Figure 2-1 to Figure 2-10 (Volume 7 Appendices)**.

The Results from the analysis are tabulated in **Table 10-1 below**:

**Table 10-1 Results of SLOPE/W Methods**

| Method | **Grid & Radius arrangement for Slip Circle** | **Exit and Entry Arrangement for Slip Circle** |
|---|---|---|
| Ordinary or Fellenius | **1.75** | **1.53** |
| Bishop's Simplified | **1.865** | **1.63** |
| Janbu | **1.725** | **1.51** |
| Spencer | **1.87** | **1.62** |
| Morgenstern-Price | **1.821** | **1.63** |

## 10.9 CONCLUSIONS FOR SLOPE STABILITY SLOPE/ W ANALYSIS

The stability analyses of critical slope at Chainage 0+50 is analyzed under different loading conditions using conventional methods of analysis revealed that Spencer Method and Morgenstern-price Method (which satisfies only force and Moment equilibrium both) normally gives the highest factors of safety while Janbu Method (gives the lowest factor of safety). The variation among the methods is upto 9%.

Morgenstern Price method and spencer's method of analysis gave the identical results in the analyses this is owing to the fact that both the methods satisfy force as well as normal equilibrium.

FOS is inversely proportional to the height of the slope.

Material used on the facing with higher value of cohesion will increase the factor of safety.



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Following general findings have been deduced for all the methods in terms of equilibriums:

| Method | Moment Equilibrium | Force Equilibrium | Interslice Normal (E) | Interslice Shear (X) |
|---|---|---|---|---|
| Ordinary or Fellenius | Yes | No | No | No |
| Bishop's Simplified | Yes | No | Yes | No |
| Janbu's Simplified | No | Yes | Yes | No |
| Spencer | Yes | Yes | Yes | Yes |
| Morgenstern-Price | Yes | Yes | Yes | Yes |

## 10.10 FUTURE RECOMMENDATION

For future, if there is possibility of water filled tension crack upstream of slopes, causing the slopes to be saturated it is proposed to carry out the study on same lines using dynamic deformations. In this way it will be possible to calculate pore pressure changes effecting FOS of the whole system/ slope. This may be carried out using another computer software QUAKE/W in association with SLOPE/W.

## 10.11 GEOTECHNICAL STABILITY OF OVERFLOW WEIR/UNGATED SPILLWAY STRUCTURE WITH RESPECT TO SEEPAGE FORCES

### 10.11.1 Seepage Analysis

The objective of the analysis in case of an overflow weir/ungated spillway structure is to determine the following parameters which will be used in various stability checks:

- Total head dissipation from u/s to d/s.
- The Pressure Head and Pressure Profiles.
- The Hydraulic xy- Gradient Profiles
- Computation of Critical Hydraulic Gradient at d/s.
- Safety against Uplift
- Safety Against Piping

Seepage analysis is done to analyze whether the structure is safe against uplift and piping with respect to highest flood level and normal level conditions.



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Seepage analysis is done by using Finite Element Analysis technique. The SEEP/W in GEOSTUDIO software used for the analysis. SEEP/W basically obeys the flow law described hereafter.

### 10.11.2 Flow Law

SEEP/W is formulated on the basis that the flow of water through both saturated and unsaturated soil follows Darcy's Law which states that:

$$q = ki$$

Where;

$q =$ Specific discharge

$k =$ Hydraulic conductivity

$i =$ Gradient of fluid head or potential

Darcy's Law was originally derived for saturated soil, but later research has shown that it can also be applied to the flow of water through unsaturated soil. The only difference is that under conditions of unsaturated flow the hydraulic conductivity is no longer a constant but varies with changes in water content and indirectly varies with changes in pore water pressure.

Darcy's Law is often written as:

$$v = ki$$

Where $v$ is known as the Darcian velocity. The actual average velocity at which water moves through the soil is the Darcian velocity divided by the porosity of the soil. SEEP/W computes and presents only the Darcian velocity.

### 10.11.3 Governing Equation of Seepage Analysis

$$\frac{\partial}{\partial x}\left[k_x \frac{\partial H}{\partial x}\right] + \frac{\partial}{\partial y}\left[k_y \frac{\partial H}{\partial y}\right] + Q = m_w \gamma_w \frac{\partial H}{\partial t}$$

Where;

$k_x =$ Hydraulic conductivity in the x-direction

$k_y =$ Hydraulic conductivity in the y-direction

$H =$ Total Hydraulic Head

$Q =$ Applied boundary flux

$m_w =$ Slope of the storage curve

$\gamma_w =$ Unit weight of water

### 10.11.4 Geology at Overflow Weir/Ungated Spillway

An overtopping concrete weir founded on slided mass is proposed after foundation treatment. Geological rock units with which weir has to be abut, includes granodiorite, intruded by



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pegmatite veins at right side. On left side, weir has to be abut with Angular Boulder Gravel and Fines (ABGM) formed by slided mass (Vol-2, AFS-GE-297). As described in Volume 3 Geology and geotechnical studies, some treatment / engineering solution have to be implemented for stability of the weir and its left abutment. The basic purpose is to provide seepage line of defenses which can lengthen the seepage path, minimize the uplift pressure at critical portions of the weir structure to make it safe against piping and uplift.

### 10.11.5 Drilling results at weir site

A borehole BH-1, has been drilled at left side slope to investigate the subsurface geological conditions. The location of the boreholes is presented (Vol-2, AFS-GE-316). No rock has been encountered in this borehole upto 90 m. The core recovery CR (%) and permeability test results are given in Table 10-2, and graphically presented in Figure 10-1. The permeability tests were conducted after every 3 m, in most of test head could not maintained due to cavities/ open works encounter in subsurface. The borehole has been stabilized with cement.

**Table 10-2 core recovery CR (%) and permeability test results**

| ATTABAD LAKE HPP | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| BH-01 | | | | | | | | | | | |
| Depth(m) | | CR | K-Value | Depth(m) | | CR | K-Value | Depth(m) | | CR | K-Value(cm/sec) |
| From | To | (%) | (cm/sec) | From | To | (%) | (cm/sec) | From | To | (%) | |
| 0.5 | 1 | 0 | | 31 | 32 | 62 | | 61 | 62 | 54 | |
| 1 | 2 | 0 | | 32 | 33 | 88 | | 62 | 63 | 44 | Head Failure |
| 2 | 3 | 40 | | 33 | 34 | 83 | Head Failure | 63 | 64 | 55 | |
| 3 | 4 | 39 | 0.046178 | 34 | 35 | 100 | | 64 | 65 | 31 | |
| 4 | 5 | 78 | | 35 | 36 | 70 | | 65 | 66 | 32 | Head Failure |
| 5 | 6 | 60 | | 36 | 37 | 78 | Head Failure | 66 | 67 | 44 | |
| 6 | 7 | 17 | Head Failure | 37 | 38 | 58 | | 67 | 68 | 45 | |
| 7 | 8 | 40 | | 38 | 39 | 69 | | 68 | 69 | 88 | |
| 8 | 9 | 29 | | 39 | 40 | 45 | | 69 | 70 | 61 | Head Failure |
| 9 | 10 | 31 | Head Failure | 40 | 41 | 46 | Head Failure | 70 | 71 | 56 | |
| 10 | 11 | 30 | | 41 | 42 | 45 | | 71 | 72 | 53 | |
| 11 | 12 | 32 | | 42 | 43 | 53 | | 72 | 73 | 65 | Head Failure |
| 12 | 13 | 12 | Head Failure | 43 | 44 | 68 | Head Failure | 73 | 74 | 65 | |
| 13 | 14 | 42 | | 44 | 45 | 81 | | 74 | 75 | 77 | |
| 14 | 15 | 90 | | 45 | 46 | 56 | | 75 | 76 | 87 | Head Failure |
| 15 | 16 | 49 | 0.002858 | 46 | 47 | 89 | Head Failure | 76 | 78 | 87 | |
| 16 | 17 | 43 | | 47 | 48 | 65 | | 78 | 79 | 64 | Head Failure |
| 17 | 18 | 16 | | 48 | 49 | 58 | | 79 | 80 | 37 | |
| 18 | 19 | 96 | 0.012294 | 49 | 50 | 63 | Head Failure | 80 | 81 | 89 | |
| 19 | 20 | 100 | | 50 | 51 | 66 | | 81 | 82 | 57 | Head Failure |
| 20 | 22 | 90 | | 51 | 52 | 33 | | 82 | 83 | 32 | |
| 22 | 23 | 65 | | 52 | 53 | 28 | Head Failure | 83 | 84 | 45 | |
| 23 | 25 | 98 | Head Failure | 53 | 54 | 58 | | 84 | 85 | 38 | Head Failure |
| 25 | 26 | 33 | | 54 | 55 | 56 | | 85 | 86 | 56 | |
| 26 | 27 | 45 | | 55 | 56 | 100 | | 86 | 87 | 66 | |
| 27 | 28 | 35 | Head Failure | 56 | 57 | 47 | Head Failure | 87 | 88 | 59 | |
| 28 | 29 | 55 | | 57 | 58 | 50 | | 88 | 89 | 55 | Head Failure |
| 29 | 30 | 99 | | 58 | 59 | 23 | | 89 | 90 | 59 | |
| 30 | 31 | 100 | Head Failure | 59 | 60 | 53 | Head Failure | End of Borehole. | | | |



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It is noticed that head could not be maintained throughout the drilling of borehole. 100 % water loss has been observed. It indicates that slided mass is highly permeable with large cavities and open works required cementing for stabilization of bore holes during drilling.

### 10.11.6 Seepage Line of Defenses

If the Structure is to be placed on it, it requires treatment of strata with stabilized soil from 4 to 14 m from (El: 2412 to 2402 m.a.s.l). The stabilized portion is not needed in the stilling basin area. There is enough permeable layers present from ( El: 2402 to 2396 m.a.s.l). Beneath is there is close to free draining.

To cater with the above problem following seepage line of defenses have been provided:

- Stabilized clayey soil
- Cement Slurry Cutoff/ Plastic Piles
- Clay Blanket to cover the upstream face of the Slide material

Trial analysis have been done on the above combinations and finally the cross section so selected for final analysis of all the parameters mentioned in 10.11.1 above. The final cross section so selected in shown in **Figure 2-1 (Volume 7, Appendices)** and in **Figure 10.4** below:

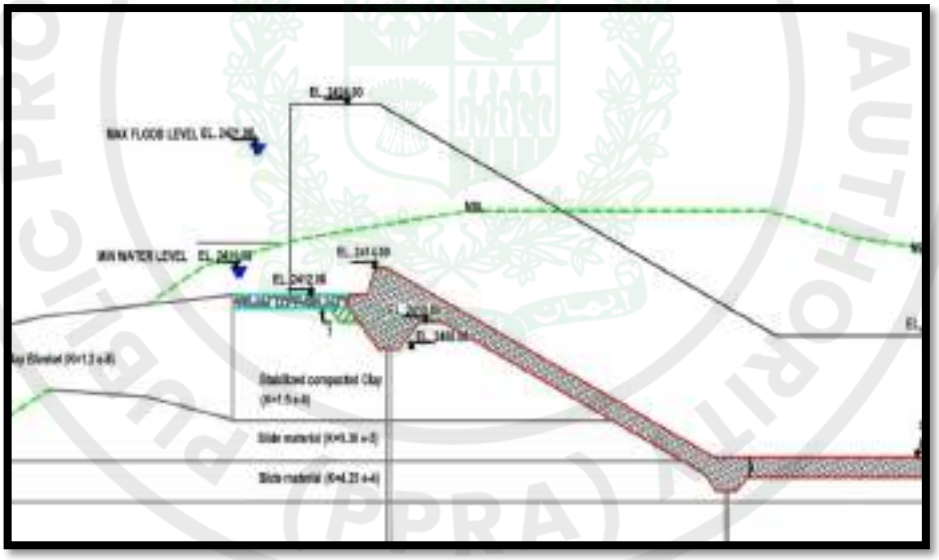

**Figure 10-4: Selected weir cross section with all seepage line of Defenses**

### 10.11.7 Selection of Stabilized Soil

The material for stabilized soil is taken from Power House Area and processed. The Soil classification done and processed soil is found to be silty clay material A-4 according to AASTHO after performance of sieve analysis, hydrometer analysis and Atterberg Limits. The results of the Sieve Analysis and Hydrometer are shown in **Figure 10.5** below:



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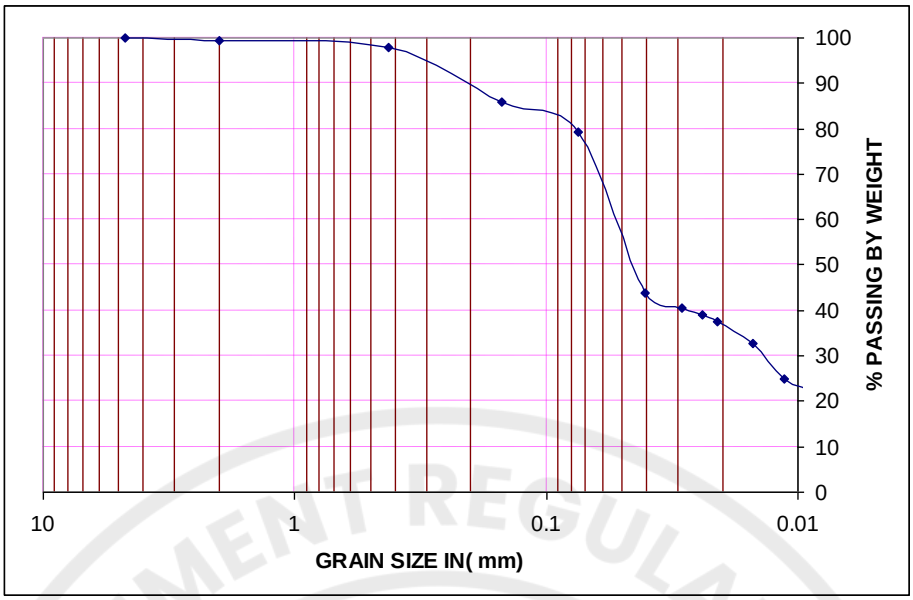


**Figure 10-5: Sieve Analysis of Soil used for Stabilization**

After classifying the soil, different samples were made with 0%, 2%, 4%, 6%, 8% and 10% of cement (3 samples for each %age). These samples were tested immediately and after 7, 14 days of casting by unconfined compression test. The results of the unconfined compression test are shown in **Figure 10.6 to 10.8** hereafter.

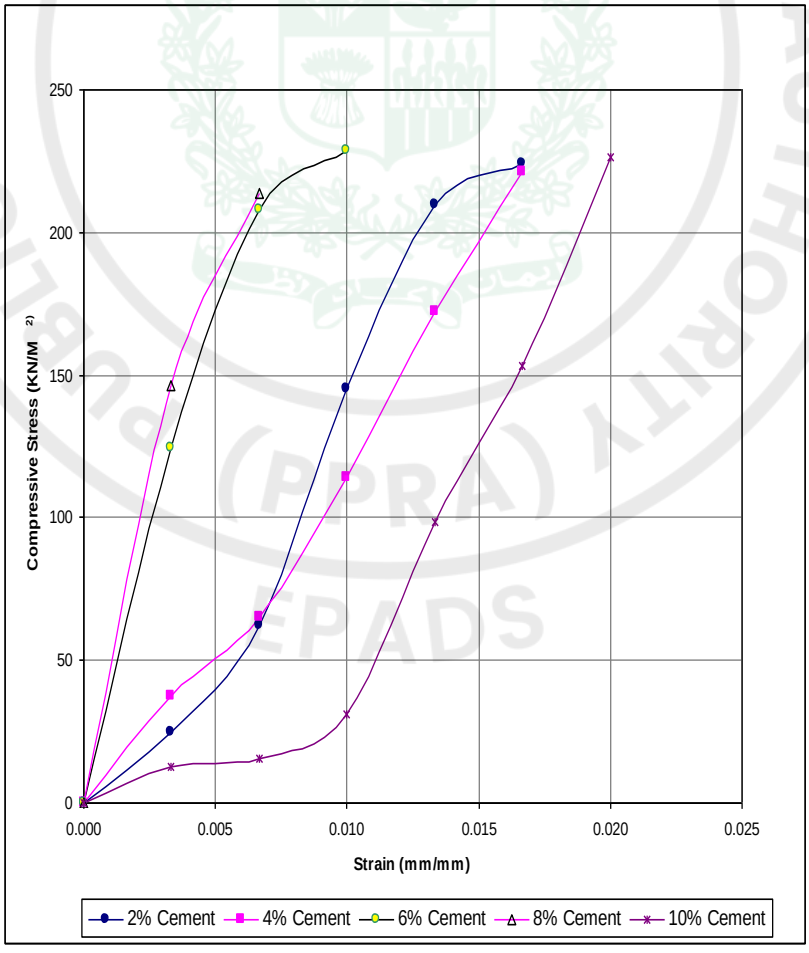


**Figure 10-6: Stress Strain Results of the unconfined compression test immediately after mixing cement**



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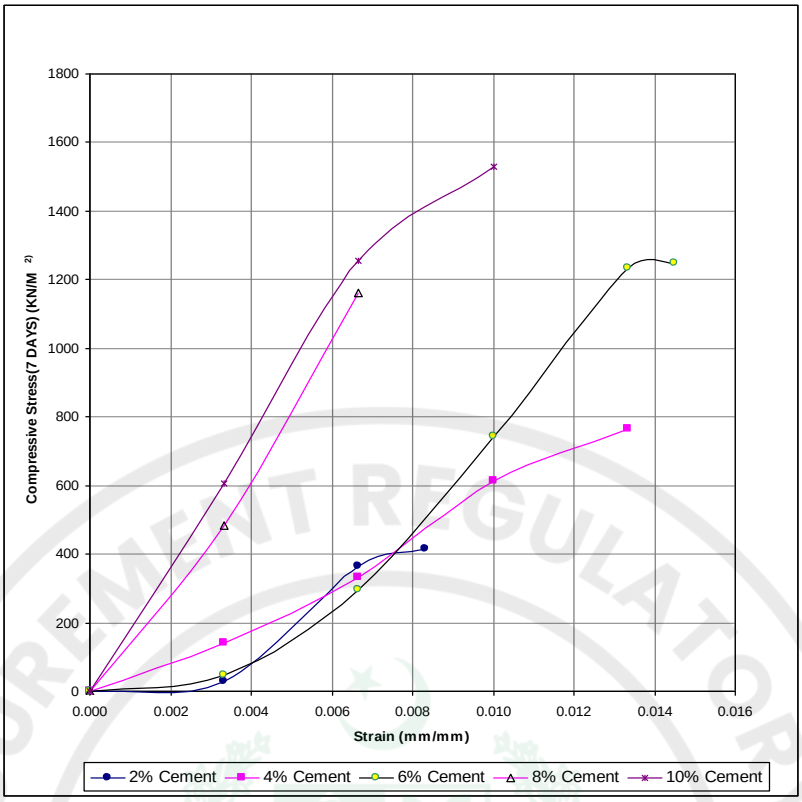


**Figure 10-7: Stress Strain Results of the unconfined compression test immediately after 7 days of mixing cement**

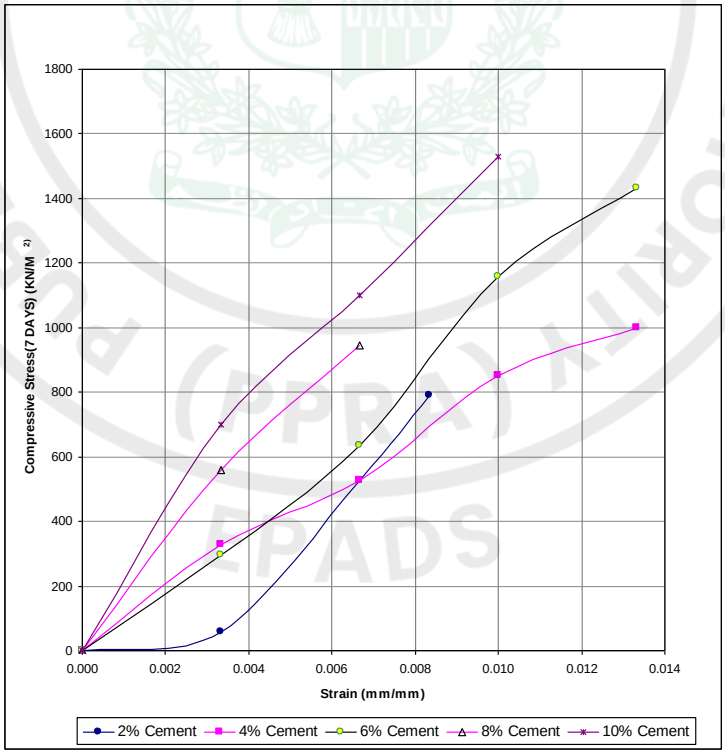


**Figure 10-8: Stress Strain Results of the unconfined compression test immediately after 14 days of mixing cement**



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The Summary of the Stress Strain Results and reduction of Plasticity index are shown in **Table 10.3** below:

**Table 10-3 Borehole Drilling Summary at Weir Site**

| Samples | | 0% | 2% | 4% | 6% | 8% | 10% |
|---|---|---|---|---|---|---|---|
| "C" in kPa | 0 days | 82.79 | 112.035 | 110.5 | 114.34 | 107 | 113.185 |
| | 7 days | 82.79 | 207.395 | 381.9 | 642.47 | 734 | 750+ |
| | 14 days | 82.79 | 394.67 | 500.48 | 716 | 749.39 | 750+ |
| P.I % | | 7.22 | 6.75 | 5.95 | 4.73 | 4.17 | 3.42 |
| Reduction in P.I | | - | 6.50% | 17.60% | 34.48 | 42.20% | 52.63% |

For economical consideration the soil with 2 % cement stabilization has been selected for the analysis and placement below the weir section. Almost 4 times the stabilization is achieved in terms of cohesion while the Plasticity index is already not in danger zone.

### 10.11.8 Material Description and Input Parameters

The permeability for the dyke foundation is taken from the permeability tests performed during borehole drilling and the for stabilized soil it's determined in laboratory.

For Stabilized soil beneath weir

$1.5 \times 10^{-8}$ m/sec

For slide material (El: 2402 to 2399m.a.s.l):

$9.38 \times 10^{-5}$ m/sec

For slide material (El: 2402 to 2399m.a.s.l):

$4.25 \times 10^{-4}$ m/sec

### 10.11.9 Geostudio (SEEP/W Analysis)

The Analysis is performed in Seep/w, a sub program of Geostudio.

The Finite element model has been prepared with Steady Seepage conditions by inputting the proper structural sizes and material properties. Water head and flux (total and unit) boundary conditions have been applied at appropriate edges within the FEM model alongwith potential seepage review face on both of the right and left embankments of channelized section. The FEM Model prepared is shown in **Figure 2-13 (Volume 7, Appendices)**.



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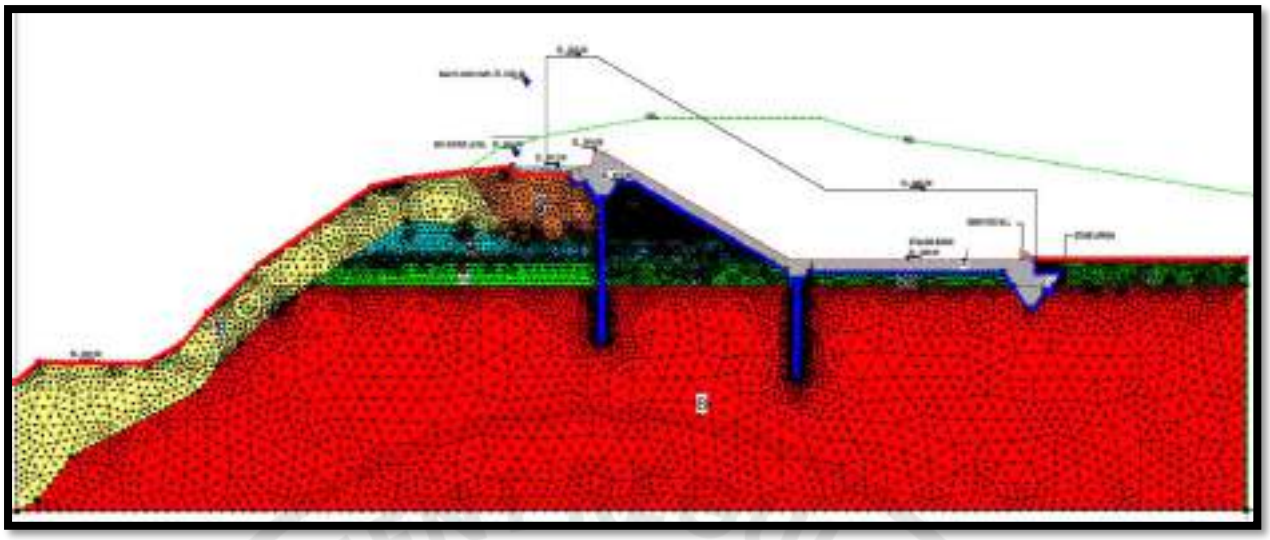
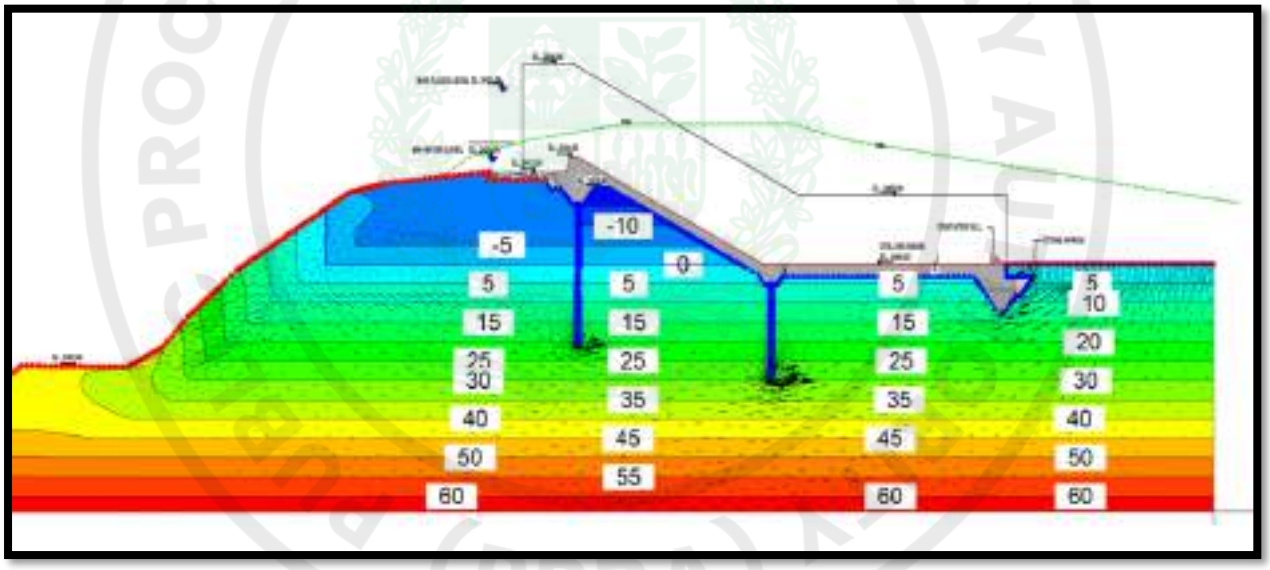


**Figure 10-9 Weir Structure at Minimum Pond Level (El : 2414m.a.s.l)**

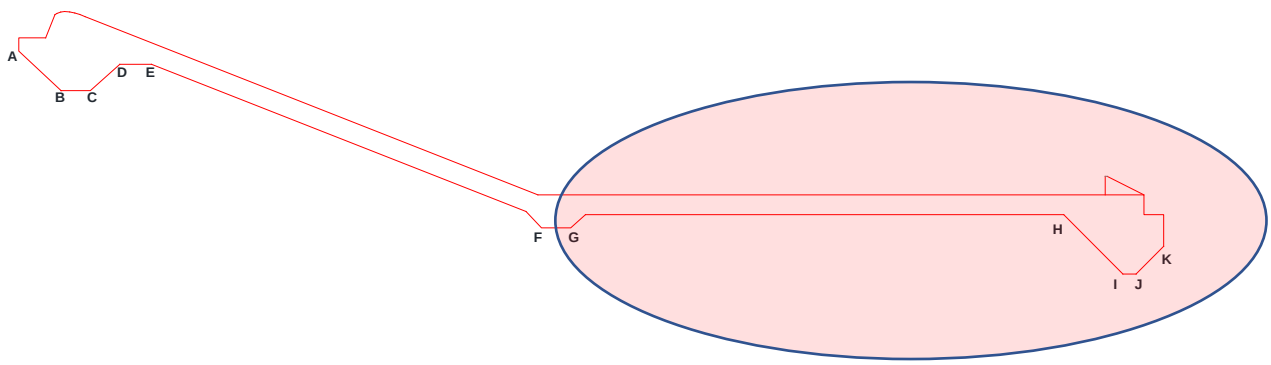
**Safety against Uplift:**

The Pressure head Profile is shown from **Figure 2-13 (Volume 7, Appendices)**.




It is quite evident from the Pressure Head Profile and visualization of phreatic surface within the foundation, only the downstream portion is critical against any uplift to check.

Pressure heads have been found at nine Nos. already provided Pressure points beneath the Barrage Structure.



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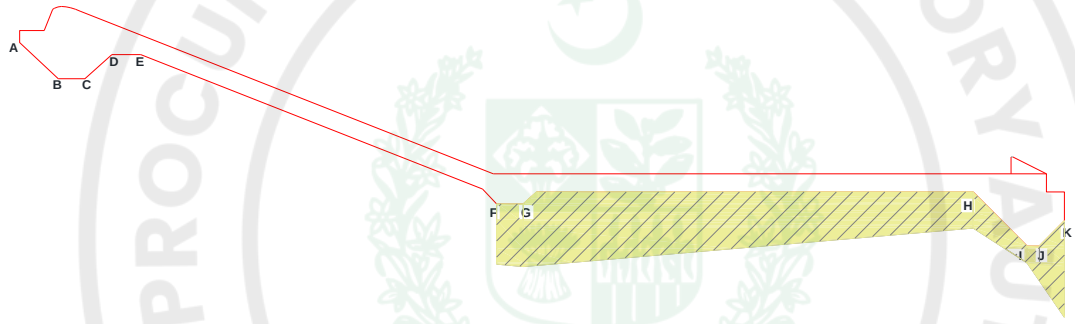
| Pt # | Press Head (m) |
|---|---|
| F | 5 |
| G | 5.2 |
| H | 3 |
| I | 1.4 |
| J | 1.6 |
| K | 8 |

Based on the Pressure Heads obtained from the SEEP/W, pressure head envelop has been plotted beneath the structure as follows:




**The Hydraulic Force per unit length of the weir is calculated by the following equation:**

- U= Unit Weight of water x Area of the Pressure head Diagram
- Area of pressure diagram between A & G= 201.3 $m^2$
- Unit weight of water = 9.81 $KN/m^3$
- U= (Total Hydraulic Force per Unit length) = 201.3 x 9.81= 1974.753 KN/m
- W=Weight of the Structure per unit length is calculated as = 2436 KN/m
- F.O.S against uplift= W/U= 1.24 (STRUCTURE IS SAFE AGAINST UPLIFT at WL EL: 2414 m.a.s.l)

**Safety against Piping:**

**According to Lane's weighted creep Theory the safety against Piping is ensured if:**

$$\boldsymbol{L_{req} > CH}$$

Where;

$L_{req}$ = Required Seepage Length



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$C =$ Coefficient taking into account the soil characteristics

$H =$ Maximum Head

According to lanes;

L available = L (vertical)+ 1/3*L(horizontal)

Where;

L available = Available Seepage length under the foundation

L (vertical) = Total vertical seepage length

L (horizontal) = Total Horizontal Seepage length

For Chashma Hydropower Project:

L available=79.8 + 1/3 (72.02) = 103.8 m

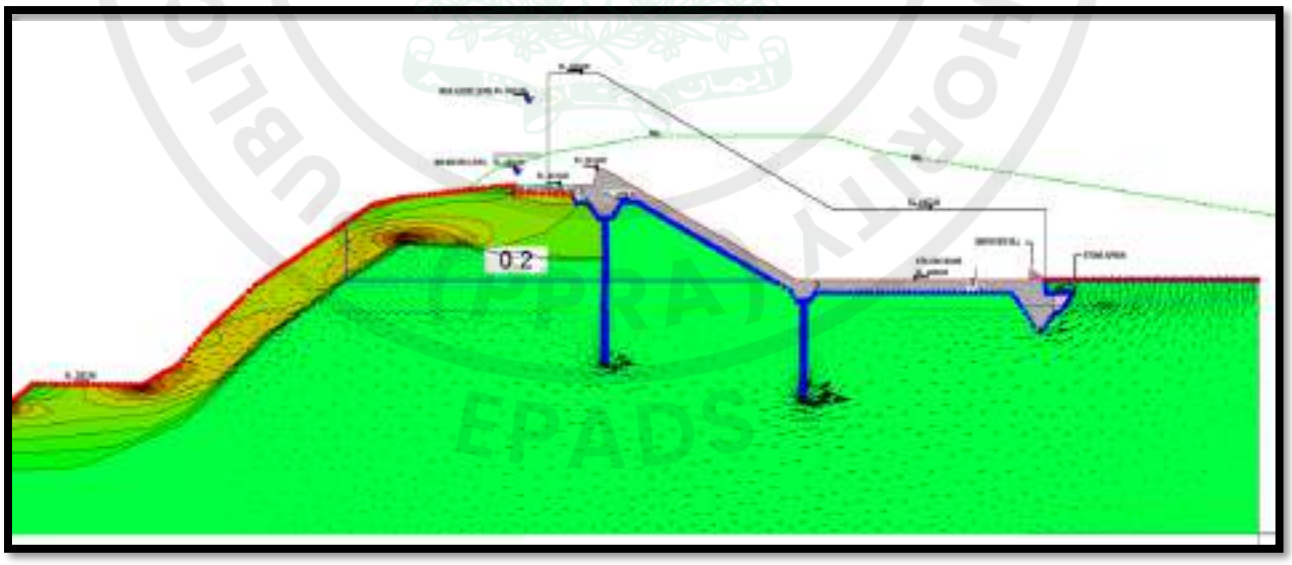
$L_{req} = CH$ = 14 X 3 = 42 m

L available >$L_{req}$, i.e. 103.8> 42

Hence, the weir structure is safe against piping forces.

**Safety against piping d/s of weir through exit gradient criteria.**

The Exit gradient profile computed from Geostudio SEEP/W Analysis is shown in **Figure 2-14 (Volume 7, Appendices)**




Exit gradient from Seep/W analysis= 0.2

Critical Hydraulic gradient= (Gs-1)/(1+e)

Where Gs= specific gravity

e= void ratio



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Critical Hydraulic gradient= (2.66-1)/(1+0.95)=0.85

Factor of Safety against piping =i (critical)/ i exit=0.85/0.2= 4.25 > 1, hence the weir structure is safe against piping.

### 10.11.9.1 Weir Structure at Maximum Pond Level (El :2424m)

**Safety against Piping:**

**According to Lane's weighted creep Theory the safety against Piping is ensured if:**

$$\boldsymbol{L_{req} > CH}$$

Where;

$L_{req} =$ Required Seepage Length

$\mathrm{C} =$ Coefficient taking into account the soil characteristics

$\mathrm{H} =$ Maximum Head

According to lanes;

L available = L (vertical)+ 1/3*L(horizontal)

Where;

L available = Available Seepage length under the foundation

L (vertical) = Total vertical seepage length

L (horizontal) = Total Horizontal Seepage length

L available=79.8 + 1/3 (72.02) = 103.8 m

$\mathrm{L_{req}} = \mathrm{CH}$ = 24 X 3 = 72 m

L available >$\mathrm{L_{req}}$, i.e. 103.8> 72

**Hence, the weir structure is safe against piping forces.**

**Safety against piping d/s of weir through exit gradient criteria.**

The Exit gradient profile computed from Geostudio SEEP/W Analysis is shown in **Figure 2-15 (Volume 7, Appendices)**



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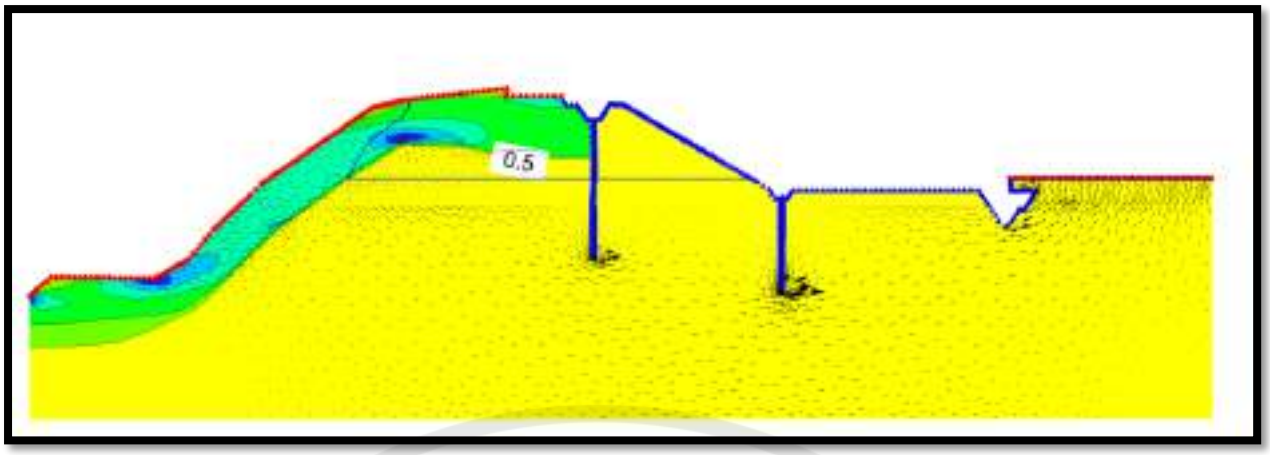


Exit gradient from Seep/W analysis= 0.5

Critical Hydraulic gradient= (Gs-1)/(1+e)

Where

Gs= specific gravity

e= void ratio

Critical Hydraulic gradient= (2.66-1)/(1+0.95)=0.85

Factor of Safety against piping =i (critical)/ i exit=0.85/0.5= 1.7> 1, hence the weir structure is safe against piping.

Due to proper seepage line of defences the phi and equipotential lines for max pond level are well below the weir foundation and follows almost same pattern at stilling basin area. The safety against piping was critical which has been checked above.

The clay blanket alongwith cement slurry cutoff and stabilized soil proved to be best in stabilizing the weir structure over the slided material.

For comparison the safety against piping has been checked for weir structure without clay blanket upstream, just to show that its presence upstream is so critical. The structure has been failed as shown below:

**Safety against piping d/s of weir through exit gradient criteria at highest pond level 2424 m.a.s.l without clay blanket.**

The Exit gradient profile computed from Geostudio SEEP/W Analysis is shown in **Figure 2-16 (Volume 7, Appendices)**



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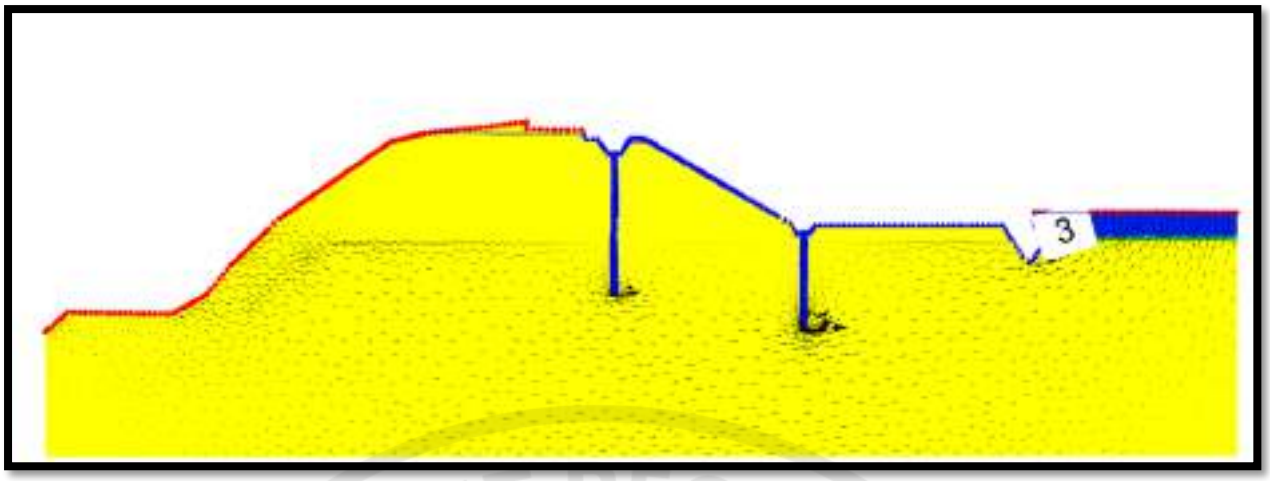



Exit gradient from Seep/W analysis= 3

Critical Hydraulic gradient= (Gs-1)/(1+e)

Where

Gs= specific gravity

e= void ratio

Critical Hydraulic gradient= (2.66-1)/(1+0.95)=0.85

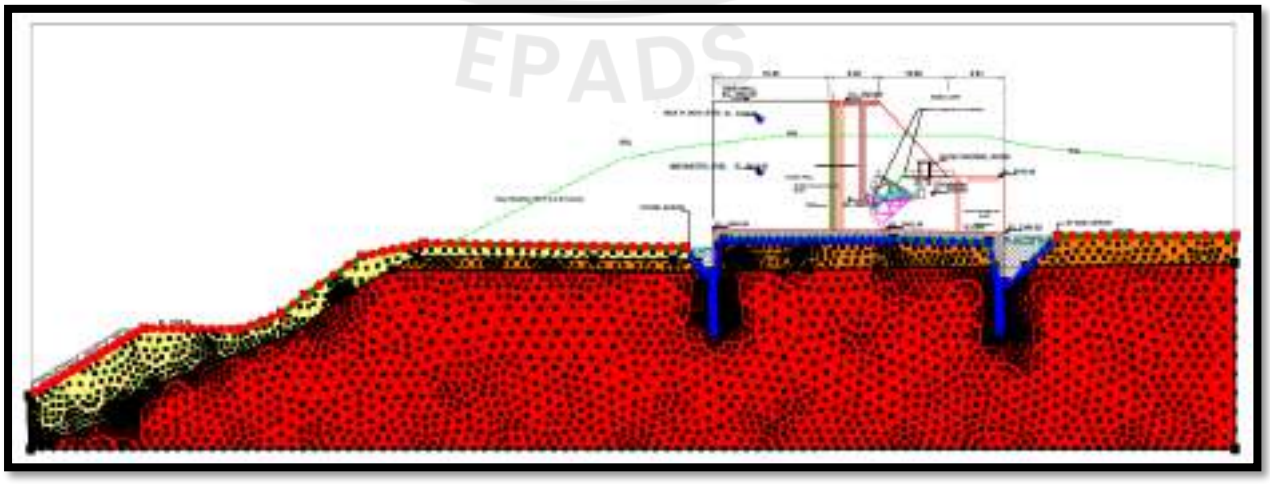
Factor of Safety against piping =i (critical)/ i exit=0.85/3= 0.28> 1, hence the weir structure is not safe against piping when clay blanket is removed.

**Under sluice Structure at Maximum Pond Level (El: 2424m.a.s.l)**

**Safety against Uplift:**

The Cross section finalized for analysis is shown in **Figure 2-17 (Volume 7, Appendices)**. Seepage line of defenses are upstream clay blanket and pile cutoffs.

The Finite Element model of under sluice section is shown in **Figure 2-18 (Volume 7, Appendices)**.





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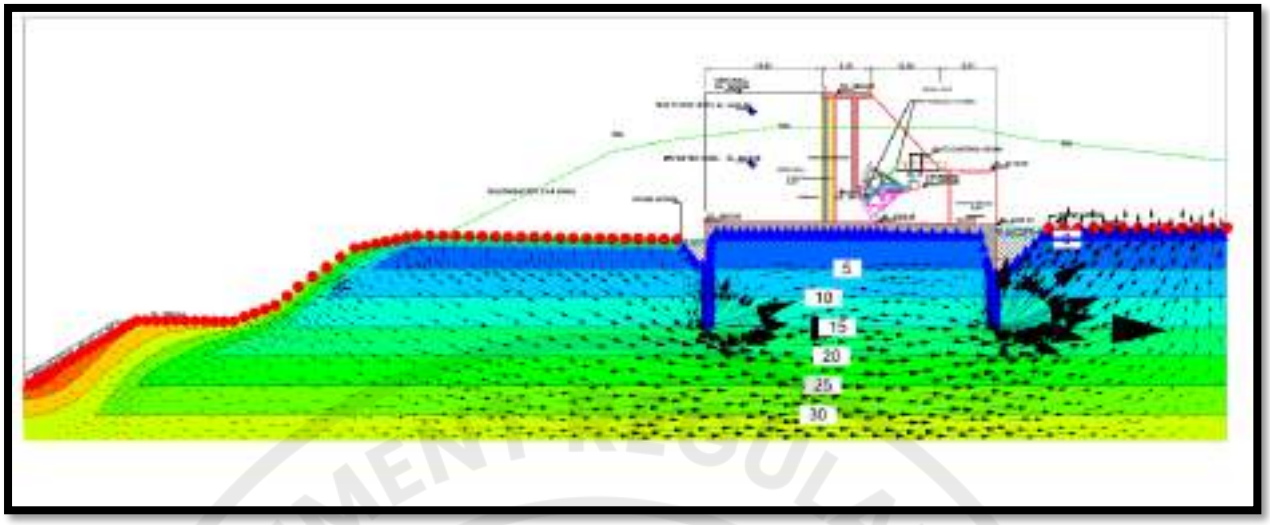
The Pressure head Profile is shown in **Figure 2-18 (Volume 7, Appendices)**.




It is quite evident from the Pressure Head Profile and visualization of phreatic surface within the foundation, only the downstream portion is critical against any uplift to check.

Pressure heads have been found at nine Nos. already provided Pressure points beneath the Barrage Structure.

| Pt # | Press Head (m) |
|---|---|
| A | 9.4 |
| B | 4.33 |
| C | 4.1 |
| D | 0 |
| E | 0 |
| F | 6.08 |
| G | 6.18 |
| H | 0 |

Based on the pressure heads obtained from the SEEP/W, pressure head envelop has been plotted beneath the structure as follows:



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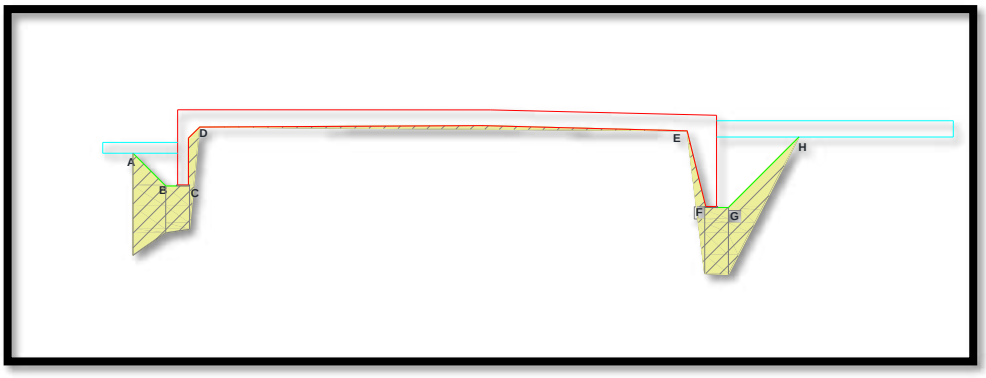


**The Hydraulic Force per unit length of the weir is calculated by the following equation:**

- U= Unit Weight of water x Area of the Pressure head Diagram
- Area of pressure diagram between A & G 82.51 $m^2$
- Unit weight of water 9.81 $KN/m^3$
- U= (Total Hydraulic Force per Unit length) 82.51 x 9.81 = 809.42 KN/m
- W=Weight of the Structure per unit length is calculated as 3147 KN/m
- F.O.S against uplift W/U 3.88 **(STRUCTURE IS SAFE AGAINST UPLIFT at WL EL: 2424 m.a.s.l)**

**Safety against Piping:**

**According to Lane's weighted creep Theory the safety against Piping is ensured if:**

$$L_{req} > CH$$

Where;

$L_{req}$ = Required Seepage Length

C = Coefficient taking into account the soil characteristics

H = Maximum Head

According to lanes;

L available = L (vertical)+ 1/3*L(horizontal)

Where;

L available = Available Seepage length under the foundation

L (vertical) = Total vertical seepage length

L (horizontal) = Total Horizontal Seepage length

:

L available=64.648 + 1/3 (49.38) = 81 m



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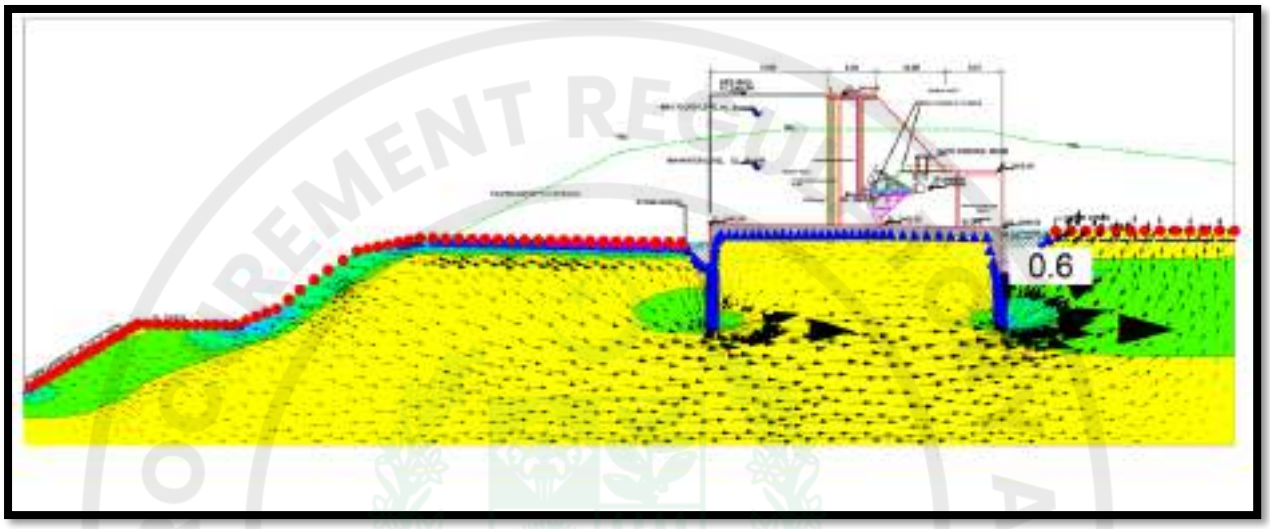
$L_{req} = CH$ = 24 X 3 = 72 m

L available >$L_{req}$, i.e. 81> 72

**Hence, the weir structure is safe against piping forces.**

**Safety against piping d/s of barrage through exit gradient criteria.**

The Exit gradient profile computed from Geostudio SEEP/W Analysis is shown in **Figure 2-20 (Volume 7, Appendices).**




Exit gradient from Seep/W analysis 0.6

Critical Hydraulic gradient (Gs-1)/(1+e)

Where Gs= specific gravity

e= void ratio

Critical Hydraulic gradient (2.66-1)/(1+0.95)=0.85

Factor of Safety against piping =i (critical)/ i exit=0.85/0.6= 1.41> 1, hence the weir structure is safe against piping.

### 10.11.9.2 Overflow Weir Structure at Max Pond Level without Blanket (El: 2424 m.a.s.l)

For comparison the safety against piping has been checked for overflow weir/ungated spillway structure without clay blanket upstream, just to show that its presence upstream is so critical. The structure has been failed details are given below:

**Safety against piping d/s of sediment flushing channel /under sluice through exit gradient criteria at highest pond level 2424 m.a.s.l without clay blanket.**

The Exit gradient profile computed from Geostudio SEEP/W Analysis is shown in **Figure 2-21 (Volume 7, Appendices)**



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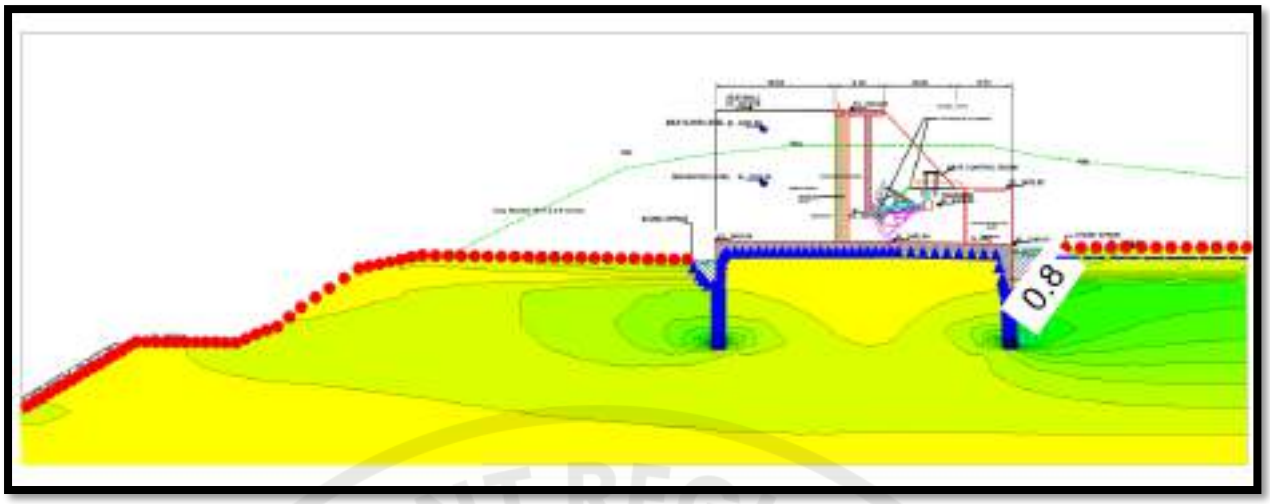


Exit gradient from Seep/W analysis= 0.8

Critical Hydraulic gradient= (Gs-1)/(1+e)

Where

Gs= specific gravity

e= void ratio

Critical Hydraulic gradient= (2.66-1)/(1+0.95)=0.85

Factor of Safety against piping =i (critical)/ i exit=0.85/0.8= say equal to 1, hence the sediment flushing channel/ undersluice structure is not safe against piping when clay blanket is removed.

## 10.12 MONITORING AND SURVILANCE OF SLOPES

Slope indicators are proposed on right side slope benching starting from overflow weir site at chainage 100+00 towards downstream @ 100m. They are really necessary to use to measure relative and absolute (total) horizontal (lateral) movement, and/or variation in inclination, with respect to a vertical or inclined reference axis.

Lateral movements in structures are measured by use of borehole slope indicators (Inclinometers). The slope indicator casing may be installed during construction of the dam, or, after in the event that excessive displacement is observed.

The instrumentation basically will be comprising of a specially designed access tube (duct), with incorporated guide tracks, which is embedded in the respective structure, embankment or foundation, aligned along the selected measurement reference axis. The access tubing is of segmental construction with telescoping joints to accommodate extension/compression movements.

The tilt of the sensor will be measured and recorded by servo-accelerometer located within the probe. Where two accelerometer are used they can sense the inclination of the tube in two directions at right angles to each other.

Portable electronic probes, with attached calibrated measurement/control cables, are provided for insertion and traversing along the access tube(s) for reading purposes. The probe readings



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are taken with special electronic readout units capable of storing the readings for subsequent direct downloading to a computer for purposes of analysis. Analysis of the readings is carried out by special computer software provided as part of the instrument package.

In the case of the inclinometer probes, readings of the inclination of the access tube at selected points are taken in two orthogonal directions (i.e. at 90º to each other) over the fixed gauge length of the probe, and by taking a series of continuous readings a profile of the deflected shape of the access tube corresponding to the deflection within the structure, embankment, or foundation can be obtained.

Provision is made in the supplied computer software for the graphical plotting of the deflected shapes and the determination of both absolute (total) and relative (incremental) displacements with time.

The accuracy of measurement is 3 mm.

Inclinometer consists of;

- Aluminum access tube (in small lengths)
- Biaxial probe
- Inclinometer data logger

The cross section details of slope indicator are presented in **Figure 10.9 & 10.10** below:



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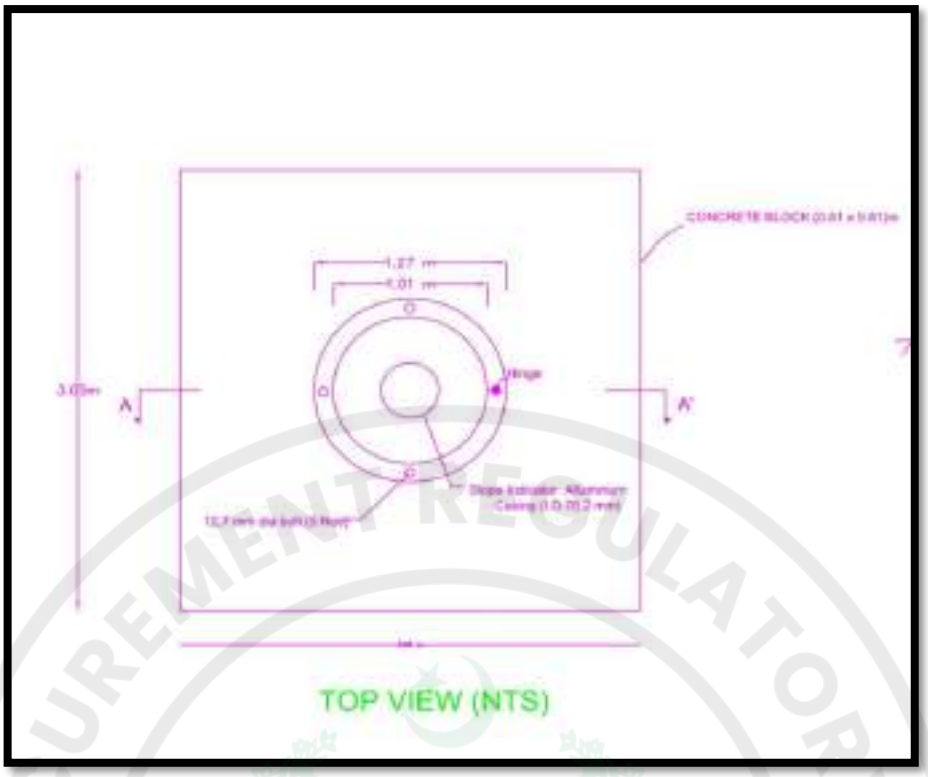


**Figure 10-10: Cross Section details of Slope Indicator (Top view)**

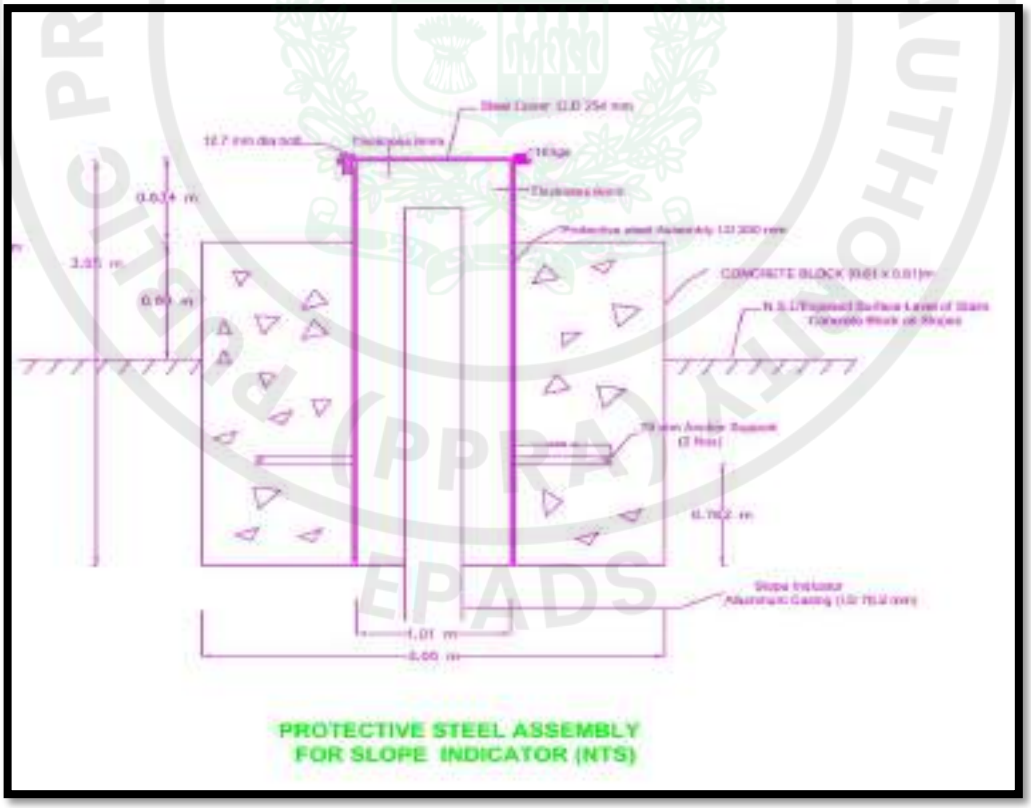


**Figure 10-11: Cross Section details of Slope Indicator (cross section)**

The depth of the slope indicator will be upto bottom of the final stepping/ bench and will start from one above the middle bench of the benched slope.



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# 11 HYDRO MECHANICAL EQUIPMENT

## 11.1 INTRODUCTION

### 11.1.1 BACKGROUND

Energy is the indispensable force that drives all economic activity the greater the energy consumption, the more the economic activity, resulting in the emergence of growth. A steady growth in the economy is a prerequisite for any nation desirous of becoming a developed country. If Pakistan adequately utilizes its energy potential to meet growing demand, it will be better poised to achieve high levels of economic growth.

Hydropower is a clean, domestic, and renewable source of energy. It provides inexpensive electricity and produces no pollution. Unlike fossil fuels, hydropower does not destroy water during the production of electricity. Hydropower is the only renewable source of energy that can replace fossil fuels' electricity production while satisfying growing energy needs. According to some estimates, Pakistan is endowed with a potential of about 40,000 MW but only 11.0% of it is presently being utilized for generation of electricity leaving the remaining untapped.

Considering the electric industry that exists today, hydropower has a distinct advantage over fossil fueled generator plants: it is clean, green and renewable. Hydropower does not contribute to local air pollution. Other energy generators are an important source of air, water, and soil pollution and greenhouse gases, and provide fewer opportunities for economic spin-offs.

### 11.1.2 Location

Attabad is a town in the Gilgit-Baltistan region of northern Pakistan. It is located at 36°19'0N 74°48'0E with an altitude of 2559 meters (8398 feet) and is famous as home of the Attabad lake. The lake was formed when Attabad Village in Hunza Valley in Gilgit-Baltistan had a landslide, 14 kilometers (9 miles) upstream (east) of Karimabad that occurred on 4$^{th}$ January, 2010. Location for the Proposed Attabad Hunza Hydropower Project has been identified in the intermediate reach along Hunza River 29km upstream of Aliabad Village and 111km from Gilgit.

### 11.1.3 Parameters

To arrive at the optimum unit rating and parameters of the power plant detailed studies for the various possible alternates were carried out. From these studies it was concluded that installation of generating units of capacity 54 MW corresponding to 375 rpm synchronous speed would be the optimum solution. The key characteristics of the unit selected for Attabad Hydro Power Project, are given below.



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| | |
|---|---|
| Full Supply Level (FSL) | 2414 m.a.s.l |
| Minimum Operating Level (MOL) | 2412 m.a.s.l |
| Maximum Tail water Level | 2307 m.a.s.l |
| Minimum Tail water Level | 2302 m.a.s.l |
| Site Gross Head | 112 m |
| Rated Net Head | 106 m |
| Installed capacity | 54 MW |
| No. of Generating Units | 03 |
| Units Rated Capacity | 18 MW (Generator Output) |
| Turbine Rated Capacity | 57 MW |
| Plant Overall Efficiency | 90.28% (0.915(T)x0.98(G)x0.985($T_f$)) |
| Transformer Capacity | 66 MVA (3 x 22) |
| Generator Voltage | 11 kV |
| Power Factor | 0.85 |
| Powerhouse Cavern | 45 m x 18 m x 22 m (L x W x H) |
| Transmission Voltage | 132 KV |

## 11.2 POWER HOUSE MECANICAL WORKS

### 11.2.1 General

This section provides general information and guidelines used for the feasibility design of the hydro-mechanical equipment for Attabad Hydro power project (AHPP). It also covers the characteristics of these equipment and various factors used to establish the size and configuration of such type of equipment. The key dimensions of turbine are also workout and given in this chapter.

### 11.2.2 Introduction

The mechanical equipment of Attabad Hydropower Project consists of the following main components:

- Vertical Shaft Francis Turbines
- Turbine governors
- Main Inlet Valves
- Powerhouse Main Crane
- Station Auxiliaries
- Cooling Water System



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- Drainage and Dewatering System
- Compressed Air System
- Oil Handling System
- HVAC System
- Fire Fighting System
- Mechanical Workshop Equipment
- Elevator
- Potable Water Supply and Sanitation System

## 11.3 STANDARDS AND BASIC DESIGN CRITERIA

The mechanical equipment will be designed according to the well reputed international standards and codes like IEC, ISO, EN, ASTM, ASME, BSS, DIN, etc.

## 11.4 MAIN DESIGN PARAMETERS

### 11.4.1 Water Flow

Flow Duration Curve (FDC) for Attabad Lake HPP is plotted on the basis of almost 51 years (1966-2016). From FDC it us evident that design discharge of 60 $m^3/s$ is available for almost 50% of the time. Therefore, design discharge of 60 $m^3/s$ is justified for the generation of 54 MW power.

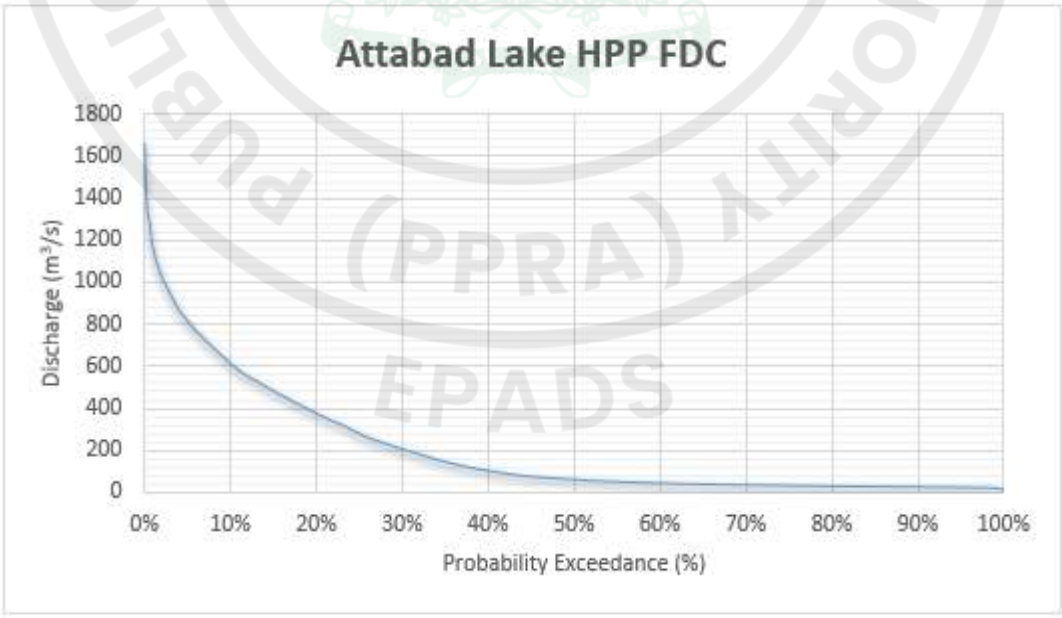


**Figure 11-1 Attabad Lake Flow Duration Curve (FDC)**



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**Table 11-1 Flow Duration Curve Results**

| Probability Exceedance (%) | Flow (m3/s) | Probability Exceedance (%) | Flow (m3/s) |
|---|---|---|---|
| 10 | 613.4 | 60 | 44.3 |
| 20 | 376.6 | 70 | 36 |
| 30 | 205 | 80 | 30.3 |
| 40 | 103.3 | 90 | 26.2 |
| 50 | 61.3 | 99 | 20.5 |

### 11.4.2 Head Calculation

**Head water Level**

The Full Supply Level (FSL) of AHPP is 2414 m.a.s.l., while minimum Operation Level (MOL) is about 2412 m.a.s.l. depending upon the availability of flows.

**Tail water Level**

Since there is fluctuation of flow, thus tail water level will also be changing accordingly. Maximum tail water level has been recorded as 2307 m.a.s.l. and minimum tail water level is 2302 m.a.s.l.

### 11.4.3 Water Head

**Gross head**

On the basis of selected water levels calculated gross head will be:

Site Gross Head: 112 m

**Rated net head**

Considering the head variation, friction losses and turbine runner central line arrangement the selected rated net head for AHPP is as follows:

Maximum Net Head: 108 m

Rated Net Head: 106 m

Minimum Net Head: 100 m

### 11.4.4 Site Elevation

Site elevation of AHPP powerhouse is 2358 m

### 11.4.5 Water Temperature

Average water temperature at AHPP site is 10˚C

### 11.4.6 System frequency

System frequency of AHPP powerhouse equipment is 50 Hz



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### 11.4.7 Plant Capacity

The Power has been carried out according to the following formula:

$$P = \rho \times g \times Q \times H \times \eta/1000$$

Where,

P= Power (MW)
ρ = Density of water = 1 (ton/$m^3$)
Q = Discharge ($m^3$/sec)
H = Available head (m)
g = Acceleration due to gravity (9.81 m/$sec^2$)
η = overall Efficiency coefficient (%)

On the bases of selected rated discharge of 60 $m^3$/sec and rated net head of 106 m and overall efficiency of turbine, generator & transformer is around 0.90. The installed capacity of power house comes out to be 54 MW.

## 11.5 POWERHOUSE MECHANICAL EQUIPMENT

The powerhouse will be equipped with three Vertical Shaft Francis turbines. The total plant out capacity of AHPP powerhouse is 54 MW. The turbine shall be capable to operate within a wide range of head and discharge at maximum attributable efficiency.

No. of Units = 03 (Vertical Francis)

Plant Discharge, $Q_{Total}$ = 60 $m^3$/s

Rated Net Head, $H_n$ =106 m

Plant Capacity, $P_{Total}$ = 54 MW

Followings are the main powerhouse mechanical equipment.

- Turbines
- Governors
- Cooling and Service Water Systems
- Dewatering and Drainage Systems
- Potable water system
- Sewage and water treatment
- Compressed air Systems
- Oil handling system



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- Heating Ventilation & Air-conditioning System
- Fire protection system
- Powerhouse Crane
- Powerhouse elevator
- Workshop equipment etc.

## 11.6 TURBINES

In the power house, three (03) turbine-generating units, each consisting of a Francis turbine and a synchronous generator rigidly coupled by a vertical shaft. Each turbine will be equipped with a main inlet valve of butterfly type at the inlet of the manifold. On the downstream side of each turbine, draft tube gates can be set to isolate the turbine pit from the tailrace channel.

At the power intake (in Attabad Lake), fixed wheel gate will be installed, which will act as emergency gate.

The size of powerhouse totally depends upon type of turbine and number of units. Discharge and net head basic is the key parameter and basic criteria for selecting the type of hydel turbine. Other factor such as gates, stop logs, trash racks, dewatering and drainage pits, loading and service bay are also important.

Since, the layout and dimensions of a powerhouse are mainly influenced by the selected type of turbine, particularly by arrangement of turbine axis either in horizontal or in vertical direction and discussed as follows:

### 11.6.1 Turbine Selection Criteria

In case of AHPP with gross head of 112 m, rated net head of 106 m and rated discharge of 60 $m^3$/sec, figure 2.2 & 2.3 refer Francis turbines to be the most suitable ones.

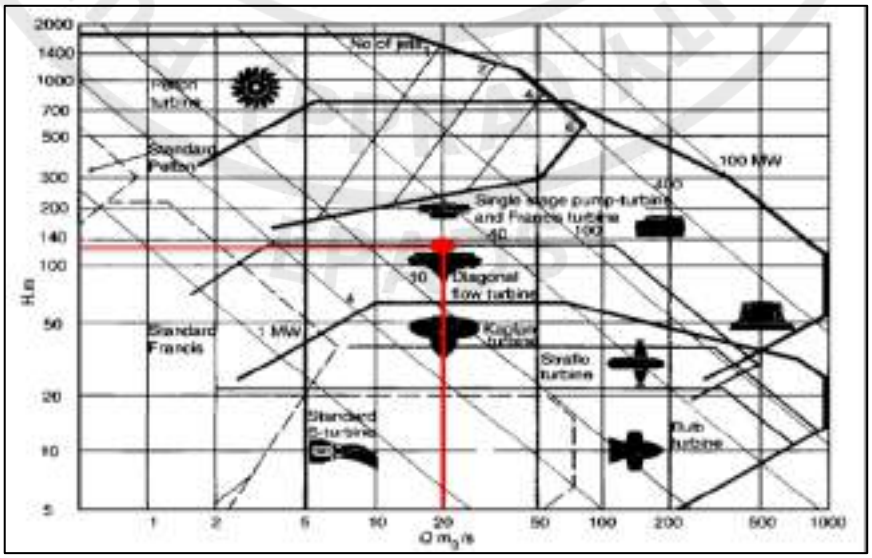


**Figure 11-2 Generalized Turbine Operation Limits**



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**(Courtesy Sulzer Hydro Ltd., Zurich)**

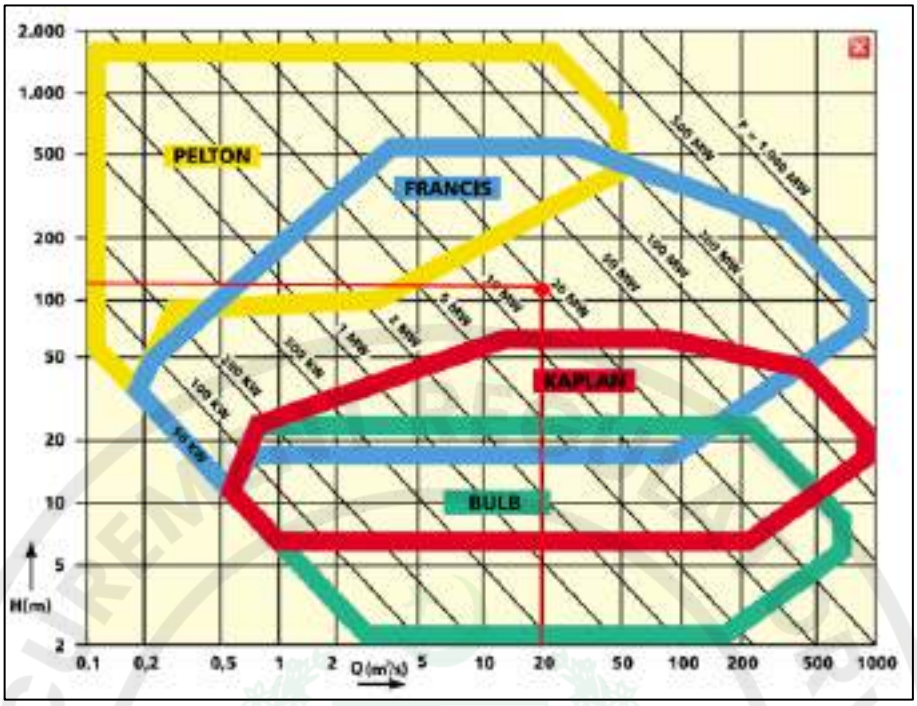


**Figure 11-3 Turbine Operating Regimes**

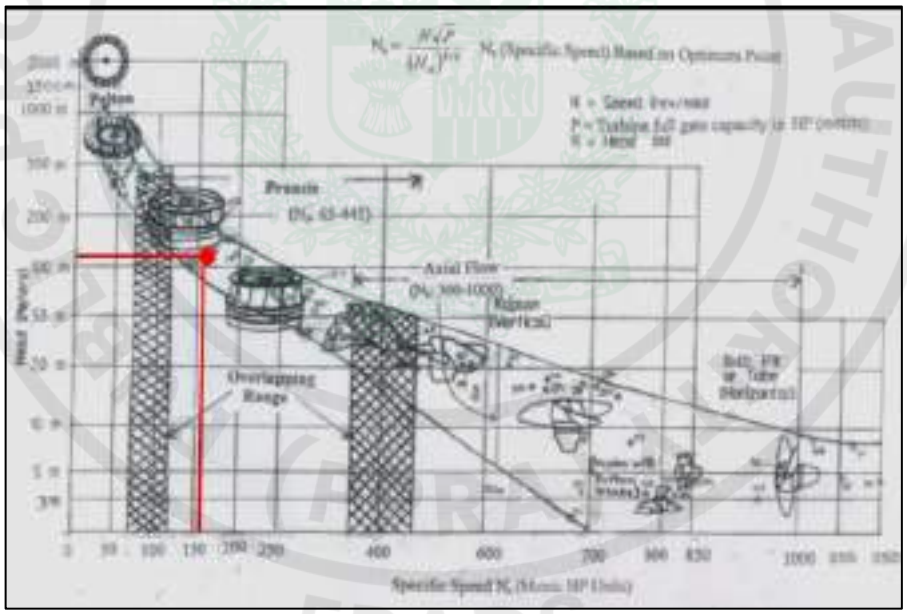


**Figure 11-4 $N_s$ Versus Head:**

This figure shows the various turbine type as a function of specific speed (Ns) and head. This figure should be used a guideline, as there is overlap between the various turbine types with respect to their operating ranges (Based on ASME–Guide to Hydropower Mechanical Design Book)

Following standards and monographs are good guides for selection of hydraulic turbines.



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- IS 12837 – 1989 – Hydraulic Turbines for Medium and Large Power Houses – Guidelines for Selection.

- IS 12800 (Part 3) 1991 – Guide lines for selection of hydraulic turbines, preliminary dimensioning and Layout of surface Hydro-Part 3 Small Mini and Micro Hydroelectric Power Houses.

Vertical Francis type turbine is best and appropriator solution for the rated discharge of 20 $m^3$/sec and rated net head of 106 m.

### 11.6.2 Specific Speed

The term specific speed used in classifying types of turbines and characteristics of turbines within types is generally the basis of selection procedure. This term is specified as the speed in revolution per minute at which the given turbine would rotate, if reduced homologically in size, so that it would develop one metric horse power at full gate opening under one-meter head. Low specific speeds are associated with high heads and high specific speeds are associated with low heads. Moreover, there is a wide range of specific speeds which may be suitable for a given head.

Flow based metric system for specific speed ($N_q$) is given by equation below.

$$\mathbf{N_q = \frac{NT^{0.5}}{H^{1.25}}}$$

Where,

$N_q$ = Specific Speed

N = Speed in rpm

T = Turbine Power

H = Net Head in meters

$$N_q = \frac{375 * 19000^{0.5}}{106^{1.25}}$$

$$\mathbf{N_q = 152.0}$$

Specific speed (metric HP units) range of different types of turbines is as follows:

Fixed blade propeller turbines - 300 – 1000

Adjustable blade Kaplan turbines - 300 – 1000

Francis turbines - 65 – 445

Impulse turbines –

- Pelton Turbine per jet 16-20 per jet for multiple jets the power is proportionally increased.

- Cross flow turbine 12-80



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Specific speed is calculated to be 152.0 which lies in range of Francis turbine (65 – 445). Hence, vertical Francis turbine is best suitable for the specific speed of 152.0.

### 11.6.3 Number of units

Normally, it is most cost effective to have a minimum number of units at a given installation; however multiple units may be necessary due to various reasons. Thus for selecting number of units following factors should be considered.

- Efficient water use
- Getting Max energy
- Space limitation for civil structure
- Transportation Problems
- Maintenance View point
- Cost effectiveness

**Table 11-2 Power Output with Different no. of Units for Attabad HPP**

| Number of Units | | 4 | 3 | 2 |
|---|---|---|---|---|
| Unit Discharge | $m^3$/sec | 15 | 20 | 30 |
| Rated Turbine capacity | MW | 14 | 19 | 29 |
| Over all Plant Capacity | MW | 53 | 54 | 55 |
| Efficiency at rated discharge | % | 90.0 | 90.0 | 90.0 |
| Turbine Speed | rpm | 429 | 375 | 333.3 |
| Runner outer diameter | m | 1.457 | 1.676 | 1.988 |
| Crane capacity | Ton | 60 | 80 | 100 |

### 11.6.4 Efficient Water Use

Efficient use of available water and getting maximum energy from hydropower station is necessary to maximize the profitability.

Selection of number of units plays a bridge role to achieve this target. On the feasibility stage, two units of same capacity and one with less capacity are considered.

One major factor for evaluation of number of units is how the power station will anticipate in operation. Particularly for AHPP, with 03 units operational reliability and given optimum annual energy. This operational advantage will also contribute in the annual energy produced by the project.



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### 11.6.5 Space Limitation for Civil Structure

Space limitation for geologic characteristic may dictate larger or smaller units. In case of AHPP, turbine capacity is 19 MW. From the Civil structure & Geologic viewpoint, no major hindrance found in power house side.

### 11.6.6 Maintenance View Point

More the number of units higher the operation and maintenance (O&M) cost, lesser the number of units less will be maintenance cost. But for the system stability and avoid the complete shutdown of powerhouse more than one unit is strongly recommended.

### 11.6.7 Transportation

The transportation of heavy construction and permanent equipment (turbine runner, generator rotor, stator, transformers) to the site is a matter which needs careful attention. In Case of AHPP, no transportation limitation is found.

### 11.6.8 Cost effectiveness

Higher the number of units more the E&M and total project cost. In case of 03 units, the difference in energy benefits is very less, however by increasing units from 03 to 04 cost will increase considerably. Thus 03 units are more suitable and cost effective.

### 11.6.9 Recommendation

Considering all above parameters/aspects, three (03) units are the most favorable solution from the technical and economical point of view. A summary of key turbine parameters are shown in Table-11.3 below.

**Table 11-3 Key Turbine Parameters**

| Name | Quantity | Unit |
|---|---|---|
| Number of Turbines | 03 | - |
| Turbine Type | Vertical Shaft Francis | - |
| Design net head | 106 | M |
| Minimum net head | 100 | M |
| Maximum net head | 108 | M |
| Maximum Turbine Efficiency | ≥ 91.5 | % |
| Design Unit Discharge | 20 | $m^3$/sec |
| Design Scheme Discharge | 60 | $m^3$/sec |
| Turbine Rated Output | 19 | MW |
| Rated Speed | 375 | Rpm |
| Runaway Speed | 649 | Rpm |

All proposed turbines are of Vertical shaft Francis type. The turbines will be directly coupled to the generator rotor.

The direction of rotation shall be clock-wise when viewed from drive end. The turbines shall be capable of giving outputs higher than rated outputs to match the overload capability of the



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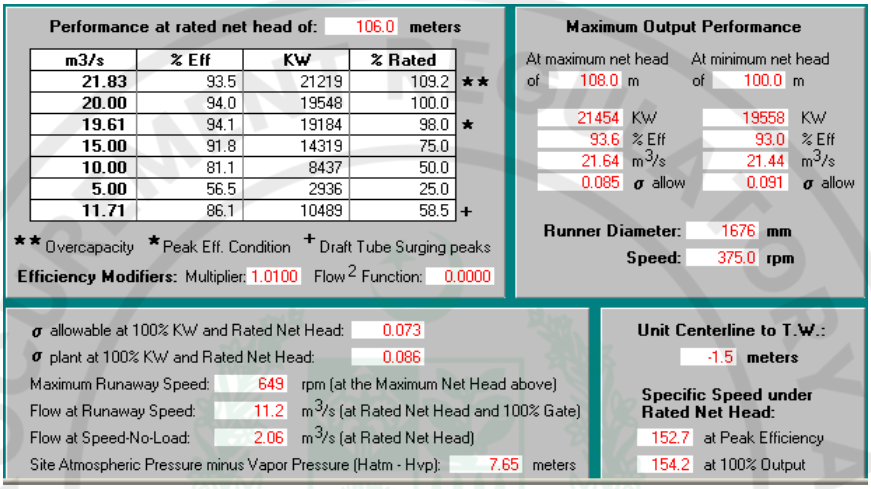
generators. Each turbine shall be designed to give a rated output at rated head at generator terminals with guide vane opening of about 80-85 %. The turbine shall have adequate capacity commensurate with the 10 % continuous overload capacity of the generators.

## 11.7 TURBINE LAYOUT AND SIZING

The layout and sizing of the AHPP turbine units have been carried out using the in house available computation programs, United States Bureau Reclamation (USBR) manual and computer software TURBNPRO. Details of computation and analysis on computer software TURBNPRO is shown below from Figure-11-5 till Figure 11-11 below:



**Performance at rated net head of:** 106.0 meters

| m3/s | % Eff | KW | % Rated | |
|---|---|---|---|---|
| 21.83 | 93.5 | 21219 | 109.2 | ** |
| 20.00 | 94.0 | 19548 | 100.0 | |
| 19.61 | 94.1 | 19184 | 98.0 | * |
| 15.00 | 91.8 | 14319 | 75.0 | |
| 10.00 | 81.1 | 8437 | 50.0 | |
| 5.00 | 56.5 | 2936 | 25.0 | |
| 11.71 | 86.1 | 10489 | 58.5 | + |

** Overcapacity * Peak Eff. Condition + Draft Tube Surging peaks

**Efficiency Modifiers:** Multiplier: 1.0100 Flow$^2$ Function: 0.0000

**Maximum Output Performance**

| At maximum net head of 108.0 m | At minimum net head of 100.0 m |
|---|---|
| 21454 KW | 19558 KW |
| 93.6 % Eff | 93.0 % Eff |
| 21.64 $m^3/s$ | 21.44 $m^3/s$ |
| 0.085 σ allow | 0.091 σ allow |

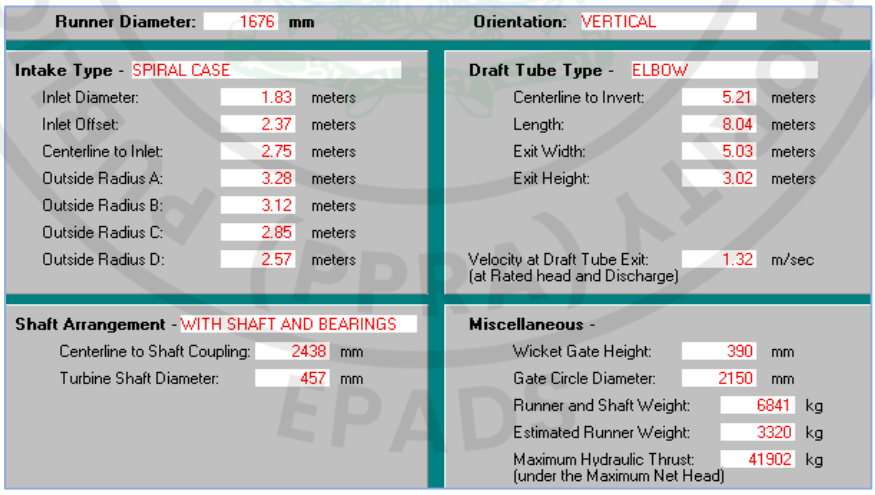
**Runner Diameter:** 1676 mm
**Speed:** 375.0 rpm

σ allowable at 100% KW and Rated Net Head: 0.073
σ plant at 100% KW and Rated Net Head: 0.086
Maximum Runaway Speed: 649 rpm (at the Maximum Net Head above)
Flow at Runaway Speed: 11.2 $m^3/s$ (at Rated Net Head and 100% Gate)
Flow at Speed-No-Load: 2.06 $m^3/s$ (at Rated Net Head)
Site Atmospheric Pressure minus Vapor Pressure (Hatm - Hvp): 7.65 meters

**Unit Centerline to T.W.:** -1.5 meters

**Specific Speed under Rated Net Head:**
152.7 at Peak Efficiency
154.2 at 100% Output

**Figure 11-5 Turbine Output Specifications**



**Runner Diameter:** 1676 mm **Orientation:** VERTICAL

**Intake Type -** SPIRAL CASE

| | | |
|---|---|---|
| Inlet Diameter: | 1.83 | meters |
| Inlet Offset: | 2.37 | meters |
| Centerline to Inlet: | 2.75 | meters |
| Outside Radius A: | 3.28 | meters |
| Outside Radius B: | 3.12 | meters |
| Outside Radius C: | 2.85 | meters |
| Outside Radius D: | 2.57 | meters |

**Draft Tube Type -** ELBOW

| | | |
|---|---|---|
| Centerline to Invert: | 5.21 | meters |
| Length: | 8.04 | meters |
| Exit Width: | 5.03 | meters |
| Exit Height: | 3.02 | meters |

Velocity at Draft Tube Exit: 1.32 m/sec
(at Rated head and Discharge)

**Shaft Arrangement -** WITH SHAFT AND BEARINGS

| | | |
|---|---|---|
| Centerline to Shaft Coupling: | 2438 | mm |
| Turbine Shaft Diameter: | 457 | mm |

**Miscellaneous -**

| | | |
|---|---|---|
| Wicket Gate Height: | 390 | mm |
| Gate Circle Diameter: | 2150 | mm |
| Runner and Shaft Weight: | 6841 | kg |
| Estimated Runner Weight: | 3320 | kg |
| Maximum Hydraulic Thrust: (under the Maximum Net Head) | 41902 | kg |

**Figure 11-6 Intake, Draft tube and Shaft Arrangement**



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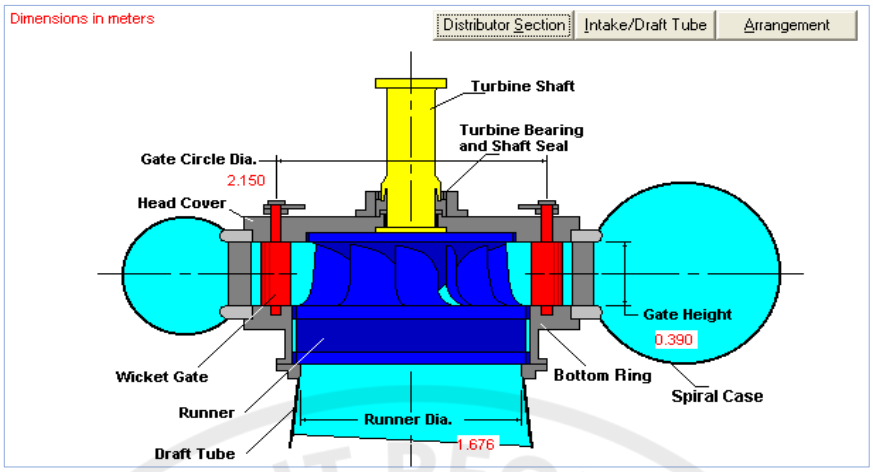


**Figure 11-7 Distributor Section**

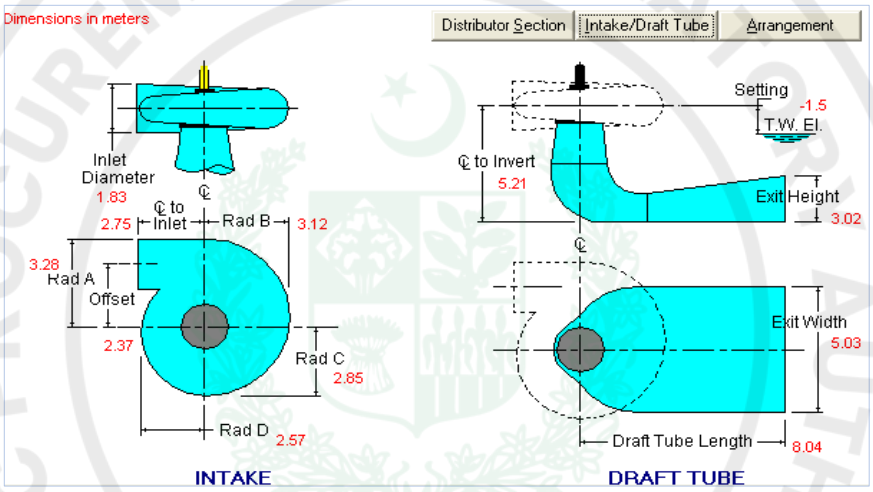


**Figure 11-8 Figure 11-8 Intake and Draft tube Layout**

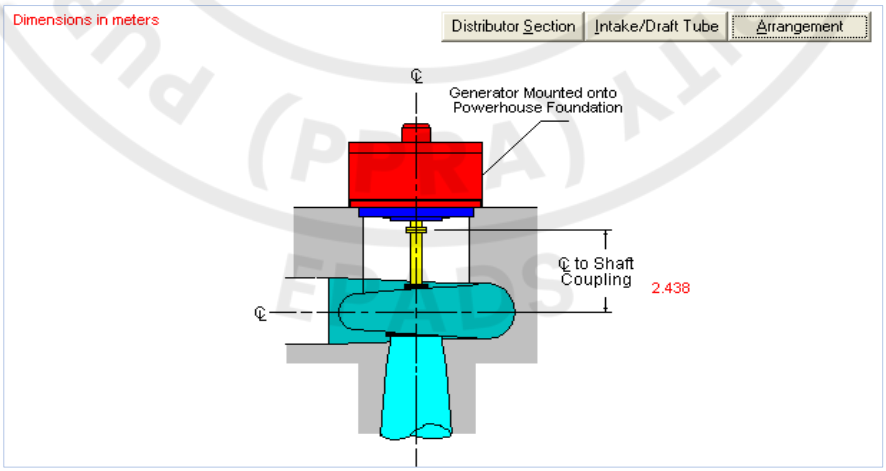


**Figure 11-9 Generator to Shaft Coupling Layout**



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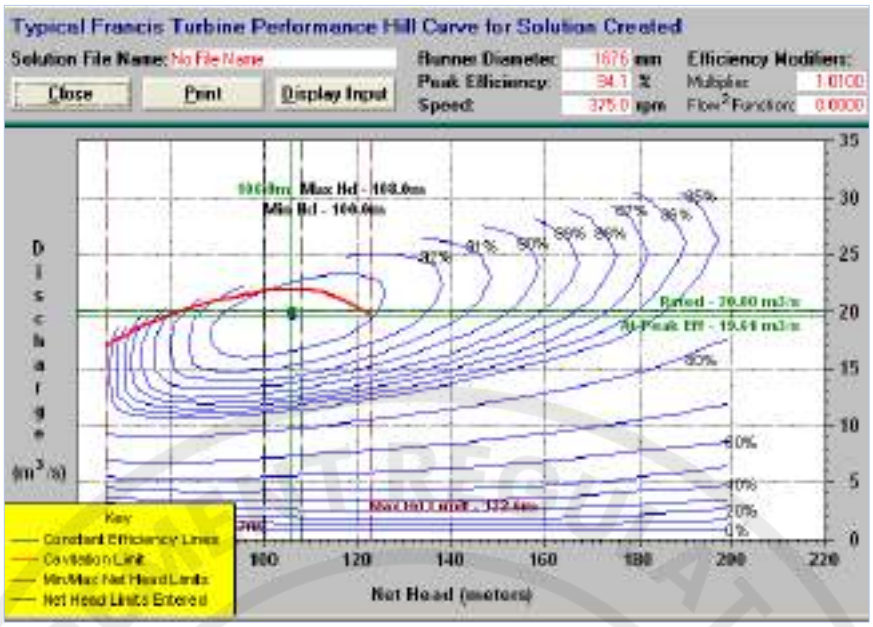


**Figure 11-10 Performance Hill Curve**

## 11.8 MAIN DATA

The turbine rated output is expressed by the following equation:

$$P_t = \rho \times 9.81 \times Q \times H_n \times \eta_t$$

Where,

$P_t$ = Turbine out Power (KW)

Q = Discharge ($m^3$/sec) = 20 $m^3$/sec

$H_n$ = Rated Net Head (m) = 106 m

$\eta_t$ = Efficiency of turbine = 91.50 %

$$\mathbf{P_t = \rho \times 9.81 \times Q \times H_n \times \eta_t}$$

$P_t$ = 1000*9.81*20*106*0.915

$P_t$ = 19 MW

Rated Turbine Output at shaft, P = 19 MW



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### 11.8.1 Turbine Speed

The main data for comparison of some turbine speeds is made as follows:

| Turbine Speed | 300 rpm | 333 rpm | 375 rpm |
|---|---|---|---|
| Runner outlet diameter | 1.828 m | 1.757 m | 1.676 m |
| Runner weight | 9.19 ton | 7.91 ton | 3.32 ton |
| Turbine setting approx. | - 2.0 m | - 2.0 m | - 1.5 m |
| Turbine efficiency | 91.2 % | 91.1% | 91.5% |
| Turbine Generator weight | 28 ton | 23 ton | 10 ton |

Considering the technical and related advantages of high speed units, a turbine of 375 rpm is selected for this project.

Turbine speed = 375 rpm

### 11.8.2 Runner diameter

Runner diameter = 1676 mm

### 11.8.3 Runaway speed

The unit Maximum runaway speed as determine by TURBNPRO comes out to 649 rpm, however an accurate value is guaranteed by the turbine manufactures.

### 11.8.4 Setting

The turbine has to place sufficiently below the tailrace level to ensure that there is an adequate submergence. The proposed minimum setting for all turbines is about -1.5 m.

The turbine setting is determined as follows from the referenced Standards.

$$Z = H_s + b + HL_{tw}$$

$$H_s = (H_b - H_V) - \sigma H_{cr}$$



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Where:

| | | |
|---|---|---|
| Z | = | Total draft head (m) |
| $H_s$ | = | Static draft head (m) |
| b | = | Vertical distance from centerline of distributor to minimum runner diameter |
| $H_b$ | = | Barometric pressure of water at station site (m) |
| $H_{cr}$ | = | Maximum head at which turbine operates with full gate for maximum generator output |
| σ | = | Cavitation coefficient |
| $H_v$ | = | Water Vapour pressure (m) |
| $HL_{tw}$ | = | Tail water tunnel loss (one unit operating) |

The cavitation coefficient σ, is normally quoted by the turbine manufacturer after undertaking a series of cavitation model tests.

### 11.8.5 Components Dimensions

The turbine major components dimension and layout have been workout by software TURBNPRO, moreover this data also compare with the similar installations in term of type and size, which have been built in the past. Components Dimensions are shown in Figure-11.4 till Figure-11.7.

### 11.8.6 Special design criteria

The turbine and its various components shall be designed to operate at a maximum load and to bear the stresses produced corresponding to maximum turbine shaft power output.

### 11.8.7 Overpressure

The maximum pressure in the spiral casing in the most unfavorable condition of head and sudden discharge, with or without wicket gate closing, will not exceed a pressure rise of about 25%.

### 11.8.8 Over-speed

The maximum momentary speed rise will not exceed 45% of the rated speed in the most unfavorable i.e. 544 rpm.

### 11.8.9 Runaway speed

The turbine will withstand the maximum runaway speed in the most unfavorable head and gate condition safely and without any abnormal reaction. Maximum runaway speed is 649 rpm.

### 11.8.10 Critical speed

The first critical speed of the combined turbine generator unit will be at least 25% higher than the maximum runaway speed.



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## 11.9 TURBINE MAJOR COMPONENTS

The main parts of the turbine are described as follows:

- Runner
- Shaft
- Bearings
- Guide Vane Mechanism
- Operating Mechanism
- Throat Ring
- Draft Tube

### 11.9.1 Runner

The runner is the energy conversion element of turbine. Francis runners use stainless steel blades, bands and crowns. Special alloys are also used to minimize erosion. In this project the runner will be a cast or welded construction of 13% chrome, 4% nickel steel. The runner shall be designed and manufactured to operate at any load, head and speed within the limits given, as well as the runaway speed at maximum head with exceeding the allowable stresses and without undue cavitation's and vibration.

All surface of the runner exposed to the flow of water will be carefully machined and finished smooth to the templates.

### 11.9.2 Turbine shaft and Coupling

The turbine shaft shall be forged carbon steel or alloy steel conforming to IS or other equivalent international standards. Wherever the flanges are integral with the shaft, the same should conform to American standard ANSI-49.1.

The turbine shaft shall be connected to the runner on one side and to the flywheel generator shaft on the other side. It shall be of ample size to transmit torque at rated speed without excessive vibration or any distortion. A renewable and removable sleeve of stainless steel shall be provided wherever the shaft passes through a shaft seal or a gland.

### 11.9.3 Bearings

The turbine bearings can be:

- The pad type or sleeve type or Babbitt lined, self-lubrication type.
- Anti-friction ball, roller bearings, oil or grease lubricated.

The turbine shall be provided with adequate number of bearings. The bearings shall be designed to withstand operation at maximum runaway conditions with cooling water supply on for a period of not less than 15 minutes and also for operation at normal speed without cooling



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water supply for 15 minutes. The bearings shall be provided with a dial type or resistance type thermometer and a pressure gauge with provision for alarm annunciation/shut down on excessive bearing temperatures.

### 11.9.4 Spiral casing

The spiral casing shall be fabricated from welded steel plate/mild steel plates and shall have suitable sections for ease of shipment and to be within transport limitation. The spiral case shall be designed to withstand maximum water pressure including water hammer and shall be complete with anchors, supports, sole plates, turn buckles, hold-down rods, all types of clamps, etc.

### 11.9.5 Guide Vanes

The guide vanes shall be made from stainless steel. Sleeves of stainless steel at the bearing and sealing surfaces shall be provided, if required. The guide vane bushes shall be of the self-lubricating type with protective seals or shall be suitable for grease lubrication.

### 11.9.6 Operating Mechanism

The operating mechanism shall have ample strength to withstand the maximum load that can be imposed on it by the most severe operating condition. All working points with relative motion shall be bronze bushed, grease lubricated/ self-lubricated. Means shall be provided for adjusting the position of the individual guide vanes to ensure close contact with adjacent guide vane in the closed position.

Each guide vane shall be individually connected to the regulating ring through suitable levers and links. Shear/ breaking link or some other suitable arrangements shall be provided on each guide vane to protect guide vane and to provide alarm on foreign body getting wedged between guide vanes.

The regulating ring shall be fabricated from welded steel plates. It shall be supported on the outer casing of top/side cover on bronze strips with provision for grease/ self-lubrication.

### 11.9.7 Guide Vane Servomotor

The guide vane shall be operated by two double acting oil operated servomotors of adequate capacity. The servomotors shall be capable of moving guide vanes smoothly during full opening and closing in required time. Standard available hydraulic cylinders of approved make, proven design and of suitable material can also be used as a servomotor.

### 11.9.8 Top Cover/ Side Cover

The top/side cover shall be of cast steel or welded plate construction. Suitable stainless steel labyrinth rings or similar sealing arrangements shall be provided in the covers.

### 11.9.9 Draft Tube

Each turbine shall be provided with a draft tube liner/suction bend of welded construction of structural steel. The draft tube cone shall have machined flange for bolting with the runner chamber. The design of the draft tube shall be such as to ensure the best overall efficiency for the turbine and stable and pulsation-free operations of the machines.



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All components will have state-of-the-art design and conform to the relevant international standards. The turbine construction will enable all maintenance and repair work, which will require standstill of the turbine, within the shortest possible time. All turbine components to be dismantled will be equipped with eyebolts, lugs and / or other devices to facilitate handling, installation and removal. All tools and devices will be delivered, which are specially made and / or require for assembling, dismantling, adjustment and maintenance of the turbine. The scope of spare parts as well as the tests to be performed in the Works and at site will be specified in detail in tender documents.

## 11.10 TURBINE MODEL TESTS

Model tests are conducted to identify early the characteristics and problems of the prototype and to do the necessary modifications. The verification of the guarantees is more accurate at the test rig than at Site. From the manifold inlet to the discharge pit, the model turbine will be of vertical and fully homologous to the prototype. The model turbine chamber will include all baffles, dummy deflectors and operating rods, air vents and all other fixtures in the runner discharge pit, which will be installed in the prototype. The discharge passage will be included, together with means for measuring the runner chamber water levels.

The model acceptance tests will be performed according to IEC 60193. The preliminary model test report will be submitted by the Contractor latest 28 days prior to the start of the model acceptance witness tests. The turbine model tests will at least include the following items:

- Performance tests to determine the performance characteristics of the prototype for various needle openings and at net heads corresponding to the various flow rates.

- Runaway tests to determine the runaway speed under the operating heads.

## 11.11 GOVERNOR SYSTEM

Each turbine shall be equipped with suitable electro-hydraulic or electronic governor conforming to IEC No. 308, governor actuator, pressured oil unit and associated control and safety devices. The governor actuator and the pressured oil unit will be arranged on the Turbine Floor, whilst the cubicle containing the digital governor will be next to the unit control board on the Machine Hall Floor. The governor shall be of proven design capable of controlling speed / output under all operating conditions. The governing system shall comprise oil pressure system, governor actuator (Mechanical), governor electronic regulator, speed signal generator, oil pipe lines and deflector position restoring mechanism. The electronic regulating functions of governor i.e., speed / gate setting, deflector limit setting, start, stop, main circuit breaker position, shutdown etc. shall operate the unit in manual mode in case governor electronic regulator is non-operative. Local control unit have the indicators for deflector position, speed of the unit and power generated by the unit.

The control should be possible:

- Locally at the governor for the control of individual components and for maintenance purposes.

- From the main control board for starting, synchronizing, loading and stopping the unit.



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- From the control room for supervising the function and operating the unit in connection with the main grid and for the local network.

### 11.11.1 Governor Head

Each governor head to be assembled in the main control board of the power station shall be equipped with

- Start and stop switches
- Quick shut down
- Speed setting
- Speed drop setting

All necessary buttons, indicators, instruments and limit switches and the control equipment for the automatic start, synchronizing and stopping sequence should be provided.

### 11.11.2 Electronic Equipment

In recent years the advent of the microprocessor has changed the design of the electronic governors from analogue to digital systems with much more effective man-machine interfaces. The electronic governor control provides functions such as turbine, start / stop, auto-frequency control and automatic load control, and provides interface connections to a main control and instrumentation system. Its monitoring functions include fault detection, alarm annunciation and unit shutdown. The governor also provides facilities for manual control of the turbine.

The electronic equipment is extremely reliable and the digital technology allows continuous self-checking of system operation. As the parameters for each turbine are stored within computer programs, there is no need for printed circuit boards to be pre-calibrated. With a digital system all the data is stored either within memory circuits (EPROMS) or is downloaded from a programming module or central computer. The governor is normally designed to allow circuit modules to be replaced whilst the unit remains connected to the grid. As the mean time between failures is usually a number of years, a large stock of spares is not usually required.

The following functions will be included in the governor:

- Speed control at no load operation.
- Automatic start and stop sequences, including automatic synchronization.
- Power output control; operation at output limitation with power feedback.
- Frequency regulation.
- Load sharing between the units in "joint control" mode.



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- Quick shutdown in case of mechanical failures.

- Emergency shutdown on electrical failures.

### 11.11.3 Hydraulic Systems

The main development in hydraulic systems over recent years has been a steady increase in the operation pressure of the governor hydraulic systems. This change has been driven by two factors: cost and size. As the system pressure is increased the cost of the hydraulic system decreases due to reduction in its size. With increasing system pressure, the size of guide van servo-motors, oil pumps, oil piping and tanks decreases. The overall effect of an increase in system pressure is a reduction in the turbine cost although there is some increase in the governor cost. For very large turbines, the oil storage requirements at low system pressures are very large and this has also encouraged the adoption of higher pressures.

One further advantage of reducing the size of the hydraulic system is that more of the equipment can be assembled and tested within the manufacturer's works. This means that site work can be limited to simply connecting a skid-mounted package containing low and high pressure tanks, oil pumps, control valves, etc., to the turbine servomotors. The reduction of site work shortens the installation time and also increases the reliability as there is less opportunity for contamination of the system.

### 11.11.4 Water Hammer within High Pressure Conduit

Water hammer is a pressure change in a close pipe caused by water deceleration or acceleration for example due to opening / closing of the turbine wicket gate. The worst case for water column deceleration within the power conduit is the emergency shut down of the unit.

For the investigation of the worst case, a check according to the empirical formulae for rigid water column theory by Parmakian, Ray S Quick's water hammer chart and Allievi Chart for determining maximum pressure rise and also United States Bureau of Reclamation (USBR) Table and empirical formulae for determining speed rise due to load rejection must been applied. It shows the order of magnitude of the water hammer for linear closing characteristic of the turbine guide vanes.

## 11.12 TURBINE INSTRUMENTATION, CONTROL AND SAFETY DEVICES

Each turbine shall be provided with a complete set of instruments, gauges, controls and safety devices for unit control board for monitoring the conditions of the unit during normal running and emergencies. The instruments and gauges for the turbines include, inter alia, pressure gauges, level indicators, temperature and flow indicators, position indicator, indicating lamps for status indication etc. The safety devices shall comprise equipment and devices for sensing abnormal operating conditions, for giving visual and audible annunciation and shut down the unit.

## 11.13 INLET VALVE

A Butterfly type shut off valve will be required at the powerhouse end at upstream of each turbine. It will allow the penstock flow to be shut off in case of turbine malfunction, maintenance or an emergency.



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The valve shall be suitable for all operating conditions of transient and maximum water hammer. The valves shall be operated by oil pressure and closed by oil pressure/counterweight, so that it is capable of being closed under all emergencies. All associated equipment such as servomotors, oil pressure units, counterweights, etc., shall be included in the offer. The valve shall close automatically under normal and emergency shut down conditions. The valve will be complete with inlet pipe, outlet pipe, with expansion joint, by-pass arrangement if required for equalization of pressure on either side of the valve, etc.

The main Data for these valves is as follows:

| | |
|---|---|
| Valve type | Butterfly |
| No of valves | 03 |
| Diameter | 1.83 m |
| Sealing system | Cast steel |
| Operating system | Pressure oil |

### 11.13.1 Operating Mechanism

The valve rotor will be driven by an oil servomotor, which will be fixed on the valve body and supplied with pressured oil by its own hydraulic unit. In comparison with servomotor operated by headwater taken from the penstock and closing by weight and opening by pressured oil or water, opening and closing by pressured oil is the most economical solution and the easiest for maintenance. The seal rings will be moved by pressured water taken from the penstock, which will be filtered.

The service valve in the by-pass will be operated by the pressured oil provided by the same hydraulic unit as for the oil servomotor. Opening and closing of the butterfly valve will be possible at the minimum operating level in the reservoir and at the minimum operating oil pressure of the hydraulic unit.

### 11.13.2 Control and Safety Devices

The butterfly valve will be designed for both fully automatic remote control and manual control locally. Normally, the butterfly valve will be controlled by the automation and control system of the power plant. However, it is possible to operate locally each valve step by step.

The operation of the butterfly valve will be so interlocked hydraulically and mechanically that it will be impossible to move the sealing rings to the closed position, unless the valve rotor is in the “closed position”. On the other hand, it will be impossible, too, to turn the valve rotor towards the open position unless the seal rings are unsealed. A manual closing device will be installed on the Turbine Hall floor. For safety reason, the maintenance seal can be mechanically locked at the closed position. Furthermore, it will only be possible to open locally. At the fully open and close position, the valve rotor can be mechanically locked.

All components will have state-of-the-art design and conform to the relevant international standards. The valve construction will enable all maintenance and repair work, which will require standstill of the turbine, within the shortest possible time. All valve components to be



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dismantled will be equipped with eyebolts, lugs and / or other devices to facilitate handling, installation and removal.

All tools and devices will be delivered, which are specially made and / or required for assembling, dismantling, adjustment and maintenance of the valve. The scope of spare parts as well as the tests to be performed at the Works and at Site will be specified in detail in the tender documents.

## 11.14 AUXILIARY SYSTEMS

The auxiliary systems in a power plant have a vital role in the power plant's successful operation. Auxiliary systems shall include the various functions like plumbing works and fixtures, sewerage system, oil handling, drainage, detecting and suppressing fire, compressing air, Heating and ventilation of powerhouse, handling of various parts, workshop facilities etc.

To have a well-functioning, easy to operate, and easy to maintain power plant, all the auxiliary systems have to be carefully considered and conceived. A major design concern for auxiliary installations (such as compressors, strainers, and pumps) is their location, performance and maintenance access. The items requiring maintenance or monitoring shall be installed in easy-to-access areas for convenience

### 11.14.1 General

The sewage, sanitation and potable water system for Attabad powerhouse includes the following systems:

- Plumbing works and fixtures
- Water supply system
- Sewerage system

### 11.14.2 Plumbing Works

The plumbing works will include glazed earthenware water closets, wash hand basins, urinals, overhead showers, kitchen sinks, electric water heaters etc.

### 11.14.3 Water Supply System

The water supply system will include hot and cold water supply piping, pressure filtration unit and water treatment with ultraviolet disinfection tube having a capacity of 25 liters per minute, valves and other fittings.

Two pumps each of capacity 50 l/min at 1 bar to operate one as main and the other as standby, will pump treated water to the potable water storage tank for further distribution.

### 11.14.4 Waste and Sewerage water

Septic tank for lavatory disposal has been foreseen, the settled sludge will be periodically removed by using sludge pump or trolley and the sewage will be drained to downstream, away from the tail race pit through drain pipe. The sewerage and drainage system will include a network of C.I spun pipes, C.I fittings, C.I floor traps man hole frames and covers, gratings,



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glazed earthen ware, soil and waste pipes, etc., to be provided on the various floors of Control Block and a steel sewage septic tank of capacity approximately 6000 liters buried underground outside the powerhouse.

### 11.14.5 Dewatering and drainage system

Depending on the general layout, the station drainage system would be required to handle waters from the powerhouse and from several other equipment and accesses located below the maximum infrequent tail water level. These will include:

- Cooling water of minor mechanical systems, such as: compressors, governing systems and alike.
- Water leaking to the turbine pit through the shaft seals and wicket gate stem seals.
- Water used for cleaning the floors of caverns and galleries.
- Seepage of water to the caverns, galleries accesses and tunnels with the inflow to fulfill geotechnical requirements to be established at the design stage.
- Water from pressure relief perforations and systems to be established at the design stage.
- Any releases from the sprinklers of firefighting water system.

The dewatering and drainage system shall be provided, which shall include all structural components and equipment required for dewatering penstocks/ draft tube for maintenance purpose, and for dewatering all seepage of structures and equipment.

Dewatering of the units will be required during scheduled or unforeseen maintenance of any of the units and incase of leakages from valve on bypass line connecting upstream of inlet valve to draft tube.

A gravity drainage system consists of various equipment drains (like compressors, gland leakage etc.) and floor drain, condensate that drain to a main sump / pit, located at lowest elevation of the Power house. The water in the sump shall be pumped into the tailrace. Pumps shall be sized to meet the required estimated seepage and drain water. Two submersible pumps are recommended. One pump will work as standby. These pumps shall operate alternatively for equal wear and tear.

### 11.14.6 Compressed Air System

A compressed air system will be provided for the service and maintenance purpose. The capacity of the system shall be sufficient to cater to all the generating units. The compressed air system shall be of the automatic start-stop design operating under pressure switches control sensing the pressure in the receiver. The compressors will be electrically driven.

The whole system of compressed air supply shall comprise 03 systems, as follows:

- Compressed air for workshop equipment.



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- Compressed air for governors pressure oil tanks.
- Service air (for generator brakes and operation of equipment etc.)

Each air system shall be supplied complete with all piping, valves, fittings and accessories for all required connections.

#### 11.14.6.1 Design Criteria and Operation Conditions

Operation pressure will be about 0.8 MPa. Two (2) identical air-cooled compressors of screw type and two (2) identical air accumulators will be provided, one for service, and other as stand-by. They will be placed on the turbine floor.

- The compressed air system will have following main components:
- Two (2) identical air-cooled compressors of screw type, each with a delivery capacity of not less than 80 $m^3$/h of atmospheric air.
- Two (2) identical air accumulators, each with a capacity of 1.0 $m^3$.
- Distribution piping throughout the powerhouse with connecting taps, to the air receivers for the mechanical brake of the generators and to other services.
- Monitoring, control and safety devices.

All components will have state-of-the-art design and conform to the relevant international standards. The scope of spare parts as well as the tests to be performed in the Works and at Site will be specified in detail in tender documents.

### 11.14.7 Oil Handling System

Two oil handling systems will be provided at the power plant, which are:

- Turbine oil handling system.
- Transformer oil handling system.

### 11.14.8 Turbine Oil Handling System

For ease of handling and filtration of turbine and governor oil inside the powerhouse, the equipment is laid out on turbine floor, with oil storage tanks and the filtration plant located under the erection bay.

The oil handling system will have the following main components:

- One (1) oil filtration plant (Stationary type)
- One (1) oil filtration plant (Mobile type)
- One (1) clean oil transfer pump (Mobile type)
- One (1) dirty oil transfer pump (Mobile type)



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- Two (2) clean oil storage tanks
- Two (2) dirty oil storage tanks
- Supply and return pipe work
- Control and safety device
- Oil testing device

The oil storage tanks will be sized to accommodate the oil of governor and all bearing of one unit. The oil treatment plant will be designed for carrying out degassing, dewatering, filtering and drying of the lubricating oil and pressure oil of the governor to prolong the life of plant. The capacity of the oil treatment plant will be 3 $m^3$/hr maximum. Mobile oil treatment plants will be provided with suitable rubber hose pipes and power cables. Each mobile unit will have a capacity to purify about 0.2 $m^3$/hr oil.

The steel pipe work will be designed for a working pressure, with supply and return headers connecting the filtration plants, oil storage tanks and the oil reservoirs of the unit.

### 11.14.9 Transformer Oil Handling System

The transformer oil handling system will have following main components:

- Two (2) oil purification and treatment plants (Mobile type).
- Two (2) oil transfer pumps (Mobile type).
- One (1) set of oil drums in enough quantities to drain one transformer completely.
- One pick-up to transport the oil drums and other equipment from and to the storage area and the powerhouse.
- One (1) fork lifter two (2) ton capacity.
- Controls and safety devices.
- Oil testing devices.
- Two (2) sets of rubber hose pipes about 15 m long, with connectors at both ends for connecting the purification plant / transformer pump with the transformer.
- The capacities of oil purification plants and transformer pumps will be approximately the same as those for the turbine oil handling system.

### 11.14.10 Heating, Ventilation and Air Conditioning System

Necessary arrangement for Ventilation, cooling and heating will be provided, according to powerhouse area requirements.



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HVAC system will be designed in view of the following objective:

- To maintain indoor temperature at a pre-determined value by extracting heat from the indoor environment. The plant will have a capacity in terms of heat extraction rate equal to maximum anticipated heat input to indoor environment from electrical-mechanical equipment, lighting, people and conduction from fresh air.

- To maintain indoor relative humidity at a pre-determined value for areas such as control room, computer room, administration areas, electrical equipment rooms etc. by condensation of moisture in air stream.

- To provide clean air to conditioned apace by filtration of re-circulated and outside (fresh) air.

- To pressurize the building up-to 0.3 mbar to prevent infiltration of uncontrolled outside air.

- To provide winter heating in areas such as control room, administration areas, computer room etc. by adding heat to indoor environment. Relative humidity will simultaneously be controlled by adding moisture whenever required.

- To recover equipment heat dissipation in winter and to use it for space heating where possible.

The proposed air conditioning system for this project calls for providing year round air conditioning and ventilation to provide comfortable and required ambient conditions for people and sensitive equipment in the specified areas.

The design criteria are, to maintain indoor temperatures at 22 ~ 24$^{o}$C. In order to maintain that temperature in offices and control room, an independent air conditioning system shall be provided. Layout, dimensioning and arrangement of air-conditioning equipment will be defined during preparation of construction drawings of powerhouse building

### 11.14.11 Fire Protection System

The fire protection system is an important auxiliary system for any powerhouse. This system mainly consists of the equipment required for detecting and extinguishing fire in the powerhouse. The fire protection systems will be provided to extinguish fire of the following equipment and areas:

- Generators

- Transformers

- Oil storage rooms

- Computer and control rooms

- Remote computer control terminal units

- Office and miscellaneous-spaces, electrical and control equipment galleries



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- Auxiliary and powerhouse equipment and maintenance workshops
- Diesel generator rooms located at head works.

There will be three common systems for fire protection:

- Water Spraying System
- CO2 Fire Protection System
- Potable Fire Fighting cylinders

In this system a group of Carbon dioxide ($CO_2$) filled cylinders are arranged in series at any suitable location and connected by a common piping system for spray through nozzles set in each generator. The system shall operate automatically with heat detecting elements. It is also possible to operate this system manually in case of failure of automatic system.

Moreover, Carbon dioxide ($CO_2$) filled fire extinguisher will also be placed at different floors to extinguish electrical fires. Oil storage rooms shall also be provided with $CO_2$ filled cylinders with auto release system initiated by smoke and fire detectors installed in the room.

Fire hydrants at different locations in control building, service area and administrative areas are to be provided. Mobile fire extinguishers shall be placed at most wanted locations in powerhouses. In addition, the power station will be provided with several taps for fire hoses. The water for the firefighting system shall be taken directly from upstream side.

Transformer fire is most common in hydro plants, thus special care and arrangement is required to overcome. Water deluge system seems to be the most successful, safest and from most aspects preferred method for fighting transformer fire. The water will be used from service water supply tank having desired water pressure with back up of fire / booster pump.

### 11.14.12 Standards and Regulations

All fire protection installations shall be designed, in accordance with the international NFPA-Codes and Standards, mainly NFPA 851, Recommended Practice for Fire Protection for Hydroelectric Generating Plants, (Latest Edition).

The design of fire protection installations shall also be in accordance with local regulations and requirements from the authority having jurisdiction.

### 11.14.13 Particular Requirements

### 11.14.14 Survey of systems

The firefighting systems to be provided are indicated in the following table as a minimum. Number and location of the various installations and systems shall be determined by the Contractor as per applicable code during detail design, subject to the Employer's / Engineer's approval. The Contractor shall, however, add and include any areas / items not listed in the table in order to cover fire protection for the entire plant.



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## Table 11-4 Survey of Fire Protection System to be Installed

| Sr. No. | Building /Area / Equipment to be Protected | Fire Fighting Systems | Fire Detection Systems |
|---|---|---|---|
| 1. | **Power House Building** | | |
| 1.1 | Machine Hall | Portable Dry powder fire extinguishers & one mobile 30Kg clean agent extinguisher | Manual fire alarm stations |
| 1.2 | Generator | Automatic & electrically interlocked CO2 gas fire suppression systems | Smoke / Heat detectors, generator differential relay. |
| 1.3 | Turbine Floor | Portable Dry powder fire extinguishers | Manual fire alarm stations, Smoke detectors |
| 1.4 | Inlet valve Floor | Portable Dry powder fire extinguishers | Smoke detectors, Manual fire alarm stations |
| 1.5 | Unloading Bay Floor | Hydrant Hose stations, Dry powder Fire extinguishers | Manual fire alarm stations |
| 1.6 | Oil Handling & compressor Plant Room, Water treatment room, HVAC room, Mechanical store | Hydrant Hose stations, Portable dry powder Fire extinguishers | Smoke detectors, Manual fire alarm stations |
| 1.7 | Elevator Hoist Machine Room | Portable dry powder extinguishers | Smoke detectors, Manual fire alarm system |
| 1.8 | Maintenance Engineers, Conference room, Operational Manager room, document room and Prayer room | Portable clean agent fire suppression system | Smoke detectors, Manual fire alarm stations |
| 1.9 | Cable Tunnel | Automatic water spray system | Smoke / heat detectors |
| 1.10 | Control room, relay room, SCADA and telecommunication room | Portable clean agent fire suppression system | Smoke detectors, Manual fire alarm stations |
| 1.11 | Workshop, Battery Room & Switchgear room | Portable dry powder fire extinguisher. | Heat / Smoke detectors Manual fire alarm stations |
| 1.12 | Corridors and Lobbies | Portable dry powder fire extinguishers | Smoke detectors, Manual fire alarm system |
| **2** | **GIS Building** | | |
| 2.1 | Switch yard | Portable fire extinguishers | Smoke detectors, Manual fire alarm system |
| 2.2 | Cable Spreading Room | Automatic water spray system | Smoke / Heat detectors |
| **3** | **Diesel Generator Room** | Portable dry powder fire extinguishers | Smoke / Heat detectors, Manual fire alarm system |
| **4** | **Penstock Valve House** | -do- | -do- |
| **5** | **Power Intake Control Room** | -do- | -do- |
| **6** | **Transformer Bays** | | |
| 6.1 | Automatic water spray system and one mobile 30Kg portable dry powder extinguisher | Smoke / Heat detectors, Manual fire alarm system | Automatic water spray system and one mobile 30Kg portable dry powder extinguisher |
| **7** | **Water Storage tank Pump House** | Portable dry powder fire extinguishers | Smoke / Heat detectors manual fire alarm system |



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### 11.14.15 Structure Fire Protection

**Fire Areas**

In order to avoid an uncontrolled fire, spread inside a building or a tunnel, which would result in a considerable or total loss of the building and equipment, and to provide safe escape routes for the personnel, the building / tunnel shall be subdivided into various fire areas, separated by approved fire resistant barriers and elements.

Fire walls, ceilings and partitions shall have a fire resistance rate of not less than 2 hours.

All penetrations for electrical cables or pipes in fire resistant walls or ceilings shall be sealed with approved seals.

**Firefighting Pump**

One electric motor driven fire pump and one electric motor driven stand-by fire pump, located in a pump house adjacent to the water storage tank, shall draw fire fighting water from the tank and supply it through the fire service main to the hose stations and water spray fixed systems. One electric motor driven jockey pump with a capacity of approx. 3 l/s shall also be provided to keep the line pressure of 5 bars.

The fire pump shall have a capacity of approx. 40 l/s at a delivery head of approx. 6 bars. The final capacity of the firefighting pump shall be verified during detail design.

The firefighting pump unit shall be connected to the safe station power supply.

The pump shall start automatically upon water flow and / or pressure drop in the fire service main.

A fire service main system shall be provided, to serve outdoor hydrants, indoor hose stations and water spray fixed systems with firefighting water.

Next to each outdoor hydrant, a weather resistant, properly ventilated and red painted fire hose cabinet shall be provided, containing four (4) fire hoses DN 65 (21/2") with couplings and two (2) jet / spray branch pipes.

Each indoor hose station shall be housed in a wall mounted or self-standing cabinet, which shall contain a valve with reducer, instantaneous couplings, swiveling hose reel and one 30 m long non collapsible fire hose with readily attached branch pipe.

**Water Spray Fixed Systems**

The water spray fixed systems shall be designed, installed and tested in accordance with NFPA15.

Complete systems will be provided with all components required for automatic operation, normally released via the fire detection and fire alarm system. Manual release will also be possible.



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The automatic operation for opening the deluge valves for the spray systems shall be initiated either by the detection of 2 heat or smoke detectors of 2 different detection lines (2 out of 2) or the transformer buchholz relay.

The deluge valve stations will be located adjacent to but not inside the same fire area they shall protect.

The following specifications shall be observed for the firefighting system of the transformers.

- The water shall be sprayed at a rate of not less than 10 l/min m2 of the projected area of rectangular prism envelope of the transformer.

- A pipe cage made of galvanized steel pipe with all necessary spray nozzles shall be installed around each transformer.

**Total Flooding Carbon Dioxide Fire Extinguishing Systems**

The total flooding carbon dioxide extinguishing systems shall be designed in accordance with NFPA 12, standard on carbon Dioxide extinguishing systems (latest edition) and will be adopted for the fire protection of Attabad HPP generators.

Complete system shall be designed, for automatic operations normally activated by the fire detection and alarm system.

In this system the CO2 gas is stored in cylinders. It is delivered to distribution nozzle through a system piping network in the fire protection area. Critical to the functioning of system is the fire detection and control network. Smoke detectors sense the presence of fire in the protected facility. The detection and control panel then sounds and alarm, shuts down air handlers, disconnect power from the protected equipment and then release agent into the protected area.

**Fire Extinguishers**

The selection, installation and testing of portable fire extinguisher shall be in accordance with NFPA-10 for initial firefighting. Portable fire extinguishers with capacities of 6 kg chemical dry powder, for rooms containing electrical equipment with capacities of 5 kg clean agent, shall be provided and placed in the rooms and buildings at strategic locations and next to exits.

In addition to the portable extinguishers, two mobile 30 kg clean agent, and two mobile 50 kg dry powder extinguishers, mounted on wheeled hand carts and furnished with 6 m hoses, shall be provided and located in the machine hall of the powerhouse and GIS floor and diesel generator room.

Other equipment like fire blankets, first aid boxes and rescue tools will be provided as required.

### 11.14.16 Powerhouse Crane

The powerhouse crane will be a bridge crane with a main hoist, which can serve any requirements for lifting and moving of heavy components during installation, maintenance work and operation, the generator rotors being the heaviest components. AHPP is equipped with 03 Vertical Francis turbines.



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The main crane hook shall be capable of lifting the tallest component of the transport vehicle and both the main and auxiliary hooks should be capable of reaching as far down as required to serve the inlet valve floor.

The hoist is mounted on a trolley of compact design enabling minimum operational hook distance from the walls and maximum lifting height. The main hoist is equipped with one hook, cable and drum, with possibility of changing the corresponding values of lifting capacity and hoisting speed with push- button from the crane driver's cabin.

Provision shall be made on the powerhouse roof above the erection bays for easy replacement of the trolleys.

**Design Criteria and Operation Conditions**

The overhead bridge crane will be designed according to the well reputed international standards likes EN, DIN, FEM, etc.

The overhead bridge crane will have a main hook and an auxiliary hook with a preliminary capacity of 80 t and 20 t, respectively. The main hook will be used for lifting heavy pieces like generator rotor and butterfly valve, whilst the auxiliary hook will be utilized for erection and maintenance work of small parts like rotor poles, servomotors, heat exchangers, etc.

Usually, the heaviest and the tallest piece to be handled by the main hoist is the generator rotor with shaft, and its weight and height will be finally fixed by the generator supplier. Thus, the capacity of the main hook and height between the powerhouse crane and the erection bay floor shall be optimized during the implementation stage.

The powerhouse crane will have the following main parameters:

| | | | |
|---|---|---|---|
| Rated lifting capacity | main hook | 80 | t |
| | auxiliary hook | 20 | t |
| | Span | 17.5 | m |
| | Hook height | 8.8 | m |
| Lifting height (total) | main hook | 17.5 | m |
| | auxiliary hook | 22 | m |
| Bridge traveling speed | normal | 20 | m/min |
| | creeping | 0.6 | m/min |
| Trolley traveling speed | normal | 15 | m/min |
| | creeping | 0.6 | m/min |
| Main hook lifting speed | normal | 1.2 | m/min |
| | creeping | 0.1 | m/min |
| Auxiliary hook lifting speed | normal | 40 | m/min |
| | creeping | 0.5 | m/min |

The crane will be controlled from an operator's cabin, provided at the upstream end of the bridge.



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### 11.14.17 Mobile crane

In addition to powerhouse bridge crane, suitable capacity mobile crane is also provided for:

- Erection of the transformer
- Erection of the machine hall crane
- Loading and unloading the equipment

### 11.14.18 Power House Elevator

**General**

One elevator has been foreseen at power plant to be used for transportation of goods from service bay to the equipment gallery and for transporting the passengers from the control room to the inlet valve gallery with electrical equipment in the erection bay and with guide rails for cabins and counterweights complete with all anchorages, bumpers, etc., and all accessories necessary for the elevator to be complete.

**Main Data for Powerhouse Elevator**

| | |
|---|---|
| **Number of elevators** | One (1) |
| **Capacity** | 13 persons / 1000 kg |
| **Lifting and lowering speed approx.** | 1.6 m/s |

For the design aspects of the elevator, reference shall be made to EN 81, A.N.S.I A17, BS 5655 or other equivalent standards.

The design of the elevator shall meet the following requirements:

- Driven by electric hoisting machine including cable and counter weight.
- Power supply 3 phases 400 v, 50 Hz.
- Shaft doors of the automatic sliding type for access to the elevator.
- Electronic door detectors as safety device for cabin doors.
- Smooth acceleration of cabin.
- Accurate floor landing / leveling without jerking and jumping.
- Continuous operation and high start / stop frequency without overheating of hoisting machine.

The elevator shall be provided with control and safety devices, preventing operation:

- Under overload conditions.
- With open shaft doors.



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The cabin control and panel shall be equipped with:

- Push button plates.
- Floor indicator and moving direction indicator.
- Safety push button for emergency stop and acoustic alarm in the central control room.
- Key locked switch for manual control of cabin position.

The panels at the shaft doors shall be provided with:

- Push button plates.
- Direction indicator.
- Gong signal indicating arrival of cabin.

### 11.14.19 Workshop Equipment and Tools

The complete maintenance workshops will be provided inside the powerhouse for preventive maintenance and repair of powerhouse equipment. The maintenance workshop will consist of followings:

- Electric shop
- Machine shop
- Portable equipment

Workshop equipment and tools should be sufficient to perform the day to day maintenance requirements such as:

Necessary tools for components repair or renewal which do not need specialized skill or experience like welding machine, portable drill machine, small lathe, electric grinder etc.

All special tools, slings, lifting devices, jacks, turn buckles, foundation plates/ bolts, etc. required for erection of the equipment shall be listed and supplied. First filling of oil and grease (if applicable) with 10% extra quantity (included in the overall scope) shall be supplied along with equipment. Welding electrodes as required for site welding and paint for finishing coat shall be supplied by the contractor.

A tentative list of the workshop machinery is as under:

- Gap bed heavy duty lathe
- Gap bed medium duty lathe
- High precision bench lathe
- Shaping machine



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- Radial drilling machine
- Drill stand
- Pedestal grinder
- Bench mounted grinder
- Hydraulic press
- Black smith forge
- Machine hacksaw
- Portable electric welding machine
- Pipe bending machine
- Anvil
- Sheet metal sheer
- Dry acetylene welding equipment
- Quenching tank
- Tool cabinets
- Tool room racks
- Lockers
- Metal working benches
- Electrical working benches
- Hand tools
- Air operated tools
- Platform trucks
- Wood saw machine

## 11.15 HYDRAULIC STEEL STRUCTURE

### 11.15.1 General

This section introduces the function and / or performance criteria and the derivation of the key dimensions of main components of the hydraulic steel structures which will be installed in the various civil structures of the Attabad Hydropower Project, namely:



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- The power intake gates
- The power intake trashracks and cleaning machines
- The power intake stoplogs
- The auxiliary hoisting equipment
- The pressure shaft
- The surge shaft and
- The draft tube gate equipment

### 11.15.2 Power Intake Gate Equipment

Intakes for power generation serve to provide hydraulically efficient water inlets to the water passages leading to the powerhouse. The passages may consist of conduits embedded in dams, excavated as tunnels, constructed as free-standing penstocks, or as short concrete passages between intakes constructed integrally with the powerhouses.

Power intakes must control the flow into the headrace tunnel during filling of the waterway and isolate the reservoir from the waterway for inspection and maintenance of the waterway and automatically close into and up to maximum flow to protect the waterway and power station in the event of a major breach in the waterway downstream of the power intake.

#### 11.15.2.1 Selection of Gates:

The type of gate to be adopted depends mainly on the size of the opening, the head on the gate, and the operating conditions (corresponding to the following circumstances).

1. If the gate must open and close under full operating head conditions with flow through the intake.

2. If the gate is only required to operate as a guard gate under no flow balanced head conditions.

Generally, a fixed wheel gate or slide gate is used. However, a high pressure gate, caterpillar gate, or a high pressure radial gate is used when the water head is high. A general comparison of slide gate and fixed wheel gate is provided below:

#### 11.15.2.2 Slide Gate

The slide gate is the simplest type of flat gate. It consists basically on a gate leaf that slides alongside guides embedded or fastened to the concrete. The leaf

is provided with sliding surfaces, usually metallic, which under tight contact at the bearing surfaces act as seals. Since it requires little maintenance, the slide gate is largely used as a control device in irrigation canals, sewage works, bottom outlets and small intakes and reservoir spillways.

Other distinguished characteristics of the slide gates are the uniform transmission of the hydrostatic load to the concrete and the absence of vibrations in partial openings due to the



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large friction forces developed between the sliding surfaces. This feature is highly desired for bottom outlet gates. On the other hand, the slide gate is not recommended for installations requiring closure by gravity, due to the large friction forces created which is a major drawback for an intake gate.

#### 11.15.2.3 Fixed Wheel Gates

High-head fixed-wheel gates are installed in recesses built in intake structures or in the face of concrete dams, at the upstream ends of outlets or penstocks. Since the primary use of these gates is to provide emergency shutoff of water to protect the penstock and downstream equipment, the preferable location of such gates is near the entrance. Therefore, fixed wheel gates is a suitable option for intake gates of Attabad HPP.

#### 11.15.2.4 Functional Requirements & General Arrangement

Two power intake conduits are proposed for tunnel. Immediately upstream of each intake gate is provision for a stop log. It will be lowered when inspection or maintenance of the intake gate is required. The stop log will be raised and lowered by a rail mounted gantry crane.

A trash rack will cover the entrance to each power intake. The bars of the trash racks will be spaced so as to block floating debris large enough to damage the turbines. This way floating debris is prevented from entering the waterway.

A trash rack cleaning machine mounted on rails on the intake structure deck will remove trash and debris collected by the trash racks.

The equipment at power intake will be designed to meet the following functional requirements:

- Two hydraulically operated fixed wheel gates will be installed, one on upstream of each intake tunnel.
- These will be capable to close under full flow in the tunnels in an emergency, if the penstocks fail or turbines over speed.
- These gates will be designed to self-lower under gravity and hydrodynamic forces (down pull). These gates will be used for emergency protection of turbines and penstocks (and will overtake the role of turbine shut-off valve).
- The gates hoisting system will be operable from local control panels as well as from power intake control room.
- Trash racks will be installed at power intake structure to prevent entry of large size trash into the tunnels and clog the turbines.
- A gantry crane operating on a runway spanning the entire structure will be provided for maintenance of the intake gates.

#### 11.15.2.5 Fixed Wheel Intake Gate

Typically, a fixed wheel type gate is used, and it generally consists of the following assemblies:



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- The gate leaf assembly, which includes the skin plate, supporting beams and girders, bracings and rubber seals.
- The wheel assembly includes the main and side rollers, lubrication provisions, and mounting brackets.
- The embedded seal path assemblies include the side seal, bottom sill, and anchors.
- The hoist tower and bridge assembly for supporting the gate hoist system.
- Hydraulic Hoist and wire rope hoist system.

#### 11.15.2.6 Gate Leaf

The fixed-wheel gate is certainly the most common type of gate and basically consists of leaf, wheels, shaft and seals. In general, leaf is formed by a flat skin plate and stiffened by horizontal girders and ribs. On each side of the leaf, the ends of the horizontal girders are welded to a vertical girder. Wheels are mounted on shafts fixed laterally to the leaf on the vertical girders and have the double function of reducing the friction forces and the transmission of the water load to the embedded parts. Submerged fixed-wheel gates have seals on all four sides. Seals on dam face gates frequently surround the opening like a picture frame.

Upstream sealing gates have been chosen as they minimize down-pull during closure into flow and provide easy access for inspection of the downstream side of the gate when the gate is closed. The fixed wheel gate will be of welded steel construction with upstream skin plate reinforced by horizontal and vertical members/beams. If necessary, the skin plate assembly will be divided into sections for ease of transportation and handling at the site. These sections will be field assembled by bolting and seal welding.

The gate will be provided with downstream J-type double stem side and top rubber seals with fluorocarbon cladding. A flat bar type rubber seal will be mounted at the bottom of the skin plate on downstream side. Wheels will be with corrosion resisting steel rim mounted. Wheels will rotate on stainless steel spherical bearings (or self-lubricated bearings).

In the steel lined gate section, the guiding parts and sealing facilities of the gates will be integrated. Above the discharge openings, provisions will be made for continuing the guiding parts and sealing facilities in steel lined slots. The steel lined slots will extend up to the equipment room level. The slots will be closed with pressure cover plates or so-called bonnets.

Each gate will be operated by one oil-hydraulic servomotor. The servomotors will be mounted on the bonnets. For each set of maintenance and service gates a common oil pressure unit has been considered. In order to promote safety, the oil pressure units will be interconnected to each other. With this is arrangement it is possible to serve all gates by one oil pressure unit. The design and performance criteria of intake gate is summarized here below:

**Table 11-5 Design and Performance Criteria of Intake Gates**

| | |
|---|---|
| Type of gate | Fixed wheel gate |
| No. of gate openings | 2 |



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| | |
|---|---|
| No. of intake gates at the Power Intake | 2 |
| No. of embedded parts at the Power Intake | 2 |
| Gate operation | Hydraulic cylinder |
| Operating Speed | 0.3 – 0.5 m/min |

#### 11.15.2.7 Gate Hoist

Each gate hoist will include a hydraulic cylinder, pipes, hoist support, servomotor, hydraulic power unit, piping, gate position indicator, electric control panel for command and signaling.

Each Fixed Wheel Gate will be provided with one hydraulic hoist. The hoist will be designed to have enough lifting force to lift the gate under any foreseeable operating conditions. Hydraulic oil for raising the gate will be supplied by motor driven oil pumps. Two oil pumps per gate will be provided to ensure reliability. Each oil pump will be rated to supply oil at the required pressure and rate to lift the gate at the maximum lifting speed selected for the gate. Lowering of the gate will be accomplished by gravity i.e. by weight of the gate itself. However, the hydraulic hoist would be able to push the gate down in case the closure resisting forces increase. Provision will be made for normal operation of the gate at all reservoir levels. The design and performance criteria of the Gate Hoist is summarized here below:

**Table 11-6 Design and Performance Criteria of Gate Hoist**

| | |
|---|---|
| Type of hoist | Hydraulic |
| Power equipment for gate operation | 415 V from Power Station |
| No. of hydraulic hoist cylinders per gate | 1 |
| Gate handling for repair and maintenance | By gantry crane or mobile crane |

#### 11.15.2.8 Gate Hoist Control System

A hoist control module will be provided with each gate, which will control the operation of the hoist. It will include hydraulic and electrical controls. A local control panel will be provided near each gate and a common remote control panel for all power intake fixed wheel gates will be installed in the local control room. The remote control panel will include one selector switch for each gate. The selector switch will provide two operating modes i.e. normal and maintenance.

Provision will also be made for emergency closure of the intake gate from the powerhouse central control room for the protection of turbine against sustained speed if the governor over malfunctions.

#### 11.15.2.9 Embedded Parts

Embedded parts for the guard gate will include anchorages for hoist cylinder, side and top seal bearing plates and guide bars, rails and sill beams. The side and top sealing surfaces will consist of corrosion resisting steel plates embedded in concrete. The bottom sealing surface will also be corrosion resisting steel plate attached to a structural steel sill beam embedded in



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the concrete floor. The embedded parts will be installed in block outs and adjusted by means of erection studs attached to the welding pads embedded in first stage concrete.

### 11.15.2.10 Stop Logs

Two stop logs for the two intake gates will be provided. Stop log slots, guides and other embedded metal work will be installed in the piers upstream of each intake gate to guide and finally seal the stop log when it is in the closed position. Exposed parts of the embedded metal work will be cladded with corrosion resistant steel cover plate.

The stop log will be of welded construction with a downstream skin plate reinforced by vertical and horizontal girders. It will have wedge type bottom seals and 'J' type side seals. Guide shoes will be provided at the top and bottom of each side of the stop log to engage the guides embedded in the concrete. The stop log will be designed to be handled by a lifting beam and gantry crane. A filling valve activated by the lifting beam will facilitate balanced head conditions across the stop log before rising. The design and performance criteria of the stop logs is summarized here below:

**Table 11-7 Design and Performance Criteria for Stop Logs**

| | |
|---|---|
| Type | Vertical lift |
| No. of Stop log | 2 |
| No. of stop log embedded parts | 2 set |
| Handling | By lifting beam and gantry crane or mobile crane |

### 11.15.2.11 Gantry Crane

One gantry crane will be provided at the power intake. The crane will be an electrically operated outdoor type, with an operator's cab located on the upstream side and raised above the deck for ensuring good visibility of all crane operations. The gantry crane will operate on rails extending over the full length of the intake deck. The crane will be required to handle the service gates and for reparation and maintenance activities within the intake shafts.

A lifting beam equipped with two automatic grappling hooks for setting and removing the stop log will be provided. After the hooks have engaged the stop log, the lifting beam will activate the filling valve, allowing water to flow through the stop log, filling the cavity between the stop log and the closed intake gate so that the stop log can be raised by the gantry crane under balanced pressure condition. The design and performance criteria of the Gantry Crane are summarized in the following table:

**Table 11-8 Gantry Crane and Lifting Beam**

| | |
|---|---|
| Type | Electrically operated |
| No. of gantry cranes | 1 |
| Hoist capacity | 25 ton |
| No. of lifting beam | 1 |



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### 11.15.3 Trashracks

Trash racks and safety grates are a critical element of outlet structure design and serve several important functions. When properly designed, installed, and maintained trash racks.

Keep debris away from the entrance to the outlet works where the debris will not clog the critical portions of the structure;

Capture debris in such a way that relatively easy removal is possible;

Trash racks can serve these purposes without interfering significantly with the hydraulic capacity of the outlet (or inlet in the case of conveyance structures) (ASCE, 1985; Allred-Coonrod, 1991).

The trashracks will prevent the ingress of debris and floating matter into the power conduit, which could block or damage the generating units.

The trashracks will be of the non-withdrawal type, consisting of fixed trashrack panels supported by streamlined cross beams. The trashrack panels and the corresponding supporting structures will be designed to withstand the design pressure with a safety factor of 1.5.

For condition monitoring of the trashracks, the differential pressure across the panels will be measured. An alarm will be triggered when the trashracks are unduly clogged, requiring action by the trashrack cleaning machines.

### 11.15.4 Trashrack Cleaning Machines

One trashrack cleaning machine (TRCM) of the cable operated type have been foreseen for installation on the deck level 2424.00 m.a.s.l. of the power intakes.

TRCM will consist basically of a steel gantry structure including the rake carriage, the bucket and the revolving apron as well as the associated hoist and control mechanisms. In addition, an articulated hydraulically operated arm with grapping hook will be provided.

The TRCM will be suitable for all purpose cleaning of the trashracks while operating under flows of 100 $m^3/s$ maximum. Moreover, the TRCM will be equipped for removing floating debris in the vicinity of the trashracks, i.e. the TRCM will be able of removing floating debris at water levels as low as the MOL = 2412 m.a.s.l. The debris will be collected either with the bucket or with the grappling hook.

The TRCM will operate in manual and semi-automatic modes, controlled from the inside of the operator's cabin.

TRCM will include also a crane hook of adequate capacity for handling the intake stoplogs at the power intakes. The design and performance criteria of Trashracks and Trashracks cleaning machines are summarized in the following table:

**Table 11-9 Trash racks & Trash rack Cleaning Machines**

| **Trash racks** | | **Trash rack Cleaner** | |
|---|---|---|---|
| Type | Non withdrawal fixed type | Vertical Inclination | 10 º |



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| | | | |
|---|---|---|---|
| No. of trash racks | 1 set | Rake “pay load” | 1 ton |
| Handling | By mobile crane | - | - |

### 11.15.5 Pressure Shaft

The lower, horizontal part of every pressure shaft will be steel lined, from the bifurcation onwards up to the spiral case inlets of the generating units.

For the feasibility design of the steel lining, safety factors of 2.0 and 1.5 were adopted to establish the required minimum plate thicknesses with regard to the prevailing internal and external pressures, respectively. Moreover, the steel lining was pre-dimensioned under the following assumptions:

- No load sharing with the surrounding rock, and
- Full external pressure with no pressure relief valves.

The material of the steel lining will be killed, fine grained steel with a yield strength of no less than 550 N/mm² for limiting the plate thickness so that no stress relieving after field welding is required.

### 11.15.6 Surge Shaft

Surge shaft is a structure provided at the end of pipe to account for water hammering effect in the pipe at its downstream. Surge shaft is considered to be an important component of power intake, especially for those involving headrace pressure tunnels.

When power house is suddenly shut down by closing the turbine valves the water in penstock stops suddenly and because of the inertia of incoming water from the back creates a resonance effect, which in a mean while causes water hammering effect. If no arrangement has been made to prevent this water hamming it may result in bursting of penstock pipe and may lead to serious stability issues of the hydropower project, the best solution is to provide a surge shat or surge tank depending upon the site constraints.

Design of Surge Shaft depends upon different parameters such as given below:

- Design discharge
- Headrace water level
- Headrace tunnel diameter
- Headrace tunnel length
- Headrace tunnel slope
- Headrace tunnel material



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Design discharge is the amount of water to be carried by the headrace tunnel of specific diameter with a pre-defined longitudinal slope, greater the slope more will be the velocity of water through headrace tunnel and hence more will be head losses.

## 11.15.7 Draft Tube Gate Equipment

### 11.15.7.1 Functional Requirements and General Arrangement

For installation, maintenance, inspection and repair of turbines, it is necessary to dewater the turbines and their related waterways. Draft tube gates are required to act as bulkheads for preventing entry of surge chamber water into the waterways when the turbines and their waterways are emptied for maintenance and inspection. Draft tube gates will work under balanced head conditions.

The draft tube gates will be vertical lift bulkhead type designed for operation under balanced head conditions created through filling valves installed on the gates.

Draft tube gate equipment will consist of bulkhead gates, lifting beam and overhead travelling crane.

### 11.15.7.2 Draft Tube Gates

**Gate Leaf**

The draft tube gates will have upstream side seals and downstream bottom sealing. Skin plate will be on downstream side. This concept of sealing and skin plate position is to prevent any uplift effect during surge tank operation. Each section will be of welded steel construction. The top section will have wedge type bottom seal and caisson type side and top seals with fluorocarbon cladding while the lower sections will have sealing plate at the top on which the upper section will be seated to seal the water passage. Guide shoes will be provided at the top and bottom of each side of the gate sections to engage the guides embedded in the concrete. For alignment of draft tube gate sections, guide pins will be installed on the top of lower sections and guide sleeves in the bottom of upper sections. Lifting pins will be provided to handle the gate sections by a lifting beam.

**Embedded Parts**

A set of embedded parts will consist of a sill beam, a lintel beam, two side bearing plates, two guide rails for installation of draft tube gates along with two guide rails and bottom supports for storage of draft tube gate sections. Welding pads will be embedded in first stage concrete to facilitate the alignment of the parts embedded in the second stage concrete. The sill and lintel beams will provide sealing surfaces for bottom and top sections of the gates respectively. All sealing surfaces will be of corrosion resisting steel. The design and performance criteria of graft tube gates are summarized in the following table:

**Table 11-10 Design and Performance Criteria of Draft Tube Gates**

| | |
|---|---|
| Type of gate | Vertical Lift Gate |
| No. of gate openings | 3 |
| No. of draft tube gates | 4 |



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| | |
|---|---|
| No. of embedded parts | 3 sets |
| Gate operation | Overhead Travelling Crane |

**Overhead Travelling Crane**

One electrically operated overhead travelling crane will be provided for handling the draft tube gates and inlet stoplogs of tailrace tunnels with the help of lifting beams. The lifting beams will operate in the slots and guide rails provided for the draft tube gates and inlet stoplogs for tailrace tunnels. The crane will operate over the rails spanning all the draft tubes of the powerhouse.

## 11.16 MECHANICAL COST ESTIMATION

It is assumed that a major portion of the mechanical equipment will be imported from foreign sources. The prices include profit, overheads and the cost of designing, purchasing raw materials, manufacturing, painting, testing and packing the products, delivering to the port of export, ocean freight, insurance, landing cost, inland transportation in Pakistan and installation. A contingency amount of 2% of the total costs of all mechanical equipment has been added to cover the additional costs arising from increases in equipment dimensions due to unforeseen physical conditions at site. Unforeseen site conditions have the greatest impact on civil works, but they can also impact, to a lesser extent, on the dimensions and cost of mechanical equipment

.



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# 12 ELECTRICAL EQUIPMENT

## 12.1 GENERAL

This chapter is aimed to summarizing the feasibility design considerations for the electrical equipment and its installation in the powerhouse. The study shall provide the basis for the cost estimates and will form the background for the final design studies.

The main electric installation would consist of 03 nos. vertical shaft synchronous generators, 02 nos. GCBs and 03 nos. three-phase step-up power transformers. Medium Voltage, Low Voltage, DC Auxiliary power supply system and safety installations will provide adequate operational and personal safety.

Three power generating units having a total capacity of 54 MW with a generation voltage of 11kV will be located in the power house. The generators shall be connected to their respective unit transformers (three phase) through GCB to step-up the generation voltage for onwards transmission to the local grid. A GPS Clock synchronized time system for the common time basis of all the equipment, Lighting & small power services will be provided in the Power house along with earthing. All equipment shall operate without undue vibration and with the least practical amount of noise.

All equipment shall be designed to minimize corona or other electrical discharges, to comply with local electromagnetic compatibility (EMC) standards and IEC 60801 and IEC 61000.

All electrical components shall be adequately rated for their most onerous duty and the specified ambient temperature. When equipment is mounted in panels, cubicles etc., due account shall be taken of any heat generated by the equipment therein and the components shall be appropriately selected, rated or de-rated as necessary to suit the most onerous operating temperatures within the enclosure.

## 12.2 STANDARDS AND REGULATIONS

The works will comply with the relevant statutory requirements of Pakistan and WAPDA. The design, materials, manufacturing, testing, inspection and performance of the works will conform to the latest current ISO/IEC publications.

- IEC 60034 Rotating electrical machines
- IEC 60085 Thermal evaluation and classification of electrical insulation
- IP 44 Degree of protection

Other recognized national or international standards and codes that ensure substantial equivalent may be acceptable. For applications where no relevant standard exists, up-to date recognized practice will apply.

## 12.3 GENERATOR

All three generators shall be installed vertically & their rotors shall be solidly coupled with the turbine runner hydraulic driven with a combined thrust and guide bearings below the rotor upper



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guide bearing neutral grounding assembly. Automatic Voltage regulators, excitation cubicles and a closed circuit cooling system surface air cooler shall be installed. A flywheel of suitable inertia will also be mounted on the same shaft to keep the constant speed of the generator & avoiding the fluctuations/harmonics resulting from varying loads and switching surges. All the Generator parts shall safely withstand stresses resulting from over speed conditions at runaway. Generator terminals are connected by Isolated Phase Bus ducts (IPBs) to Generator Circuit Breaker (GCB).

Each generator shall be provided with a set of brakes arranged for pneumatic operation from station compressed air system. A rotor maintenance jacking system will be supplied to lift the turbine and generator rotating parts.

Each generator shall have a closed circuit air-cooling system in which the circulation of the air is achieved by the fan action of the rotor. The air leaving the generator will be cooled by a number of surface type air/water coolers. With one complete heat exchanger out of service, the maximum continuous output will be maintained without the stator and rotor winding temperatures exceeding Class B permissible temperature rise. Electric heaters shall be provided in all generator housing to prevent condensation when the generator is not working. The lower bearing bracket shall support the weight of the rotating parts and the hydraulic thrust of the turbine. The bearing arrangement shall be according to IEC60034-7. Stator and rotor insulation shall be rated for class F; however, the temperature rise of the stator and rotor windings shall not exceed the Class B limits specified in IEC 60034-1.

### 12.3.1 Type & Description

The three-phase synchronous generators shall be of the vertical shaft type, hydraulic driven, with a combined thrust and guide bearing below the rotor, upper guide bearing, neutral grounding assembly, $CO_2$ fire extinguishing system and a closed system of ventilation with surface air coolers. Generator terminals will be connected by Isolated Phase Bus ducts (IPBs) to Generator Circuit Breaker (GCB).

The Generator shall be suitable for direct connection to a Francis type vertical shaft turbine. The direction of rotation of the turbines will be clockwise when viewed from non-driven end. The stator bore shall be such that it allows lifting the largest turbine component through it. The neutral grounding of the generators shall be through a dry-type distribution transformer connected between the neutral of the generator and earth with resistor connected at the secondary winding.

The generators shall be designed to withstand all fault situations that can be experienced during operation without any displacement of its windings or mechanical damage to any of its parts or to the generator foundations, such as short circuit between two or three phases at its terminals, faulty synchronization, magnetic imbalance due to pole winding failure and runaway conditions etc.

The generator condition monitoring system shall comprise the following features:

- On-line Vibration Monitoring System
- On-line Partial Discharge (PD) Monitoring System
- Generator Air Gap Monitoring System



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**Table 12-1 Main Parameters of the Generators**

| | |
|---|---|
| **Generator Shaft Orientation** | Vertically Coupled |
| **No. of Units** | 3 |
| **Nominal Capacity** | 21.2 MVA (18 MW) |
| **Rated Speed** | 375 RPM |
| **No. of Poles** | 16 |
| **Efficiency** | 98 % |
| **Unit Output Voltage** | 11 kV |
| **Frequency** | 50 Hz |
| **Power Factor** | 0.85 |
| **Insulation Class** | F |
| **Limit of Thermal Utilization** | B |
| **Excitation** | Static |
| **Excitation Voltage** | 220 V DC |
| **Runway speed** | 648 rpm |
| **Connection** | Y, Neutral Grounded through transformer resistance |
| **Cooling System** | Closed circuit Air-cooling system with surface type Air/Water Coolers |

### 12.3.2 Design

The generator shall be of a standard construction according to the respective IEC-60034 standard. The design of the generator is determined by the construction, layout and speed of the turbine. The choice of a vertical shaft Francis turbine with 375 rpm defines a vertical generator with 16 poles with upper guide and thrust bearing and lower guide bearing. The design of the frame and the foundation will have to carry the weight of the turbine and the generator as well as to take over the stresses caused by the dynamic forces produced during short circuit conditions on the generator side as well as the stresses caused by seismic activities. CO2 fire extinguishing system and a closed system of ventilation with surface air coolers. Generator terminals are connected by Isolated Phase Bus ducts (IPBs) to Generator Circuit Breaker (GCB). The nominal voltage of the generator has been chosen 11 kV which is appropriate for this size of the Generators and standard WAPDA system. The generators are capable to run at 15% continuous overload without exceeding the temperature limits of class F insulation.

The generator is designed to withstand all fault situations that can be experienced during operation without any displacement of its windings or mechanical damage to any of its parts or to the generator foundations, such as short circuit between two or three phases at its terminals, faulty synchronization, magnetic imbalance due to pole winding failure and runaway conditions etc.

The power factor of the machines is proposed to be 0.90. The generator shall meet the specified temperature rise limits, based on an ambient temperature not exceeding 40C. The voltages withstand levels for the generator shall be in accordance with IEC 60071.



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### 12.3.3 Rotor

The rotor structure supporting the pole pieces built up of steel laminations shall be of steel plates or with a central cast steel/fabricated spider, equipped with field windings as well as with collector rings. The poles shall be laminated and provided with a damper winding for the required operating stability. Any method of securing the poles to the rotor body shall depend on the stressing by the centrifugal force that is developed at the runaway speed. The poles shall be fully consolidated laminated assemblies fitted to the rim. The pole fixing shall be designed so as to limit stress concentrations, and ensure uniform load distribution between fixings.

The insulation class of the pole windings has to be "F" but for extended insulation life the generators would be rated at class "B" temperature rises. Damper bars of copper shall be braced into ring segments at both ends of the rotor. The rotor is provided with a continuous low resistance damper winding in the pole pieces to minimize over voltages due to unbalanced faults. The damper winding is designed to make the ratio of quadrature-axis sub-transient reactance (xq'') to direct-axis sub-transient reactance (xd'') nearly equal to 1.0 for stabilizing the power system transient swing.

A segmental brake ring shall be fitted to the rotor with provision for expansion and contraction due to repetitive normal braking. The design shall be such that the brake ring segments can be readily removed for resurfacing or replacement. The brake ring shall be sufficiently thick to prevent thermal distortion. It shall comprise bolted segments which shall present a smooth even surface to the brake pads. Bolts shall be well countersunk.

The Generators shall be efficiently cooled with closed air system. For proper cooling, the Generators shall be equipped with surface air water coolers having sufficient cooling capacity to maintain the air temperature at 40˚C or less, with the generator delivering continuously 100% rated output. The circulation of the air shall be by means of the fan action of the Generator rotor.

### 12.3.4 Stator

The stator should be framed by welded steel rings on both sides, which transmit all dynamic and static forces through thrust bearing to the plates laid in the concrete foundations. Stator bars shall be treated with anti-corona protection and wound in the slot with conducting materials designed to compensate for relaxation in service, in order to eliminate the possibility of slot discharge damage. Stator wedges shall be fitted in such a way that radial pressure is applied to the bars even after relaxation in service. The interval between wedge re-tightening, and the method adopted, shall be subject to the Engineer's approval. Stator bar joints shall be brazed, and bar to bar joints fully insulated with tape material.

For proper and effective cooling the generator core shall be divided by radial and axial air gaps for air flow through the generator core. The stator winding shall be designed so that a generator wave form as close as possible to the sine curve could be obtained. The stator winding is star connected and neutral point is grounded through a grounding transformer. The stator winding is provided with an online partial discharge measuring system with necessary partial discharge sensors to measure the partial discharge activities in such various plates of stator windings as external to the stator winding, slot surface, slot wall, insulation/copper interface and end turn

The stator winding shall be made of bar or coil winding system with an insulation of continuous tape impregnated with synthetic resin in vacuum and subsequently cured. The coil shall be provided with a necessary anti corona protection in the slot section and at the ends, if



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necessary. The insulation shall meet the requirements of the temperature class F. Grounding of generator neutral through grounding transformer is proposed. The Grounding resistors shall be installed in a separate housing with proper insulation provided.

The winding shall be designed to minimize temperature variation throughout the slot content. Bars shall be manufactured and wound to an agreed quality plan which shall be approved by the Engineer.

Stator bars shall be treated with anti-corona protection and wound in the slot with conducting materials designed to compensate for relaxation in service, in order to eliminate the possibility of slot discharge damage. Stator wedges shall be fitted in such a way that radial pressure is applied to the bars even after relaxation in service.

The interval between wedge re-tightening, and the method adopted, shall be subject to the Engineer's approval. Stator bar joints shall be brazed, and bar to bar joints fully insulated with tape material.

Windings shall be braced and supported so that they can withstand short circuit forces and accommodate thermal cycle movement without damage. Slot wedges shall be locked in position so that they cannot fall out of the slot. Bars shall be fixed, using conformable packing, to insulated non- metallic support rings. All bar clamping devices shall be locked by approved means. The method of winding support and wedging shall be shown in the drawings to be submitted by the Contractor.

Stator bar joint and connecting ring maximum temperature rises shall not exceed those allowed in the slot portion of the winding. The predicted maximum temperature rises, shall be validated by tests.

Air gap measuring probes shall be fitted in the slot wedges to monitor abnormal air gap changes. The probes shall be connected to a processor mounted outside the machine enclosure. The proposed system shall be complete with interface equipment to provide signals to the Distributed Control system (DCS) for alarm purposes and for deterioration analysis, required to plan preventative maintenance.

Suitable connections shall be installed in each phase of the winding to monitor "on line" discharge levels of the bars, without taking the unit out of service.

### 12.3.5 Generator Bearings

Guide bearings shall be of the segmented multiple pad design, oil lubricated self-pumping type. Their design shall permit vertical movement of the shaft system for adjustment and removal of the thrust bearing shoes. Bearing pads shall be individually adjustable and shall be lined with high grade white metal, no less than 5mm thick, securely bonded to the pads. The bond shall be ultrasonically examined. Bearing pads shall be easily removable without the removal of any other major component. A portion of the bearing shall be continually immersed in oil to provide initial lubrication during a unit start.

All bearings shall be equipped with water-in-oil sensors with alarms. Each generator bearing housing shall be sealed and ventilated to ensure that oil vapor does not enter the generator, slip-ring housing or turbine pit. Vapor pipe work from each bearing housing shall be terminated in a convenient location in the turbine gallery, by condensate containers equipped with drain



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and level indicator. If necessary to completely eliminate vapor release from the bearing housings, an external vapor extraction and condensation system shall be provided for each unit.

#### 12.3.5.1 Generator Lower Guide Bearing

The lower guide bearing may share an oil reservoir with the thrust bearing. In this case oil supply to the lower guide bearing may be by the pumping action of the thrust bearing. Otherwise the guide bearing shall be self-pumping.

If a separate oil reservoir is used, the coolers of the lower generator guide bearing shall be external to the guide bearing housing and shall be easily isolated and removable for cleaning and maintenance.

Alternatively, if self-pumping is proven to be impractical with external coolers then coolers may be installed in flanged recesses in the bearing houses such that they can be removed without the necessity of dismantling any major component.

#### 12.3.5.2 Generator Upper Guide Bearing

The bearing shall be of self-pumping design mounted in the upper bracket. Coolers shall be consistent with those on the lower guide. It shall be possible to remove the upper guide bearing pads without dismantling the brush gear or its enclosure.

#### 12.3.5.3 Generator Thrust Bearing

The thrust bearing shall be self-pumping by rotation of the shaft. It shall be mounted in a lower bracket designed to transmit axial loads into the concrete foundations. The design shall be such as to limit thermal expansion forces whilst maintaining the bearing concentricity with the shaft. The thrust pads shall be supported so as to ensure uniform load distribution between pads and provide ease of adjustment for maintenance. The bearing shall be designed to accommodate repetitive restarts immediately after hot shut down. Removal of the pads shall be possible sideways by jacking the generator rotor. The Contractor shall supply all special tools and devices for this purpose.

The thrust bearing runner shall be a one-piece forging. Weld repair of the runner surface will not be accepted. The bond of the white metal to the bearing pads shall be inspected ultrasonically.

The thrust bearing shall be equipped with a high pressure oil lift system which shall normally be operative during start up and shut down. However, it shall be possible (and demonstrated during commissioning) that the unit can be stopped without the pumps in operation without any appreciable temperature rise and any damage to thrust bearing pads. The results of this demonstration shall be visually verified by inspecting two thrust bearing pads at random. Each pad shall be equipped with non-return valve integral with the pad. The high pressure system shall comprise two pumps (normal and standby) with all necessary starters and associated controls for automatic switching. The standby pump shall be dc motor driven which shall start automatically upon failure of ac motor driven main pump. The required oil film thickness shall be established in about five (5) seconds. Remote indication and local visual indication shall be provided for excess inlet and outlet filter pressure drop.



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The high pressure lift system shall be located external to the unit so that it can be easily inspected and maintained without entering the unit. Automatic drainage of any leakage oil shall be provided. Bearing oil coolers shall be mounted outside the bearing housings with isolating valves so that they can be removed for cleaning. There shall be indicating devices or visual aids to observe foaming of oil in the bearing.

### 12.3.6 Condition Monitoring System

The generator condition monitoring system will comprise of the following features

**On-line Vibration Monitoring System**

The generators are provided with a vibration measuring system to monitor vibrations of radial and axial directions as well as shaft run-out at each bearing of the turbine and generator unit. The vibration measuring system is arranged to measure the following items.

a) At upper guide bearing: Vibrations of radial (X and Y) directions
   Shaft runout of radial (X and Y) directions
b) At thrust bearing: Vibrations of axial direction
c) At lower guide bearing: Vibrations of radial (X and Y) directions
   Shaft runout of radial (X and Y) directions
d) At turbine guide bearing Vibrations of radial (X and Y) directions
   Shaft runout of radial (X and Y) directions

The vibration indication units are mounted on the turbine control panel.

The vibration measuring system is designed to give alarm (1st stage) and unit trip (2nd stage) signals in the event of excessive vibration.

**On-line Partial Discharge (PD) Monitoring System**

In order to indicate the condition of winding insulation, a partial discharge analyzer (PDA) is provided to monitor the partial discharge activities of the stator windings. The system consists of permanently mounted partial discharge sensors (capacitive couplers) on the line and neutral windings.

**Generator Air Gap Monitoring System**

Air gap monitoring system consists of stator mounted probes to detect the deformation of rotor and stator concentricity. Data will be used for analysis of irregular behavior of rotor and stator due to effects of centrifugal force, magnetic force and thermal expansion on generator.

### 12.3.7 Excitation System

The generator excitation system will be of the static type comprising three-phase cast resin type excitation transformer, thyristor converter, field flashing and field discharge equipment, automatic voltage regulator and control circuitry. The excitation transformer will be installed in a



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self-supported steel plate cubicle to achieve personnel safety. The excitation transformer shall be AN cooled and of dry insulated type using non-flammable Class B insulating material.

Static excitation with excitation transformer, controlled rectifier and the automatic voltage controller has the advantage of providing quick response, being capable of reversing its output voltage in case of load rejection and unit over speed. Therefore, the proposed Power House shall have a static excitation system.

Excitation systems feed the field winding via slip rings and brushes allowing rapid response for voltage regulation. The automatic voltage regulator will be equipped with automatic and manual channels with follow-up control to allow change of mode without bumping. The excitation rectifier envisaged will be of solid-state type with controlled silicon power thyristor for both polarities. While considering forced ventilation, redundancy of the cooling system must be provided to avoid shutdown of the generator in the event of breakdown of the fan motors. Cooling fans must be self-powered from the excitation transformer so that loss of station service does not cause excitation failures.

The excitation system will be capable of providing sufficient margin of stability under all steady and transient load conditions. The voltage regulator will have a voltage variation range of ± 10 % of the rated generator voltage. The field current control will be used as the manual channel of the regulator. The excitation system shall have built-in protection and supervision equipment. All fault signals shall be displayed on the AVR front panel.

For excitation start-up / field flashing, an additional supply from the DC system will be provided. The excitation system will communicate with the distributed control system (DCS) via a standard bus system.

The static excitation systems will consist of:

- Digital type AVR’s
- Rectifier assemblies
- Excitation transformers
- Field cubicles with breakers, discharge, control & protection devices and cooling circuits
- Field flashing circuit/equipment
- Excitation leads between excitation cubicles and slip rings

The excitation system will be provided with the following features:

- Following of line voltage during synchronization
- Quadrature droop parallel operation compensation
- Under-excitation or load angle limitation with adjusting device
- Time graded limitation of the maximum excitation current



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- Time graded limitation of the maximum stator currents (under-/ overexcited)
- Power system stabilizer

### 12.3.8 Generator Circuit Breaker

The Generator Circuit Breakers will be SF6 gas type as insulating and interrupting medium, high current type and complying with IEEE C37.013. For current interruption the self-blast interrupting principle is applied. The arc voltage of the circuit breaker is high enough to ensure current zeros in case of generator-source short-circuit currents with delayed current zeros. The Generator Circuit Breakers will be suitable for synchronizing duties and provided with interlocks to avoid incorrect operation of the disconnector or the earth switches. The Generator Circuit Breaker is capable of interrupting currents under out-of-phase conditions with out-of-phase angles up to 180 degrees.

The Generator Circuit Breakers will conform to IEC 60694 and suitable for the normal load current specified with natural cooling and with a temperature rise in accordance with IEEE C37.013.

## 12.4 OTHER ELECTRICAL EQUIPMENT

Generator protection comprising all the required relays according to the size and specifications of generator.

- Control and metering panels.
- Control and protection cables.
- MV/LV switchgears.
- 220V DC Battery Set & Battery Charger.
- Energy Hour Meters shall be used to monitor energy generation.

## 12.5 POWER TRANSFORMERS

Power transformers configuration have been considered to transmit the power from power house to local grid station.

Each generator connected to its own unit transformer.

It has advantages of being flexible in case of problems with the equipment. Each unit is independent so that availability of the generation is higher than the group transformer. Thus for this hydropower project, each generator is proposed to connect to its own step-up transformer. Off load tap changer is proposed on high voltage side. An allowance of 10% continuous over load is also proposed. Detailed parameters of the recommended transformer are as under:



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**Table 12-2 Recommended parameters of the Transformers**

| | |
|---|---|
| **Description** | For Generator I to III |
| **No. of Transformers** | 03 |
| **Nominal Capacity** | 22 MVA |
| **Cooling Type** | ONAN/ONAF |
| **% Impedance** | 12% |
| **Primary Voltage** | 11 KV |
| **Secondary Voltage** | 132 KV |
| **Frequency** | 50 Hz |
| **Type** | 3-Phase, 2 windings (HV/LV) |
| **Tap Changer** | OFF Load |
| **Vector Group** | Ynd11 |

A spare power transformer shall also be provided. As per standard practice, Buchholz Protection and all other necessary Protection will be provided. The delta connected winding on the low voltage side will provide short-circuit for possible third harmonics from the generator. The high voltage winding is star (Y) connected with the neutral taken out on a separate terminal for connection to earth.

## 12.6 STATION SERVICE TRANSFORMER

One transformers of 2 MVA, 132/11 KV rating will be installed for power supply to intake, auxiliary supply, control room, transformer bay, intake, crane, Lighting Load, DC supply and power house supply and as alternative supply in case of emergency.

The ratings of transformer are as under:

| | |
|---|---|
| No. of Transformer | 1 |
| Capacity | 2 MVA |
| Primary Voltage | 132 kV |
| Secondary Voltage | 11 KV |
| Frequency | 50 Hz |
| Temperature rise | 55˚C |
| Cooling | ONAN |
| Type | Dry/Oil |



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## 12.7 AUXILIARY TRANSFORMERS

Two nos. Unit Auxiliary Transformers (UAT's) will be installed for power house auxiliary supply. It is not necessary to install a unit auxiliary transformer with each unit. Here, It is considered economical to install 11/0.4 kV transformer only with two units. Another unit auxiliary transformer will be used to interconnect unit auxiliary supply with station supply to get the supply from station service transformer. The ratings of unit auxiliary transformers are mentioned below.

| | |
|---|---|
| No. of transformers | 3 |
| Rated Capacity | 630 kVA |
| Transformation voltage | 11 kV / 0.4 KV |
| Insulation class | H |
| Cooling | ONAN |
| Type | Oil |
| Percentage Impedance | 4 % |

Two auxiliary transformers of capacity 400 kVA each shall supply the electrical power to the auxiliary equipment of intake and switch- yard control building. Oil filled distribution type transformer with a capacity of 400 KVA, 11KV/0.4kV, has been selected based on the required capacity of load in the plant. Natural air circulation cooling has been chosen due to the operational safety. The insulation material shall be self-extinguishing and varnish shall prevent any spreading of fire. The units shall be installed close to the space where the power is needed. The ratings and characteristics of the auxiliary transformer shall be as follows.

| | |
|---|---|
| No. of transformers | 2 |
| Rated Capacity | 400 kVA |
| Transformation voltage | 11 kV / 0.4 KV |
| Insulation class | H |
| Cooling | ONAN |
| Type | Oil |
| Percentage Impedance | 4 % |

## 12.8 SWITCHGEAR SYSTEM

The generators shall be connected to 11kV switch gear, which consists of medium voltage circuit breakers, medium voltage disconnecting switches and the corresponding metering and protection equipment.

### 12.8.1 132kV Switchgear

Conventional air insulated type switchgear is applied for 132 kV switchyard for connection of the outgoing 132kV transmission line which includes voltage and current transformers for protection relays.

132kV switchgear is figured with one and a half circuit breakers system being generally applied for high voltage system in substation and power house.



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### 12.8.2 11kV Switchgear

The primary purpose of the 11 kV switchgear is to provide auxiliary supply for the powerhouse, intake and also to support any adjoining areas. The switchgear has been planned to be located in a separate room in the 132kV switchyard.

The incoming 11 kV supply from 132/11 kV service supply transformer will be terminated in the 11 kV bus bar. Some 11kV feeders supply power to rural areas and will be finalized in the tender design stage.

The necessary 11 kV feeders and service supply transformer will be equipped with modern fuse disconnecting switches or circuit breaker of SF6 or vacuum type (to be decided at detailed design stage) enclosed in cubicles thus obtaining high personnel safety.

The main data for the circuit breaker shall be the following:

| | |
|---|---|
| Nominal voltage | 11 kV |
| Maximum voltage | 12 kV |
| BIL | 95 kV |
| Rated short circuit current | 31.5 kA |

### 12.8.3 400 Volt Switchgear

It is proposed to use a 400V switchgear scheme to supply power to station auxiliaries. The AC supply of 400V shall be obtained from the 630 KVA station service transformers. Miniature Circuit Breaker and Molded Case Circuit Breaker (MCB's & MCCB's) shall be used accordingly for the 400V supply.

The following LV switchgears are provided for Unit and Station Auxiliary power supply.

a) Unit Auxiliary service boards

b) Essential service boards

c) Common service boards

Switchgear assemblies will be comprised of low voltage power air circuit breakers, moulded case circuit breakers, buses, current transformers, voltage transformers, indicating instruments, relays, control devices, associated wiring and test blocks.



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## 12.9 CONTROL, INSTRUMENTATION AND PROTECTION EQUIPMENT

### 12.9.1 Instrumentation & Control

#### 1) One-Man Control System

The control system for each generating unit; hydraulic turbine, generator, unit transformer and 132kV circuit breaker will be designed for “one-man control system” in which any operation of the generating unit can be carried out remotely by an operator from the machine hall in the powerhouse as well as from the main control room of the central control building.

In the one-man control system, the unit start-up and stop operations will be made by automatic sequential control with the aid of the programmable logic controller for each unit. All auxiliary equipment of the unit will be actuated and stopped by automatic control sequence program loaded in the PLC.

#### 2) Control Mode

Each generating unit will be operated under three (3) control modes of "Remote- Auto", "Local-Auto" or “Local-Manual” as follows:

#### a) Remote-Auto” Control Mode

The generating unit operation including unit start/stop, turbine speed adjustment, load adjustment and generator voltage adjustment will be carried out remotely from the control room of the main control building.

The unit start/stop operations will be carried out under the full-automatic mode. The remote-auto control mode will be used for ordinary start and stop operation.

#### a) Local-Auto” control mode

The generating unit operation will be carried out remotely from the machine hall floor level of the underground powerhouse.

Under the local-auto control mode, the unit start/stop operations will be made by full-automatic mode or step-by-step mode.

Under the full-automatic mode, the generating unit will start up automatically to the step of the generator synchronizing when the “Start” command is given, and the running unit will be automatically brought to the unit standstill when the “Stop” command is given.

The step-by-step mode is a semi-automatic control mode to start and stop the generating unit from the unit local control board with confirmation of each step operation. This local-auto control mode will be used when the SCADA system is out of service.

#### b) Local-Manual” Control Mode

The local-manual control mode is to operate the turbine and generator unit by manual control of their governor, excitation system and auxiliary equipment without using the automatic control function of the programmable logic controller.

This mode will be used only for testing and trial operation of the turbine and generator unit after maintenance and repair, or when the programmable logic controller is out of service.



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Indicating, measuring and control instruments have been considered necessary for the major components of Power House. For monitoring and control of the overall power plant, Latest control system (DCS/SCADA) should be installed for plant control. The transducers shall be installed where necessary. All indications shall be visible in the main control room.

The control of the single unit shall be local and remote, able for auto or manual selection. It is necessary to provide a separate control desk and mimic panel that shall be located in the main control room and include the most important remote control functions.

### 12.9.2 Protection Equipment

Separate relay protection cubicles comprising modern electronic relays will be installed. All relays shall preferably be of the same make (manufacture) to build a uniform modular system.

The relays are to be organized in two groups so that one group provides back-up protection for the other group The outline of protection scheme for the Generators, Main Step-Up Transformers, is shown on the Design Drawing. The general principle for the protection is that all parts of the installation (Generator and Main Step-Up Transformers) are covered by two high speed protection schemes which are independent to avoid common-mode failures.

The protection equipment is provided with all relay panels, instruments, meters, interposing and auxiliary relays, control switches, interposing current and voltage transformers, transducers and all auxiliary equipment. The protection system aims at compliance with IEC 62351. Control supply will be taken from 220 VDC system. Separate circuits will serve the two groups of relays in order to obtain maximum reliability. Protection equipment is designed and supplied to provide maximum discrimination between faulty and healthy circuits. All equipment is to remain inoperative during transient phenomena which may arise during switching or other disturbances to the system.

Signals and data provided by the protection relays will be monitored by the DCS.

#### 12.9.2.1 Generator Protection

- Under voltage protection (27)
- Reverse power protection (32)
- Loss of excitation protection (40)
- Negative sequence current protection (46)
- Generator winding thermal monitoring (49 G)
- Over current / short circuit protection (50; 51; 51 N)
- Over voltage protection (59)
- Rotor earth fault protection (64 R)
- Stator earth fault protection (95 % & 100%) (64 G)
- Under frequency protection (81)



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- Three phase generator differential current protection (87 G)
- Shaft current protection
- Vibration and shaft movement supervision protection

#### 12.9.2.2 Power Transformer Protection

The following transformer protections are recommended:

- Transformer Differential protection
- Restricted earth fault protection
- Back-up earth fault protection
- Buchholz protection
- 132 kV XLPE cable differential protection

And also over current protection for excitation transformer and unit auxiliary transformers will be provided.

It is also recommended that the numerical transformer protection system be combined with the main generator protection system and contained in one cubicle or in an adjacent cubicle.

The following devices, supplied as part of the unit transformer shall be integrated in the transformer protection and supervision scheme.

- Level of insulating oil, maximum and minimum (71T);
- Oil temperature (26);
- High voltage (HV) and low voltage (LV) windings temperature (49T);
- Gas release (63);
- Pressure relief valve (63VS)

#### 12.9.2.3 132kV Transmission Line Protection

The 132kV transmission line protection shall be comprised by redundant multifunctional numeric IEDs, with exclusive hardware.

- Transmission line differential protection (87L)
- Transmission line distance protection (21)
- Breaker failure protection (50BF)



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## 12.10 SYNCHRONIZING

### 12.10.1 Automatic Synchronizer

A solid-state automatic synchronizer for each unit, to automatically synchronize and connect the generators to the power system via the unit 132 kV circuit-breakers will be provided.

I. The automatic synchronizing equipment will be mounted on the unit control panel.

II. A check synchronizing relay for each unit, which will be arranged to prevent closing pulses from the auto-synchronizer reaching the circuit breaker if the phase angle difference at that time is greater than nominal 5 degrees will be provided. Operation of the auto -synchronizer circuit breaker closing pulse without the check synchronizing relay operating will lockout the auto-synchronizer and initiate an urgent alarm.

### 12.10.2 Manual Synchronizing Facilities

A manual synchronizing for each turbine generator unit in the power station control room will be provided.

All hardwired voltage and speed control signals of the Project Plant units on the above console, to enable the operators to adjust the voltage and speed of the unit during manual synchronizing, will be provided.

## 12.11 MEASURING EQUIPMENT

Each feeder will be equipped with current and voltage transformers between the power transformer and the circuit breaker. Measuring accuracy of the protection cores shall be as per IEC standard. CT's shall be designed to carry the same nominal and short circuit currents as the other switchgear equipment and shall have separate cores for measuring and protection purposes. All measuring transformers are assumed to be dimensioned to meet all the needs of the operation of the power plant.

### 12.11.1 Current Transformers (CT)

Current transformers shall comply with IEC 61869-2 as amended and supplemented by the following requirements. Separate current transformers shall be provided for protection, instrumentation and metering purposes. For measuring current transformers, the following accuracy classes shall apply;

a) For generator output for the purposes of acceptance testing, and for tariff metering of large supplies, unless otherwise specified

b) For plant record metering, and for other acceptance testing purposes

c) For automatic voltage regulators (AVRs)

d) For indicating instruments.

Current transformers used for indication/metering purposes shall be designed to saturate at a value of primary current sufficiently low enough to protect the secondary circuit from damage at all possible values of primary fault current up to the associated primary short time rating.



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Current transformers for protective/indication purposes shall be designed to suit the particular requirements of the associated protection which, in general, shall be in accordance with the recommendation given in IEC 61869-2. Class 5P current transformers shall be used for combined over current and earth fault protection of the inverse time over current type.

The rated accuracy limit with actual burden connected shall be equivalent to the ultimate maximum symmetrical three phase fault current or earth fault current of the protected circuit. The current transformers shall be capable of meeting the 5P error classification at rated accuracy limit current over the full range of relay settings.

Current transformers for combined purposes e.g. inverse time relays and indicating meters, shall have a dual Class 5P/Class 1 performance and where necessary the secondary circuits shall have an approved means of protecting the meters and reducing their burden under system fault conditions. Current transformers for protection using high impedance relays shall be of the low reactance type and their performance shall be stated in terms of the Class TPS, TPX, TPY and TPZ parameters of IEC 61869-2 (low reactance current transformers are preferred for all forms of protection), or equivalent approved standard.

The rated volt-amp output of each current transformer shall not be less than the connected burden, as installed in service, the burden of cable connections being taken into account. Current transformers shall be capable of withstanding without damage the peak and rated short time currents of their associated equipment. The secondary windings of each set of current transformers shall be earthed at one point only, via a bolted disconnecting link.

The current transformer core, where accessible, shall be separately earthed. When multiple ratio secondary windings are specified, a label shall be provided at the secondary terminals of the current transformer, indicating clearly the connections required for each tap. The connections and the ratio in use shall be indicated on all connection diagrams. Design magnetization curves and DC resistance values shall be submitted before manufacture for each current transformer used for protective purposes and shall be subsequently verified by works routine tests. For metal-clad switchgear, all current transformers shall be located on the outgoing circuit side of the circuit breaker. Current transformers may also be provided on the bus bar side of the circuit breaker to permit protection zone overlap.

The primary conductors of all current transformers shall be readily accessible for primary injection testing on site. Where current transformers have to be mounted on apparatus provided under other contracts, shall be responsible for ensuring compatibility with the other apparatus. Current transformers incorporated in equipment which are spare or for future use, shall (if not connected to associated relays, instruments etc.) be provided with a suitably rated shorting link mounted at a convenient terminal block to avoid the current transformer being energized with its secondary connections open circuited. Bushing type current transformers shall be provided with taps to measure capacitance and loss factor (tan delta).

### 12.11.2 Voltage Transformers (VT)

All voltage transformers shall comply with the requirements of IEC 61869-3 as amended and supplemented by this specification. They shall have outputs 50% in excess of the present requirements unless otherwise specified.

The voltage transformer secondary circuits shall be complete in themselves and shall be earthed at one point only. Metal cases shall be separately earthed. The transformer core,



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where accessible, shall be separately earthed. All voltage transformers at the same voltage level shall be earthed in the same manner. Where it is required to earth the primary neutral of a metal clad voltage transformer, the neutral earthing connection shall be insulated from the tank and brought out separately from the secondary earthing connection. Primary windings shall be connected through fuses with current limiting resistances or having current limiting features. However, such fuses may be omitted when the voltage transformer is located within the overall protection zone of the main circuit. Secondary main protection fuses or miniature circuit breakers shall be provided as close as possible to, and preferably mounted on, each voltage transformer, within a lockable or bolted enclosure.

Secondary main protection fuses or miniature circuit breakers shall be labeled to show their function and phase color. It shall not be necessary to de-energize the primary circuit or remove the voltage transformer of metal clad switchgear to gain access to the fuses or miniature circuit breaker. Auxiliary contacts shall be provided for alarm purposes in the event of loss of supply. Voltage transformers shall be so designed that saturation of their cores does not occur when 1.732 times normal voltage is applied to each winding.

Magnetization curves shall be submitted for approval for each type of voltage transformer prior to Works Tests. The standard secondary voltage between phases shall be 110 V unless special circumstances dictate otherwise. Secondary circuits of different voltage transformers shall not be connected in parallel. Voltage transformers shall preferably be mounted on the outgoing circuit side of circuit breakers. Three phase voltage transformers having an earthed - star primary winding shall have cores with five limbs, the outer two of which shall be unwound

## 12.12 SURGE ARRESTERS

On the outgoing transmission line surge arrester (SA) will be connected to each phase. In addition, one group of three SA will be included on each transformer bushing.

Surge arrestors shall be gapless non-linear metal-oxide resistors (Zinc oxide surge arrestor). The magnitude and duration of temporary power frequency switching over voltages are important design criteria and are to be defined during the final design stage.

## 12.13 DC POWER SUPPLY

220V DC Power shall be obtained by rectifying the AC Power. The DC supply shall also be supplemented by a DC Battery Set. Purpose of the battery system is to provide a safe and reliable DC power to all primary functions. The system is almost independent of all other power supply systems and ensures reliable execution of the control functions, both for selected normal operation and during possible fault conditions.

The DC battery system will mainly provide power to the complete Plant Control System. Some instruments, protection devices or computer interfaces will need 24 V or 48 V DC supply. In this case AC/DC converters should be used. The use of separate 24 V or 48 V batteries is not recommended. The Ah capacity of batteries shall be finalized at the final design stage on the basis of the actual DC load requirements of each powerhouse.

## 12.14 CABLES

The insulating, sheathing and non-metallic filler materials used in the cables shall be selected to ensure compliance with statutory and Section 16 for flame retardant or fire resistance,



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reduced propagation or low emission of smoke, acid gas and halogens free for the cable as a whole. Cables installed on or connected to equipment that is subject to vibration, movement and/or expansion shall have stranded copper conductors throughout. These cables shall have crimped connectors for the termination of the conductors. Only conductors carrying signals of the same category shall be contained within any one multi core cable. To reduce the risk of common mode failure all cabling associated with high integrity signals, such as data transmission signals, signals from fiscal metering systems or with protection and/or safety systems shall be segregated from control cabling over the entire length of the cable run.

This segregation shall also apply to junction boxes and terminations. A further segregation is required to ensure that conductors forming part of intrinsically safe circuits are contained in cables reserved solely for such circuits. A minimum of 20 % spare capacity shall be included in all cables carrying either binary or analogue signals.

### 12.14.1 Power Cables

The power cables to be used between the generators, transformers and their respective 11 kV switchgears shall be XLPE as per IEC/WAPDA standards. Actual quantity/Length of the respective cables shall be decided at the final design. The insulation is of extruded chemically cross-linked polyethylene (XLPE) with sheath of LSHF and either of fire retardant or of fire resistance characteristics. The cables will be armoured and will contain semi-conducting screens and any tapes, binders, separators or bedding required to manufacture reliable, technically proven, high quality cable

### 12.14.2 Control Cables

Control cables are used for protection, instrumentation, control and communications. These shall be of stranded copper conductors or armored cables. These cables shall be standard product of a reputed manufacturer with a proven track record. The construction of the cables will be in compliance with the specified requirements and the related IEC Standards. Control cables will be laid in perforated steel trays or at the bottom of concrete trenches. . The earthing and lightning protection system is designed in accordance with the IEC / IEEE standards. The cable trays shall be mounted on the floor underneath the local control area, to have short connections between the different control panels, distribution boards, equipment and other auxiliary installations.

### 12.14.3 Telecommunication Cables

The application of telecommunication type cables shall be restricted to voice and data communication purposes. These cables shall comprise multiple twisted pairs, triples or quads, with copper conductors, polyethylene or XLPE insulated, laid up and screened overall. Each pair/triple/quad may be individually screened, where required to minimize cross-talk or interference. Cables which are to be direct buried or installed in accessible areas without external mechanical protection shall be armoured, un-armoured cables shall have a braided screen. Minimum 20% spare capacity shall be included in all cables. The insulation of the cores shall be colour coded in accordance with an appropriate international standard. In addition, the colour , construction, marking, etc., of telephone cabling shall be subject to any requirements laid down by the local telephone company or authority. Telephone type cables laid in the ground alongside power cables shall be capable of withstanding induced voltages from the power cable.



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### 12.14.4 Fiber Optics Cables

Fiber optic cable shall be made up cores sheathed in 125 µm cladding, coated and reinforced using strengthening fibers for protection against crushing forces and excessive tension during installation. All fiber optic cables shall comply with an appropriate international standard. The outer jacket shall be made of a flame retardant polymer. A loose tube with minimum strain configuration that provides protection from external forces shall be used in dry and indoor applications.

Specific measures shall be taken to protect the fibers from the ingress and propagation of moisture. The outer sheath shall be resistant to water and hydrocarbon contamination. Gel filled loose tubes shall not be used for vertical cable runs or in submerged applications. Tight buffered or ruggedized fiber optic cable type shall be used for long runs or where the cable is to be buried or submerged.

Each cladded core shall have two coatings, the first coat 250-900 µm plastic layer; the second coat 200-400 µm layer of waterproof acetate. Direct buried fiber optic cable shall be of a steel wire or steel tape armoured construction. Single-mode fiber optic cables shall be used when there is only one propagation mode (single wave length) or where there is a long transmission distance. The fiber optic cores shall be either 7.1 or 8.5 µm diameter.

The cable shall be suitable for transmission of laser light. The optical cable shall be of the single mode type equipped with at least 24 fibers and shall be suitable for direct burial underground. The fiber cladding diameter required is 125 micron, optimized for 1310 nm, but suitable for transmission at 1550 nm wavelength. Construction and type testing shall be in accordance with the appropriate international standard with a maximum cabled fiber attenuation not exceeding 0.4 dB/km at 1310 nm; and not exceeding 0.35 dB/km at 1550 nm Multi-mode fiber optic cables shall have a core diameter of 50, 62.5 or 100 µm, of all dielectric construction, with a graded index, suitable for use in the wavelength range 850 to 1300 nm. Construction and type testing shall be in accordance with the appropriate international standard. Multimode fibers shall be suitable for the transmission of infrared light produced by LEDs.

Simplex fiber optic cables consist of only one fiber link and should be used for applications that require only one-way data transfer. Simplex can be applied to both single and multi-mode type fiber optic cables. Preferably the fiber optic cable shall be installed in one length without joints, however where joints cannot be avoided shall complete all jointing as specified below. No intermediate joints are permitted in multimode fiber optic cable joints shall be housed in a weatherproof joint box. Joint boxes shall be provided with the cable.

The joint box shall be made of corrosion resistant aluminum alloy or similar material. The cover shall be provided with a long life neoprene gasket to provide a seal against moisture and dust in an ambient environment of 100% humidity and 55 ºC. The cable inlet shall be similarly sealed. If joint box locations will be exposed to the sun then sunshades are required and these shall be provided with the joint boxes. Intermediate cable joint boxes will be provided at approximately 2 km intervals, subject to the maximum fabrication/drumming requirements from the manufacturer. The joint box shall be placed in suitably accessible positions and be appropriately marked.

The fibers shall be spliced by fusion techniques for minimum signal loss. A heat shrink optical supporting sleeve with inner mechanical reinforcement shall protect the splice. Terminations at either end of the cable runs will be performed into patch panels using ceramic ST connectors supply the patch panels unless otherwise stated in the general technical requirements. A fan



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out kit to protect each fiber strand in its own buffer sheath shall be used when terminating loose-tube cables. Patch cords shall be used between patch panels and equipment cabinets within buildings. Patch cords shall be performed, tight buffered, single or duplex fiber cables, 62.5/125 micron, multi-mode type, provided in standard lengths complete with factory-installed ceramic ST connectors and with sheathing suitable for internal building use.

All patch cords shall be supplied and installed. All patch cord runs between cabinets shall be mechanically protected in conduit or closed trunking provided and installed. The conduit or trunking shall contain only fiber optic cables and fit fiber optic patch panels for all fiber optic cables in their supply.

The supply shall include any cabinet or enclosure necessary for their installation or protection. Patch panels shall be provided with sufficient ports to terminate all fibers entering the respective building, with 20 % spare installed connectors. Connector type shall be ST. Sufficient room shall be allowed within the patch panel for adequate cable and fiber management, allowing for bend radius control. Independent patch panels and splice trays shall be provided. Smooth fiber and tube management shall be provided. After cable installation and splicing the completed fibers shall be inspected and tested using an Optical Time Domain Reflectometer (OTDR). The OTDR traces generated shall provide as-built evidence of the actual losses on the installed cables.

## 12.15 ILLUMINATION AND SMALL POWER

An adequate indoor and outdoor lighting with illumination levels in accordance with recognized standards will be provided. Inside the powerhouse, an emergency lighting system powered from the station battery must be installed. The system will operate the instant when the normal power supply fails.

AC lighting and small power socket outlets, for 230 V, shall be single-phase, connected between phase and neutral of the 400 V system.

### 12.15.1 Lighting/Illumination System

A complete LED lighting system, with the individual components being of approved type and constructed of best quality materials shall be supplied, installed and commissioned. The scope of supply shall comprise, but is not limited to the following:

- Indoor and outdoor lighting for all equipment, structures, roads and outdoor operation areas as required for the plant
- Lighting main distribution
- Lighting sub-distributions
- Lighting fixtures with LED luminaries
- Power socket outlets
- Portable LED lamps



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- Cabling, wiring, conduit system for the low voltage wiring, convenient outlets, lighting fixtures and lighting panel boards and lighting switches as well as all required installation material

- Specified spare parts and special tools

The average illumination levels, as measured at a height of 0.8 m above floor (above ground level), at any location, shall be as follows (minimum levels):

| | |
|---|---|
| Turbine /Generator Floor | 300 lux |
| Mechanical Floor and Rooms | 300 lux |
| Unit Transformers and Outdoor transformers | 200 lux |
| Street lighting | 20 lux |
| Oil and water storage tank areas | 50 lux |
| Outdoor operating areas, intake / spillway area | 150 lux |
| Accessible cable trenches with fixed covers | 60 lux |
| Indoor transformer rooms, corridors, stair cases, basements 200lux locker rooms, store rooms, toilets, machine rooms | 200 lux |
| Switchgear rooms, battery rooms, day rooms foreman's rooms, dispensary | 360 lux |
| Workshops, offices | 500 lux |
| Control rooms, Relay rooms | 800 lux |

An aging factor of 20% shall be taken into account and therefore the lighting intensities of the fittings must be achieved as a minimum during the acceptance tests.

Throughout the installation the lighting intensity at local measuring and control points and instruments panels shall be at least 200 Lux. Additionally, all local push button stations, control stations, control panels, instrument racks, hand operated equipment like valves, etc., shall – if required due to the low surrounding illumination levels – be lit separately by means of suitable LED luminaries, mounted on poles or at adjacent structures, so as to obtain at least 200 lux illumination level.

The systems include light fixtures operating at 230 VAC (line to neutral connected). The power source for the internal lighting shall be derived from the 400V lighting switchboard.

The machine hall will be provided on both long walls with a chain of fluorescent lamps which are used for normal access. During maintenance and repair jobs on a unit, additional portable lamps will be used where necessary. The control room will have intensity controlled illumination, so that it might be adapted to special situations. Special attention will be paid to avoid reflections on monitor screens.



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Fluorescent light fittings are preferred everywhere indoor where they are feasible. High pressure sodium vapour lamps with built in control gear which are economical and long lasting will be installed outdoors. In order to reduce the number of equipment types and sizes which have to be stocked as spares, there must be standardization of both lamps and fittings. This will result in relatively few varieties.

The illumination level for the emergency lighting will be at least 10 Lux in the entire powerhouse area except control room and unit control panel area. The illumination level of 30 Lux will be specified in those areas.

Portable battery handsets will be made available for additional lighting during maintenance works, e.g. in case of AC failure. These will be located at various important places in the powerhouse, switchyard and intake structures.

Exit lights will be installed above doors, staircases and floors along the emergency exit ways and those will be powered by the uninterruptible power system in the event of failure of auxiliary power supply.

### 12.15.2 Emergency Lighting:

In normal operation, it will be directly powered from the 400 VAC essential switchboards. When plant auxiliary supply fails following will occur,

The first 60 seconds, energy supply will be taken over by the uninterruptible power supply system. After 60 seconds, the supply will be obtained from the emergency diesel generator unit (Emergency load switchgear is separated from normal supply).

Both systems will have a main concept, common distributed “on / off” switches. Emergency lighting will therefore not come on automatically in vacant rooms where the lights are off. However, special consideration will be paid to areas containing “escape routes”.

## 12.16 EMERGENCY DIESEL GENERATORS

One no. 200kVA diesel generator set shall be provided to feed essential station load in case of outage of generating units. This will be connected to Low voltage switchgear board at P/H and will supply power to essential auxiliaries of the units, required for restart of units, a 75kVA DG Set at intake for emergency gate operation and selected emergency lights. The diesel generator will be standard 400volts, 4 wires, 50Hz, Auto start type. The diesel generators shall be supplied with a local control panel which shall include all facilities for remote, auto start and control by the station control system (SCS) as well as facilities for manual starting and loading.

The diesel generator sets will be installed in a properly ventilated room, equipped with fire detection and firefighting arrangements.

## 12.17 ELECTRICAL WORKSHOP

The power plant will be provided with an electrical workshop. It shall be consisting of essential equipment to perform the day to day maintenance of electrical equipment. The necessary electrical T&P and testing equipment i.e. voltmeter, ammeter, ohmmeter, odometer, megger meter, etc. with whole range of special and standard tools necessary to perform all electrical as



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well as the associated mechanical work for maintenance and repair of the power plant equipment shall be required in the workshop.

Sizes and technical data of equipment shall principally be maintained but may be adjusted to fit with vendor's standard production program. Sizes of wrenches and other relevant tools shall be supplied according to the metric system.

## 12.18 GROUNDING SYSTEM

Metallic parts of all the electrical equipment in or around the powerhouse shall be connected to the grounding system for safety of the personnel and equipment. It shall use stranded bare copper conductor in the concrete floor slabs. Ground rods shall be driven in soil surrounding the powerhouses. The number of electrodes shall be determined during the final design stage, keeping in view the soil resistivity and touch/step voltage. The grounding grid shall be capable to sustain without damage heavy currents during short-circuits for specified time. The Engineer/contractor during detailed design study shall carryout the necessary measurements to determine the ground and ground water resistivity to be used for the calculations and the design.

The actual cross-section of the earthing conductors will be defined in the earthing system calculation. All equipment associated with the plant including reinforcement steel and embedded steelwork will be bonded to the earthing electrodes by adequately dimensioned conductors. Surge arresters and transformer neutrals will be directly connected to the main earthing conductor and /or particular earthing rods.

## 12.19 SCADA AND TELECOM SYSTEM

### 12.19.1 Functional Overview

The SCADA and Telecommunication system shall comprise three sub-systems:

- An In-plant Instrumentation and Control system allowing monitoring and control of the plant (referred hereafter as the station) including generators, all auxiliaries, the associated switchgear, and 132 kV switchyard.
- An interface to the existing NTDC SCADA system at the National Power Control Center (NPCC) Islamabad enabling system dispatchers partial control of the Attabad Lake Hydropower Plant from Islamabad.
- A Telecommunication System for the distribution of voice and data within the Power Plant and for exchange of voice and data with NPCC Islamabad.

### 12.19.2 Station Instrumentation and Control (I&C) System

An in-plant I&C system shall be deployed for the monitoring and control of the power house and auxiliary systems, including:

- Control of generators including output power and ALFC.
- The monitoring of rotor vibration and air gap for generators.



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- The monitoring and limited control of spillway gates, power intake flows, water levels, and their auxiliaries.

- The operation of 132 kV Circuit Breakers (in association with NPCC).

The plant instrumentation and control functions can be performed by either a hierarchical SCADA or a distributed control system (DCS). In view of the modularity and superior fault tolerance capabilities of the DCS the latter is proposed for the in-plant or station I&C system. The DCS shall comprise smart transducers and instruments installed across the plant. The controllers, transducers and associated field devices shall communicate over a plant wide LAN. Internet Protocol (IP) and other open standard protocols shall be deployed with built in diagnostics to monitor device health and predict problems thereby avoiding downtime. Field transducers shall communicative with the controllers over industry standard protocols. The station operational staff shall be provided with a Human machine interface (HMI) set up in the station control room for control and routine operation of the power plant.

### 12.19.3 Interface with Existing NTDC SCADA System

Selective key parameters of the Attabad Lake power complex shall be remotely monitored by NPCC and key functions will be remotely controlled from the National Power Control Centre (NPCC), Islamabad in line with NTDC's standard operational practices. The generation of power and 132 kV transmission system at Attabad will be managed by NPCC and the DCS in control room of Powerhouse will be responsible for station control and instrumentation requirements.

NPCC will be responsible for the overall generation and transmission management associated with the Project, while the station DCS will be responsible for the overall station control and instrumentation requirements as well as interfacing with NPCC through appropriate hardware.

All the important plant parameters like active and reactive power of generators, and transmission lines, station frequency, busbar voltage, reactors disconnect switches and faults alarms will be monitored remotely.

The plant DCS shall monitor and display position of circuit breakers, isolators, all local/remote switches for generators and circuit breakers and indication of Automatic Load Frequency Control (ALFC) etc.

### 12.19.4 SCADA Facilities for Tele-Control by NPCC

To enable NPCC to control selective key parameters of the Attabad Lake Power Plant, the following two alternative methods have been considered:

**Alternative-1**

This alternative is an extension of the existing hierarchical SCADA system based on front end computers deployed at NPCC Islamabad. It deploys conventional Remote Terminal Units (RTUs) serving the NPCC SCADA System and is independent of the station DCS at Attabad.

The SCADA requirements will be handled by two separate RTUs, one for monitoring and control of the Powerhouse and one for monitoring and control of 132 kV Switchyard.



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Inter RTU communication shall be provided, if required. The RTU in the powerhouse will be configured in the most effective manner, for example:

- As a separate RTU, or
- As a distributed input/output module from the AIS RTU, or
- As a “slave’ unit scanned by the AIS RTU.

The RTU equipment will be capable to cater for future requirements of Powerhouse and switchyard augmentation.

For the measurements of MW, MVAr, kV and frequency etc., separate transducers will be provided in the SCADA Interface.

**Advantages**

Since the RTUs would be obtaining their own information from the field mounted sensors and transducers, a breakdown in the station DCS would not hamper the flow of information from the field.

**Alternative-2**

This alternative comprises hardware establishing an inter-computer data communication link bridging the station DCS with front end computers hosting the NPCC SCADA applications. A redundant gateway controller/inter-center communication controller, for data inter-change between the station DCS and the SCADA master system at NPCC Islamabad will be installed in the station control room for monitoring and control of the station equipment under SCADA. Dual processors configured as online and hot standby with duplicated database and operating system will be employed in the gateway controller. The gateway will interface with DCS equipment through dual redundant communications infrastructure Gateway or Inter-center communication controller fulfilling all aspects of the communications between NPCC and Attabad Lake HPP Control Room.

In this alternative, no information shall be collected afresh by NPCC rather a subset of information already collected by the station DCS for station control shall be passed on through the Communications Gateway to NPCC.This would save duplication of transducer for data collection, thereby precluding additional interfacing. For reliability, both path and media redundancy shall be deployed for data communication between the station DCS and NPCC utilizing PLC, optical fiber or alternate telecommunication means.

The amount and type of information exchanged between the station DCS and NPCC shall be a software configurable parameter of the gateway controller. The authorization of 132 kV circuit breakers control will be from the NPCC and the station DCS will only monitor the status of circuit breakers. However, this authorization can be set to local control during emergencies or maintenance. The authorization of each 132 kV circuit breaker control will be set individually from the DCS operator console. The selectable authorization levels shall be SCADA, DCS, or local. Similarly, the assignment of ALFC authorization of each generator will also be done from DCS.



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### 12.19.5 Local/Remote Switches

"Three position" (i.e. SCADA/DCS/Local) switches will be provided in the local control panels of 132 kV switchgear equipment and the generator/governor local control panels (LCP) for the 11 kV circuit breakers and generating units respectively.

### 12.19.6 SCADA Control Philosophy

Normally the operation of 132 kV circuit breakers will be from NPCC and the switchyard DCS will only be monitoring their status. However, during emergencies or maintenance, the control authorization of circuit breakers will be set on local control (either station DCS or local control panel). The authorization of each 132 kV circuit breaker control shall be set from the individual three position local/remote switch (SCADA/DCS/Local).

The assignment of each generator set point control or ALFC authorization to SCADA/DCS/Local will also be done from the respective generator local/remote switch. ALFC control from NPCC will be either in the form of a set point value or increase/decrease command to the unit's governor. Operation of the plant local/remote switches will be authorized from NPCC.

RTU communication with NPCC Front End Computers will be through duplicated data channels along the PLC/fiber optic links.

### 12.19.7 Telecommunication System

Dual play data transmission media for transmission of speech, facsimile, data (including energy metering) shall be set up between NPCC and Attabad Lake Powerhouse. Tele protection channels, provision of telecom equipment for power interface with existing NTDC operational telephone network for operational traffic between Attabad Lake HPP and NPCC/existing stations, along with the facilities to meet the administrative traffic for the Power Complex shall also be set up as part of the Telecommunication system.

#### 12.19.7.1 Powerhouse Communication

A communication system consisting of Local Area Network (LAN), digital telephone system (PAX/PABX), VHF radio systems and station clocks will be provided for communicating the power house with intake, switchyard, and residential camp and outside.

A digital telephone network has been planned to be installed in the powerhouse to cover the entire plant (powerhouse, switchyard, intake, the residential camp and outside).

Each generating unit will include at least one noise cancelling telephone per floor. And also step up transformer area will be provided with noise cancelling telephone sets. The outside telephones will be weather proof and installed in the switchyard and other appropriate locations. All offices, workshops, ventilation rooms, battery charger rooms etc., in the power house will be provided with telephone extensions from the digital telephone system.

#### 12.19.7.2 Power House Intake Communication

A fiber optic cable clamped to the 11 kV feeder from powerhouse to intake has been planned to be used for communication purpose. This will have advantages in reliability, quantity of



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information which can be transmitted and most important no problems with electro-magnetic compatibility which outweighs by far its higher price.

A backup digital radio communication link will be provided from powerhouse to intake for communication and protection purposes.

#### 12.19.7.3 External Communication

WAPDA uses Power Line Carrier (PLC) for its communications between powerhouses and the load dispatch centre. The coupling is done between one phase and earth which makes it necessary to install for each communication line, one-line trap and one coupling capacitor at each terminal.

The location of the equipment will be partially in the switchyard and partially in the area of the control room. The 50 VDC communication supply will provide necessary power when there is a power failure in the normal auxiliary supply.

This system will give the possibility for voice and signal transmission on 132kV line between the remote powerhouse and the load dispatch center.

The control room will be additionally connected to the public telephone system to guarantee the communication with the power plant in case of failure of the PLC system.

### 12.19.8 Teleprotection

For 132 kV transmission lines emanating from the Powerhouse, duplicated teleprotection channels will be provided for high speed direct tripping (for breaker failure and reactor protection) and permissive tripping (for distance protection) of lines along with blocking of tripping. In order to achieve maximum security and redundancy, the direct tripping signaling will utilize different equipment to that used for permissive/blocking schemes. The teleprotection signals will not interfere with the speech signals. The equipment for teleprotection will have the flexibility for transmission over any communication medium i.e. PLC or OPGW.

### 12.19.9 Public Address System

For announcement and instructions to the staff in the Powerhouse area, a Public Address system shall be provided which consist of a central power amplifying unit/ and a number of microphones and loudspeakers.

Control consoles with microphones will be provided in the CCR and in each local control area. The complete system will be modular in structure. The system will be capable of selecting a single loudspeaker or a group of speakers.

### 12.19.10 Un-Interruptible Power Supplies (UPS)

A 48 V DC UPS system will be provided for SCADA & telecom equipment to remain functional and operative at all times. The UPS will supply the loads for PLC, Fiber Optic Terminal, RTU, Teleprotection, PABX, PAX and public address equipment. The UPS system will be fully redundant and will comprise duplicated battery chargers, battery banks and DC distributed boards to supply the loads.



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### 12.19.11 Time Synchronization

A station clock system will be provided to ensure constant time keeping across the plant. A master clock will use local time and be synchronized using the Global Positioning System (GPS). The master clock will run slave clocks installed at key locations around the powerhouse especially on the generating unit panels. For tagging of events

satellite based Global Positioning System (GPS) with accurate time synchronization, will be utilized with time receivers at Powerhouse and NPCC. These receivers will communicate with Powerhouse and NPCC master clock system.

### 12.19.12 Video Surveillance System (CCTV)

The Video surveillance system shall comprise CCTV cameras, power supplies and video recording equipment enabling selected locations of the power house premises to be monitored remotely from the control building. The objective of video surveillance system shall be to monitor the entry/exit gates, boundaries, power house premises for security purposes.

The closed-circuit television (CCTV) system will be provided to monitor the condition and status of the project area remotely from the control room of the main control building. The following places

- Intake structure
- Powerhouse
- Entrance gate
- Erection bay (entrance of powerhouse)
- Machine bay
- Essential rooms
- Transformer and 132 kV AIS
- Unit transformer room
- Entrance gate of switchyard
- Entrance of main control building

Video archives for past seven days shall be maintained to facilitate post facto analyses of any untoward incidents. System design shall be flexible to permit future extension of the system. This subsystem shall comprise of the following major components:

a) Video cameras

b) A network video recorder capable of storing video bit streams generated by each camera of up to the last seven days.

The CCTV system shall be extended according to the requirements.



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# 13 TRANSMISSION LINE STUDY

## 13.1 GENERAL

This chapter aims to summarize the interconnection of 54 MW Attabad Lake Hydropower Project (being proposed at Attabad Lake on Hunza River in Hunza District) to Regional grid through 132 kV transmission line network.

The main objective of the transmission system studies is to ensure that the power plant could be connected to the proposed 132kV regional grid at Aliabad and Sost, in a safe, cost effective and reliable manner.

The Northern Areas of Pakistan, located at the gateway to China, Central Asia, Afghanistan and India, are spread over mountainous regions with world's famous mountain ranges of Himalaya, Karakoram and Hindukush. It covers an area of more than 72300 km². The population settlement is normally near the confluence of small streams with main nullahs and the river. In some cases, it also exists inside the valleys where the nullahs have mild gradients with morainic deposits. Slopes of the streams and the tributary rivers, creates tremendous potential that can be harnessed to get cheaper renewable source of energy for feeding to the regional as well as the national grid.

Transmission system of an individual project can only be developed in an appropriate manner when the parameters and layout of existing system that will be needed to satisfy the production and demand of the area, for a certain planning horizon is available. Unfortunately, there exists no comprehensive and integrated transmission network in the entire northern areas, hence no proper data is available that can provide the basis for the planning of transmission system. However, Water & Power Dept. GILGIT BALTISTAN has made a plan to establish certain parameters for the future planning of transmission system in the area.

To cater with the growing energy needs of the area, transmission of power from the national grid to the northern areas can be considered as one of the possible options. But the most suitable option to meet the immediate energy needs of the area, is the rational exploitation of renewable energy sources in the area.

Attabad Lake Hydropower Project is one among these identified run of river schemes that can be developed for the regional grid. The project is located in Attabad area at Hunza river, at a distance of 27 km from Aliabad and 120 km from Gilgit. In order to evacuate the power generated by the project, and taking into account the technical and economical parameter, a regional transmission network shall be developed, to link effectively, the load centres that can efficiently absorb the energy. The surplus power shall be required to transmit to the regional grid in Gilgit through the interconnection network of 132 kV transmission lines.

Currently, entire region of Gilgit Baltistan is facing the shortage of electricity. Water & Power dept. of GILGIT BALTISTAN has prepared the plan to meet the demand by installing new hydropower projects with the commissioning and upgradation of transmission network. In this scenario, Attabad Lake HPP will help out to meet the energy demand in Hunza and other cascaded districts.



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Following are the necessary activities to establish basic project parameters / information on which the whole transmission line project will be based.

- Identification of tentative transmission line route from Attabad to the nearest load centers.
- Study and analysis to select the main components e.g. conductor, tower's type, insulator' type & strength and related hardware.
- Quantification of different components of transmission line.
- Development of cost estimate.

## 13.2 EXISTING GILGIT BALTISTAN TRANSMISSION SYSTEM

Gilgit-Baltistan lies between longitude 73 degree and latitude 35 degree and the population of about 1.5 million people spread over an area of 72496 sq, km. Topographically the region is mountainous and hilly surrounded by the ranges of Karakorum, Himalayas and Hindukush with deep gorges and narrow valleys. The region is not connected with the national grid due to its mountainous terrain, non-availability of high-power transmission line system and extreme weather conditions. The electricity demand of the area is mostly met by developing isolated micro and small hydro power stations having capacity 0.4-18MW installed on various rivers and nullahs. Electric power so generated is transmitted through 66KV, 33KV and 11KV overhead transmission lines and distributed through 400V LV distribution system on off grid basis.

## 13.3 ESTABLISHMENT OF REGIONAL GRID

Presently Gilgit-Baltistan area grid of 140 MW capacity is operating in many islands and is not connected to any grid system. There was need of assembling the data and model the present grid system and plan the interconnection along with new incoming large hydro plants. Presently the power network is based on off grid and the aim of the project is to bring them on one-grid in the region and readiness for further connection to the National Grid.

The main objectives are as under:-

Reduction of the present power loses of over 35% to the allowable limits.

Efficient management of power supply in Gilgit-Baltistan due to interconnection of all the power stations and increase of diversity factor.

Development of HPPs at the most promising sites due to availability of high voltage transmission network.

Connection to the National Grid would be possible for evacuation of surplus power to the National Grid to meet the shortage at the National level.

Attraction to the private sector to invest in the hydro power sector on IPP & PPP modes to supplement the National Grid to overcome energy shortage and to minimize subsidy and circular debt.

The regional grid would further be connected to the National Grid for evacuation of surplus power and to attract private investors to develop HPPs at the most promising sites in the region to meet the energy shortage at the National level. High voltage transmission lines of 132 KV



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and 66 KV along with grid stations have been proposed according to the feasibility study conducted through an independent consultant.

## 13.4 PARAMETERS FOR TRANSMISSION LINE STUDY

Transmission system of an individual project can only be developed in an appropriate manner when the parameters and layout of existing system that will be needed to satisfy the production and demand of the area for a certain planning horizon is available. Unfortunately, there exists no comprehensive and integrated transmission network in the entire northern areas, hence no proper data is available that can provide the basis for the planning of transmission system. However Water & Power Dept. GB has made a plan to establish certain parameters for the future planning of transmission system in the area.

Following are the necessary activities to establish basic project parameters / information on which the whole transmission line project will be based.

In coordination with Water & Power Department Gilgit-Baltistan, identification of transmission line route from Attabad to the nearest load centers.

Quantification of different components of transmission line.

Study and select the main components e.g. conductor, towers, insulators and related hardware.

Development of cost estimate.

## 13.5 TRANSMISSION LINE FROM ATTABAD LAKE HPP

The power generated by the Attabad Lake Hydropower Project shall be mainly supplied to the load centers in the central Hunza, Aliabad and the upper Hunza (Sost) through 132 kV transmission lines. The transmission line from Attabad Lake HPP to Aliabad & Sost shall fulfill the transmission requirements keeping in view N-1 contingency and transmission of power generated by the expected future hydro power projects. A double circuit 132 kV transmission line of 27km will be connected to the proposed Aliabad Grid station to further disperse the power in the Regional Grid Network (RGN).

Alongwith double circuit 132 kV transmission line to Aliabd, a 132 kV single circuit of 70 km transmission line is also proposed upto the existing 33kV grid station Sost which is already in operation to cater for the domestic electricity demand and likely to be upgraded to 132/33/11 kV grid station. Govt. of GB is planning to make the Sost area industrialized and a dry port there in upcoming years. In the route of Aliabad to Sost, population is less and scattered therefore to meet the domestic electricity demand, already existing 33 kV line will be used to disperse the power from Sost to upper and lower nearby populated areas.

Aliabad is the commercial and administrative centre of Hunza district. Water and Power Dept. (GB) has proposed the 132/66/11 kV, 55 MVA capacity grid station in the Aliabad. There are 3 suitable sites located aside the bank of Hunza River passes near to Aliabad Town. The coordinates of these sites are listed below:



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| Alliabad Grid Station | Longitude | Latitude |
|---|---|---|
| Site 1 | 74°38'6.65611"/ 74.6241230583 | 36°18'8.71248"/ 36.3024201327561 |
| Site 2 | 74°38'6.65611"/ 74.6351822536 | 36°18'34.36322"/ 36.309545339016 |
| Site 3 | 74°38'7.22723"/ 74.6353408969 | 36°18'33.69423"/ 36.309359508971 |

All sites are located above the river water surface level. The studies regarding flood dangers will be carried out at design stage by Engineer. Large gravels are found at sites 1 & 2, while site 3 is located on plane ground. Final site to construct the Grid station will be selected by Water and Power Gilgit Baltistan.

## 13.6 TRANSMISSION VOLTAGE

As per Pakistan's Grid Code, the voltage of all the busses under normal operating condition should remain within the bandwidth of +8% to –5% of Nominal System Voltage. Under (N-1) contingency operating conditions, the voltage variation shall be in the range of +10% and –10% of Nominal System Voltage.

132 kV will be most suitable and economical to transmit power of 54 MW from Attabad-Lake Hydropower Project to Aliabad & Sost grid stations as the same voltage level (132 kv) has been selected for up-gradation of regional grid.

## 13.7 LOADABILITY CHARACTERISTICS

Load ability or transfer capability of transmission line depends upon the following:

- Voltage of the system
- Length of the transmission line
- It is represented as a percentage of its Surge Impedance loading (SIL) permissible with in the allowable voltage drop, thermal and stability limits.
- An increase in power (current) in a line will:
- Increase $I^2R$ loss and hence temperature of the conductor denoted
- Cause increase sag of the conductor.
- Increasing sag decreases the clearance to the ground of conductor.
- Increase the voltage drop.
- increase the transmission line angle.
- All the above mentioned factors limit the maximum power transfer capacity of the transmission line. In fact, the governing limitations are different for different lines depending on:
- Line length
- Type and degree of compensation
- System characteristics / conditions



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According to the universal load ability curve for overhead transmission lines, load ability for a transmission line of 80 km length is 3.0 times its SIL (Surge Impedance Loading) and increases exponentially for lines of length shorter than 80 km.

## 13.8 NUMBER OF CIRCUITS

Numbers of circuits for a power transmission line are determined by the power carrying capacity of a particular voltage level over the required distance. Transmission line loadings should not exceed 85% of their normal ratings under steady state operating (normal) conditions. Under outage/contingency conditions, the transmission lines may be loaded up to their short term or emergency ratings which are equal to their SIL (Surge Impedance Loading) or thermal ratings depending upon the line length involved.

A double circuit transmission line is envisaged from Attabad to proposed Aliabad grid station, which will further disperse the power in the Regional Grid Network (RGN).

The double circuit transmission line to Aliabad will be necessary keeping in view the 'N-1' criterion as well as possibility of induction of additional power from future power projects in the area, The option of single circuit is also otherwise not feasible because system voltage and stability will remain at stake even under normal operating conditions, if full capacity of about 130 MW on 132 kV line is utilized with future local generation.

A single circuit with N contingency is proposed to transmit the power Whereas, from Attabad Lake HPP to Sost.

## 13.9 TRANSMISSION LINE ROUTE

Detailed visits of the project area concludes that the possible transmission line route will be along KKH road/ Hunza River depending upon the accessibility to the transmission line route while no alternate route is available. The whole terrain is mountainous with steep gorges and tight bends on the road. The areas along the route may be subjected to snowfall on some sections from the project site to the load centers.

Access to the tower sites during execution phase will mainly be possible from the existing road. At some places the tracks / kacha roads exist which may require repairs, along with construction of new approaches for transportation of construction machinery and line materials. In order to overcome certain constraints, the line may have to be crossed to the other bank of Hunza River. Few locations may not be accessible; in such cases material will have to be transported to site through alternate means.



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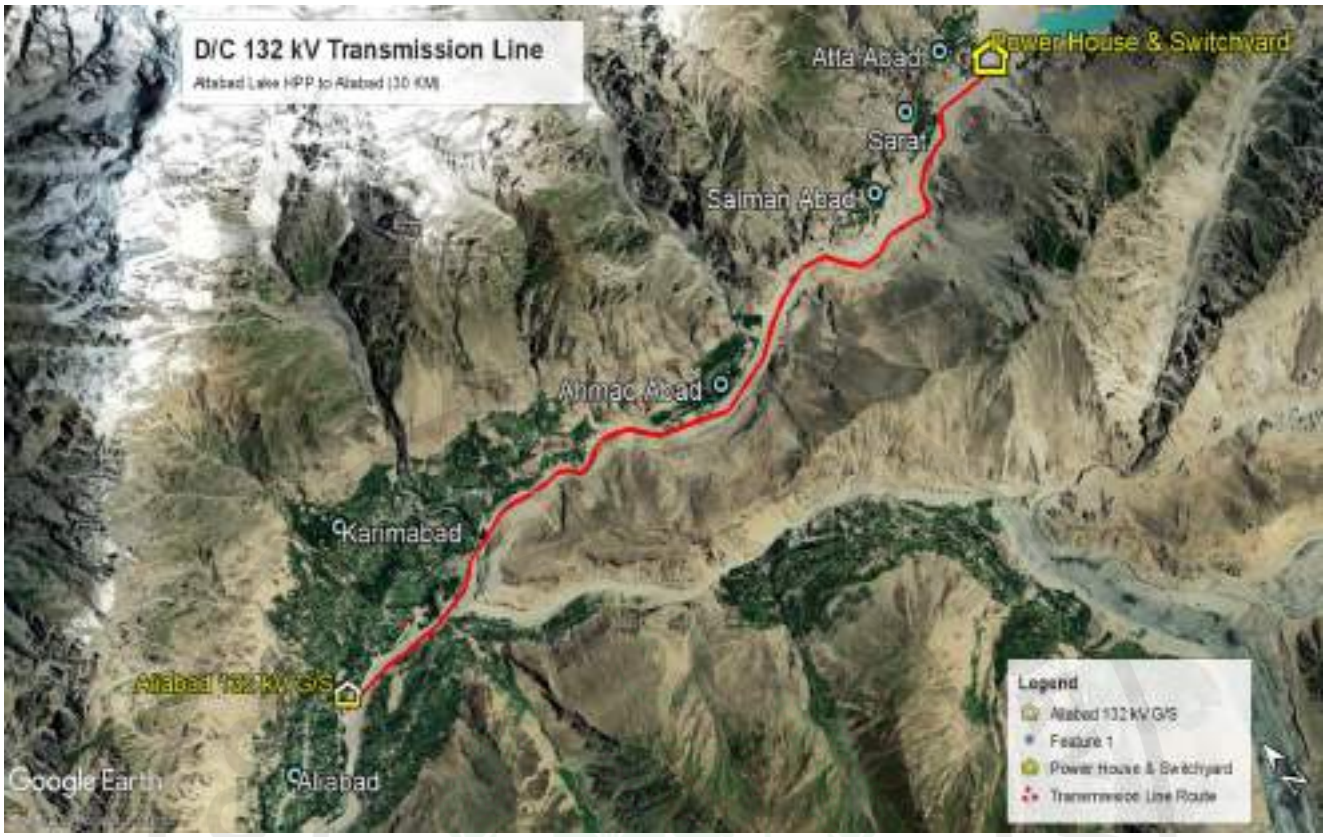


**Figure 13-1 Transmission line route -Project Site to Aliabad G/S**

The types of rock observed along the line route corridor are suitable for tower foundations on hill slopes. Controlled blasting will also be required both for making approaches and constructing tower foundations. In view of the prevailing terrain and environmental conditions along the proposed line route, careful design considerations such as providing higher ratio of angle towers to suspension towers along with its extent, shorter spans, insulators of suitable type and higher strength and related hardware of compatible strength are required.

Detailed survey followed by preparation of plan & profile drawings and spotting of towers will however be done separately during the detail design stage.



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**Figure 13-2 Transmission line route -Project Site to Sost G/S**

## 13.10 CLIMATIC CONDITIONS

The Gilgit / Hunza River basin falls in the “subtropical continental high lands” climatic region. The weather of the area is characterized by moderate summer and severe winter. The winter season starts from November and extends up to April, and summer from May up to October. The temperature data of areas is presented in Table 13-1.

**Table 13-1 Monthly Max. and Min. Temperatures**

| Location | Mean Monthly Max. | Mean Monthly Min. |
|---|---|---|
| Attabad | 25° C | - 10° C |
| Hunza | 30.6° C | - 8.0° C |
| Gilgit | 36.1° C | - 2.7° C |

## 13.11 SELECTION OF CONDUCTOR

As a normal rule, the conductor of a double circuit transmission line is selected on the following basis:

- The conductor should be capable of carrying the desired quantum of power under normal operating conditions, as well as under the situation of contingency outage of one of the two circuits.

- It should be strong enough to withstand extra loadings due to ice and wind pressure.



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- It should be helpful in improving system operating conditions, including voltage profile, phase shift / stability, power losses etc.

Selection of conductor for the line has been done through comparison of Lynx, Panther and Rail conductors, which is presented in Table 13-2.

**Table 13-2 Comparison of ACSR Lynx, Panther and Rail Conductors**

| Sr. No. | Description | ACSR LYNX Conductor | ACSR Panther Conductor | ACSR RAIL Conductor |
|---|---|---|---|---|
| 1. | Number and diameter of each aluminum strand (mm) | 30/2.79 | 30/3.00 | 45/3.70 |
| 2. | Number and diameter of each steel strand (mm) | 7/2.79 | 7/3.00 | 7/2.47 |
| 3. | Overall diameter (mm) | 19.53 | 21 | 29.61 |
| 4. | Area of cross section of aluminum ($mm^2$) | 183.4 | 212.10 | 483.43 |
| 5. | Area of cross section of steel ($mm^2$) | 42.77 | 49.40 | 33.43 |
| 6. | Total area of conductor ($mm^2$) | 226.17 | 261.50 | 516.86 |
| 7. | Weight (Kg / Km) | 842.4 | 973.8 | 1600.2 |
| 8. | Ultimate tensile strength (Kg) | 8483 | 9410 | 11749 |
| 9. | DC resistance (Ω/ Km) | 0.1580 | 0.1363 | 0.0600 |
| 10. | Current carrying capacity at 40° C (min. at w nd vel. of (m/s) (Amp) | 330 | 367 | 626 |
| 11. | Power loss (W/Km/Amp) | 0.474 | 0.408 | 0.180 |

### 13.11.1 TENSILE STRENGTH

The above comparison shows that the ultimate tensile strength of Rail conductor is around 38% & 24% higher than that for Lynx & Panther conductors, respectively. Hence, Rail conductor will be more reliable and secure in difficult terrain encompassing high mountains, steep gorges, sharp bends & difficult crossings as well as high to low degree of snowfall & wind pressure along the proposed transmission line route.

### 13.11.2 POWER TRANSFER CAPABILITY

The current carrying capacity of Rail conductor is around 90% and 70% higher than that for Lynx and Panther conductors, respectively.



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One circuit of Rail conductor will accommodate safely up to 130 MW with acceptable voltage and other system conditions. Hence, in case of outage of one circuit from Attabad Lake HPP to Aliabad, other circuit with rail conductor will not only accommodate full power of 54 MW from Attabad-Lake Hydropower Project but will also have provision of accommodating additional power of other possible future power projects in the area.

### 13.11.3 POWER LOSSES

Power loss through Rail conductor will be about 62% and 56% less compared to that for Lynx and Panther conductors, respectively.

### 13.11.4 RECOMMENDATION

Due to the above mentioned advantages, it is recommended to use Rail conductor for the subject. Rail conductor will be in accordance with WAPDA / NTDC Specification No. P-50:88.

## 13.12 TOWERS

### 13.12.1 TYPE AND BASIC DATA

Towers will be as per WAPDA / NTDC Standards and Specifications applicable to double circuit & single circuit 132kV transmission line using Rail conductor.

Types of these towers as designated in the Specifications are “ZM-1”, “ZM-30” and “ZM-60”. “ZM-1” is Suspension tower whereas “ZM-30” & “ZM-60” are Angle towers. Basic data of these towers is as follows:

**ZM-1**

| | |
|---|---|
| Deflection Angle | $30^0$ |
| Wind Span | 230 m |
| Weight Span | 260 m |
| Weight of the basic tower | 4275 kg |
| Weight of 3 m Leg extension | 708 kg |
| Weight of 6 m leg extension | 1400 kg |



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**ZM-30**

| | |
|---|---|
| Deflection Angle | $30^0$ |
| Wind Span | 230 m |
| Weight Span | 260 m |
| Weight of the basic tower | 6415 kg |
| Weight of 3 m Leg extension | 1242 kg |

**ZM-60**

| | |
|---|---|
| Deflection Angle | $60^0$ |
| Wind Span | 230 m |
| Weight Span | 260 m |
| Weight of the basic tower | 8594 kg |
| Weight of 3 m Leg extension | 1739 kg |

### 13.12.2 TOWER CONFIGURATION

WAPDA/NTDC Standard configuration will be used as much as possible. This shall facilitate design, erection, maintenance, stock, etc. and shall also use the organizational experience in construction, operation and maintenance. Therefore the existing WAPDA/NTDC drawings for double circuit & single circuit 132kV are to be taken as base.

The new tower configuration has to consider the behavior of conductors and earth wires in different Zones under the conditions with and without ice, under wind acting on them and considers the movement of conductors due to dropping of ice.

To minimize stresses in earth wire peaks at suspension towers due to unequal span length or unequal additional loading. It is recommended to clamp the earth wires by V frame with approximately 0.7m length at the tension tower peaks. This would prevent grid mounting and allows balance of difference in tensions. For the new tower configuration it is assumed that sag and ground clearance shall be the same as for standard 132kV lines built so far.

It is assumed that towers will need increased internal clearance to consider different behavior of conductors under the no load and load conditions as well as the unequal dropping down of accretions.

### 13.12.3 MIX OF DIFFERENT TYPES OF TOWERS

The numbers of each type of tower shall be finalized as per site during the detail engineering design.

The ratio of suspension tower to angle tower come out to be 30: 70 as compared to the ratio of 80: 20 generally used in plain areas. The low ratio of suspension towers to angle towers will be one of the most important factors with respect to the reliability and security of the subject transmission line along the difficult route involving difficult, mountainous terrain, steep gorges and sharp bends. Provision of appropriate number of WAPDA / NTDC Standard 220 kV towers of types EA, ED & EG, respectively, is also recommended for use specially at locations involving crossings of steep gorges, river etc.



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The average span shall be based on the site conditions during the detail engineering design stage. The important aspects for length of span are however are the acceptable margin of safety, additional estimated combined loading of up to 25 % on towers due to ice accretion. If required, the spans can be further reduced for line stretch in high ice zone and with longer spans in low ice areas, during project execution stage.

As mentioned earlier, the task of detailed survey, preparation of plan and profile drawings and spotting of towers will be undertaken during the project execution stage. Type of tower and span at each identified location throughout the line stretch will also be determined and finalized with the approval of the Engineer.

### 13.12.4 ADDITIONAL LOADINGS DUE TO ICE AND WIND

During extreme winters, additional combined load on towers due to ice accumulation on conductor, insulators and cross arms is expected to be up to 25 % of normal loading, ranging from maximum to minimum between project site to load centers.

The number and mix of angle to suspension towers with much reduced spans will help sustain the additional loading on towers due to ice and wind. However, larger foundation base may be essential requiring design of new towers and tower foundations to withstand simultaneous impact of ice and wind pressure especially in the high ice zone. This aspect should be got checked by NTDC, based on their experience of existing transmission lines in the similar areas.

If concerns about stability of towers against extreme ice and wind conditions could not be resolved, then employer should consider awarding this project on EPC basis wherein the contractor will also be responsible for design of new towers and associated foundations, if needed.

In any case, design and testing of new towers is highly specialized and an independent task which is not covered under the present scope of work.

### 13.12.5 WAPDA / NTDC SPECIFICATIONS

For proposed towers, the related WAPDA / NTDC Specifications are as under:

| | |
|---|---|
| Fabrication of Steel Structure | P-139:80 |
| Zinc Coatings | P-82:81 |
| Steel Nuts and Bolts (Inch Series) | P-19:83 |
| Barbed wire | P-162:81 |
| Danger & Sign Plates | P-104:76 |
| Steel Washers | P-20:68 |

### 13.12.6 FOUNDATIONS

Tower foundations will be in accordance with WAPDA / NTDC Standards and Specifications.

Foundation type and design will be corresponding to each type of Standard tower used.



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Geotechnical investigations for construction of foundations will be carried out during the project execution stage. Foundations will be classified as normal, pile, rock-anchor, or any special foundation not covered in the WAPDA / NTDC Specifications.

For each foundation, each type of foundation will be identified during project execution stage which will be reviewed / approved by the Engineer. The design and method of construction for any special foundation not covered in the WAPDA / NTDC Standards will also be submitted to the Engineer for review / approval.

### 13.12.7 INSULATORS

In order to avoid flash-over due to ice and fog, Fog type porcelain insulators are recommended to be used. In normal areas, insulators of 80 kN strength are used on 132 kV transmission lines in NTDC system. However, because of difficult conditions associated with route of the subject transmission line, Fog type insulators of 100 kN strength have been considered to make the line completely reliable and secure. 8 numbers of insulators per string is recommended. The Fog type Insulators will be in accordance with WAPDA / NTDC Specification No. P-8:96.

The WAPDA / NTDC Specifications for insulator hardware will be as under:

| | |
|---|---|
| Suspension Strings: | P-140:82 |
| On Strings | P-143:82 |

### 13.12.8 MISCELLANEOUS ITEMS

Miscellaneous items of transmission lines will be according to the following WAPDA / NTDC Specifications:

| | |
|---|---|
| Galvanized Steel Wires | P-12:80 |
| Earth Wire Fittings | P-141:80 |
| Mid Span Joints and Repair Sleeves | P-144:80 |
| Stock Bridge Vibration Dampers | P-142:83 |
| Grounding Material | |
| Earth Rod | P-116:81 |
| Copper Wire for Earthing | P-16:68 |

## 13.13 OPTICAL OVERHEAD GROUND WIRE (OPGW)

In order to protect the transmission line and grid station equipment from lightning and to transmit the protection and communication signal optical ground wire will be provided.

The main features of the cable will be

| | |
|---|---|
| OPGW size | 70 mm2 |
| Outer diameter | 11.4mm |
| Breaking load | 8000kg |
| DC resistance at 20$^{o}$C | 1.02 ohm/km |



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| | |
|---|---|
| Nominal weight | 458kg/km |
| Number of fibers | at least12 |

## 13.14 ENVIRONMENTAL ASPECTS

In high voltage range, the conductor selection is based on

a) Corona losses
b) Radio interference (RI)
c) Television interference
d) Audible noise (AN)

### 13.14.1 CORONA LOSSES

The effect of increasing the operating voltage of a line as its critical surface gradient (21.2kV/cm) is approached, is producing power losses in the lines and causes the conduc tor to generate emanate higher frequencies causing radio and television interference.

For Attabad-Lake HPP transmission line, the conductor diameter will be higher than the permissible limit. In view of the rail conductor, there will be no problem of corona, radio interference and television interference.

### 13.14.2 AUDIBLE NOISE

Up to 220 kV level, the audible noise generated by transmission lines is usually no concern. The level of AN generation with conductor design which satisfies the RI requirements sufficiently low.

### 13.14.3 Surface Gradient

The clearance between overhead transmission lines and nearest objects are set primarily to avoid any possibility of flash over. The proposed design ensures that there will be no problem of surface gradients causing charging current through the human body or passing vehicle.

## 13.15 MINIMUN CLEARANCE OF 132 KV TRANSMISSION LINE

The minimum clearance of the proposed 132 kV overhead line is as follows:

| | | |
|---|---|---|
| i. | 132 kV lines across country | 6.71m |
| ii. | Over roads and highway | 7.92m |
| iii. | Over rivers and canals | 9.14m |
| iv. | Minimum clearance from building Vertical | 5.18m |
| v. | Horizontal | 6.10m |



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# 14 PROJECT QUANTITIES AND COST ESTIMATES

## 14.1 GENERAL

The cost estimates form the basis of the economic and financial evaluation of the Project. These have to be prepared on the basis of representative unit rates for the various construction activities and the respective quantities. The estimation of cost for Attabad Lake Hydropower Project (ALHPP) has been carried out on the basis of Feasibility Drawings.

The cost estimate for ALHPP covers quantities and costs for Preparatory works, Environmental Mitigation, Civil and Electrical & Mechanical (E&M) works. Civil Works items such as earthwork, concrete, reinforcement, shotcrete and grouting, etc. have been estimated based on Feasibility Drawings. Rates adapted are based on WAPDA Composite Schedule of Rates, Material based Survey Rates and recently tendered WAPDA Projects.

### 14.1.1 Basic Assumptions

Few assumptions are always made in cost estimation. For this costing, following assumptions and exceptions are considered:

- No allowance has been kept in the rate analysis for price escalation. All rates have been evaluated on March, 2021 prices.
- Project layout and alignment of structures will not change.
- The survey on which the whole study has been according to prevailing International Standards.
- Specifications for the construction would be according to prevailing International Standards.
- Land acquisition of the Project Area and other pre-construction activities will be completed before Contractor's mobilization.

## 14.2 COST ESTIMATION

Cost estimation of any Project or its component is based on two factors; one is Quantity and the other is Unit Rate. The cost estimates for various works including Preparatory works, Civil and E&M works have been prepared by multiplying unit rates with the relevant quantities of different items.

### 14.2.1 Price Index

For Local & Foreign cost component the rate of 1 US$ = Pak Rs. 157 of March, 2021 price level has been adopted.

### 14.2.2 Development of Unit Rates

To develop the unit rates, the operating cost of the equipment, labour and material cost has been worked out from basic data.

**Rental and Operating Cost**



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The operating cost of the equipment are worked out which includes the rental cost of machinery, operators' charges and fuel, lubricant and minor repair costs.

**Labour Cost**

The rates of wages for the skilled, un-skilled and operators for various construction equipment are required to work out operating cost. The selected rates are based on market wages in Hunza District. These rates are based on 8 hours of work per day.

**i. Rental and Operating Cost**

The operating cost of the equipment are worked out which includes the rental cost of machinery, operators' charges and fuel, lubricant and minor repair costs.

**ii. Labour Cost**

The rates of wages for the skilled, un-skilled and operators for various construction equipment are required to work out operating cost. The selected rates are based on market wages in Hunza District. These rates are based on 8 hours of work per day.

**iii. Material Cost**

These costs fall under two categories:

- Manufactured items: e.g. cement, POL, steel, etc. The unit rates taken for these items are ex-factory rates including transportation to the site.
- The other category includes concrete aggregates and riprap which are readily available at site. These materials will be processed in size as per requirement at site and used. Local market rate has been taken for these materials for rate analysis.

### 14.2.3 Rate Analysis

Rate analysis for each major item of work includes the rates for individual machines involved in a process, generating composite rates for each major item of works by combining the required number of different machines to develop a workable group and loading it with necessary operators/drivers and materials.

International price for the major equipment were used including its transportation from Karachi port to Project site. Duties and taxes are not included in the equipment cost as it is considered feasible by many foreign contractors to procure the machinery on import/re-export basis by submitting the guarantees against duties and taxes. Bank charges for these guarantees have been accounted for in the computation of Contractor's indirect cost.

Transportation of equipment from Karachi to Project site has been estimated on the basis of cargo handling charges through existing roads. On the basis of rates selected earlier for labour, material and operating equipment, the unit rates for each item is then derived. Specified field conditions are taken into consideration. Provision of overheads, idle hour, supervisions staff cost and contractors profit has been taken while working out the equipment and labour cost components. It has been assumed that:



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- Work will be carried out for 8 hours per day and
- 26 working days per month

### 14.2.4 Basis for Unit Rates

The Project cost is sensitive to the unit rates. Thus, care has been exercised in deriving the unit rates. Unit rates for most of the items of Civil Works of ALHPP have been estimated using rates analysis method. The rate analysis for several items of Civil Works such as excavation, structural reinforced cement concrete, plain cement concrete and, shotcrete have been derived and applied to the quantities for cost estimation. For certain items, the unit rates have been compared and checked with the rates of recently WAPDA tendered projects. The WAPDA Composite Schedule of Rates, 2013 has also been consulted. For some of items related to Project, due escalation has been applied for price level of March, 2021 to arrive at most reasonable and realistic rates.

Cost of E & M equipment is based on budgetary prices from reputed manufactures, both local and foreign. The following factors have also been assumed during the development of Civil and E&M works cost estimate:

- Construction of major civil works and installation of majority of the E & M equipment will be performed using Pakistani or an equivalent cost competitive labor force; and
- Where feasible, equipment fabrication will be carried out locally. Locally produced items could include trashracks, stoplogs, embedded parts and the rolling & welding of steel manifold.

Unit rates adopted for different items are presented in Table-14.1.

### 14.2.5 Civil Works Quantities

Civil works quantities for cost estimate have been calculated using Feasibility Drawings consisting of plans and sections of all the Project components. These drawings are presented in Volume-2 of Feasibility Report. Efforts have been made to estimate the quantity of each major items of each Project component with accuracy.

Major portion of the Civil Works estimate includes calculations for earthwork, concrete and reinforcement etc. For the major structures such as Main Weir, Sediment Flushing Channel, Power Intake, Low Pressure Headrace Tunnel, Surge Tank, Penstock, Powerhouse, Switchyard and Tailrace Channel, the quantities of earthwork, concrete and reinforcement are presented in Table-14.2.

## 14.3 BREAKDOWN OF ESTIMATES

The basis for costing of different project components is briefly discussed as under:

### 14.3.1 Land Acquisition and Environmental Mitigation

Land Acquisition and Environmental Mitigation cost contains the cost of permanent land acquisition for project components, temporary land acquisition, building compensation, spoil disposal area rehabilitation, rehabilitation of villages, livelihood allowance for affectees, monitoring &evaluation and land conservation etc. The total cost of land acquisition and environmental mitigation is estimated as Rs. 208.450 Million (Ref: Table-14.4).



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### 14.3.2 Preparatory Works

The items under this component includes construction of access roads within the Project area, site installations, Contractor camps, construction of camp/colony for Consultants' and WAPDA staff, construction of bridge near powerhouse. The cost for mobilization and demobilization and reservoir slope stabilization & construction risks costs are also included. The total cost for preparatory works is estimated as Rs. 952.945 Million (Ref: Table-14.5).

### 14.3.3 Main Weir

Estimate for Main Weir includes construction of Main Weir itself along with the construction of upstream and downstream coffer dams to facilitate the working of the main civil structures. The total cost is estimated as Rs. 2,008.821Million (Ref: Table-14.6).

### 14.3.4 Sediment Flushing Section

Cost of construction of Sediment Flushing Section consists of cost for clearing & grubbing, soil and rock material excavation, rock excavation, concreting, reinforcement, grouting etc. The total cost of Sediment Flushing Section is estimated as Rs. 2,326.679 Million (Ref: Table-14.7).

### 14.3.5 Power Intake

Cost of construction of Power Intake consists of cost for rock excavation, concreting, reinforcement etc. The total cost of power intake is estimated as Rs. 429,289 Million (Ref: Table-14.8).

### 14.3.6 Low Pressure Headrace Tunnel

Cost of construction of Low Pressure Headrace Tunnel consists of cost for rock excavation, shotcrete, rock bolts, concreting, reinforcement and access tunnel cost etc. The total cost of headrace tunnel is estimated as Rs. 1,820.182 Million (Ref: Table-14.9).

### 14.3.7 Surge Tank

Cost of construction of Surge Tank consists of cost for rock excavation, shotcrete, rock bolts, concreting, reinforcement etc. The total cost of surge tank is estimated as Rs. 132.727 Million (Ref: Table-14.10).

### 14.3.8 Penstock

Cost of construction of Penstock consists of cost for soil and rock excavation, shotcrete, rock bolts, concreting, reinforcement, penstock (steel liner) etc. The total cost of penstock is estimated as Rs. 713.256 Million (Ref: Table-14.11).

### 14.3.9 Powerhouse and Tailrace Channel

Estimate for Powerhouse and Tailrace Channel contains the cost of all the civil works for construction of Powerhouse. It covers the cost of soil excavation, earthen backfill, concreting, reinforcement etc. The total cost of powerhouse and tailrace channel construction is estimated as Rs. 708.792 Million (Ref: Table- 14.12 & 14.13).

### 14.3.10 Watershed Management at Shimshal Nullah

At Attabad Lake, most of the sediment load comes from Shimshal Nullah, therefore, check dams has been proposed in the Nullah for which survey and field investigation will be carried



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out during the detailed design. An amount of Rs. 392.500 Million has been kept for the construction of 03 check dams to control the rate of sediments entering in Attabad Lake.

### 14.3.11 Hydraulic Steel Structures

Estimate for Hydraulic Steel Structures include procurement of power intake main gate, intake trashracks, intake trashrack cleaning machine, draft tube gates and gantry cranes. The total cost of hydro-mechanical equipment is estimated as Rs.139.730 Million (Ref: Table -14.14).

### 14.3.12 Hydro-Mechanical Works

This section deals with the Hydro-Mechanical Equipment which includes procurement of turbines, governors, inlet valves, powerhouse bridge crane and mobile crane, cooling water system, drainage and dewatering system, compressed air system, firefighting system & powerhouse elevators and HVAC system etc. etc. The total cost of hydro mechanical equipment is estimated as Rs. 1,690.890 Million (Ref: Table-14.15).

### 14.3.13 Electrical Works

This section deals with the procurement of Electric Equipment and comprises of generators, transformers (main & auxiliary), MV/LV& DC equipment, grounding, telecommunication and lighting systems, spare parts etc. The total cost of electrical equipment is estimated as Rs. 2,249.339 Million (Ref: Table-14.16).

### 14.3.14 Switchyard Works

This section deals with the procurement of 132 kV Switchyard Equipment and comprises of circuit breakers, communication system, control equipment, spare parts etc. The total cost of Switchyard equipment is estimated as Rs. 428.453 Million (Ref: Table-14.17).

### 14.3.15 Transmission Lines

This section deals with the civil works and procurement of equipment for 132 kV Double Circuit Transmission Line from Powerhouse to Aliabad and 132 kV Single Circuit Transmission Line from Powerhouse to Sost. The total cost of transmission lines is estimated as Rs. 1,500.135 Million (Ref: Table -14.18).

### 14.3.16 Transportation Charges

The E&M equipment for the construction of Project including turbines and generators etc. are to be imported. These equipment are to be shipped from the country of its manufacturing to the Project Site. The transportation charges of equipment have been estimated as Rs. 420.598 Million which are 7% of the E&M equipment cost.

### 14.3.17 Erection & Commissioning

Erection & commissioning charges have been taken as 8% of the E&M equipment cost. The cost of erection and commissioning has been estimated as Rs. 480.684 Million.

### 14.3.18 Engineering and Supervision

This represents the cost of preparation of tender documents, pre-qualification of bidders, evaluation of bids, review of detailed design and submittals by the Contractor, administration of the construction contract and measuring of work. The cost for engineering and supervision has been taken as 7% of the Project cost and is estimated as Rs1,229.539 Million.



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### 14.3.19 Physical and Numerical Modeling

The physical and numerical modeling plays a fundamental role in the analysis of the hydraulic structures behavior of a Project. A lump sum provision of Rs. 5.0 Million has been kept for model studies during detailed design.

### 14.3.20 Physical Contingencies

Contingencies have been included in the estimate. These need to be viewed as an integral part of the estimated construction cost. To cover some of the unforeseen that may occur over the period of construction, 3% of the costs of Civil, E&M and Preliminary works have been applied. Contingencies are estimated as Rs. 526.945 Million.

### 14.3.21 Admin, Audit, Accounts, Legal and Client's Expenses

Administration, audit, accounts, legal and client's expenses have been taken as 2% of the Civil, E&M and Preliminary works costs. The cost of these expenses has been estimated as Rs. 351.297 Million.

### 14.3.22 Authority Overheads

Factor of 1.5% has been applied on the costs of Civil, E&M and Preliminary works to cover this head and Authority Overheads cost is estimated as Rs. 263.473 Million.

### 14.3.23 Insurance Cost

The cost of insurance has been taken as 0.5%of the costs of Civil, E&M and Preliminary works, estimates to Rs. 87.824 Million.

### 14.3.24 Local and Foreign Components

The cost estimates for various works including the preliminary works, civil works, hydraulic steel structures, hydro-mechanical and electrical equipment has been further subdivided into local and foreign cost components. This job has been accomplished by consulting recently tendered WAPDA projects and prepared by multiplying factor (percentage) to the whole cost of different components.



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## 14.4 PROJECT COST

The total cost of the Project by summing up all the costs mentioned above is presented below:

- Total Base Cost Rs. 20,028.916 Million
- Total Base Cost US$ 127.573 Million

The summary of the Cost Estimate is presented in Table-14.3.

The Equipment, Material and Labor rates adopted are given in **Annexure – A.**

## 14.5 PROJECT PHASING

Estimated time for Project construction is 03 years. Accordingly, Project phasing plan has been designed to fulfill the Project needs as per requirement (Ref: Table-14.19).

**Table 14-1 Unit Rates for different Items**

| Description | Unit | Rate (PKR) |
|---|---|---|
| Excavation in common material | $m^3$ | 958 |
| Excavation in Rock | $m^3$ | 2,714 |
| Tunnel Excavation | $m^3$ | 20,278 |
| Shaft Excavation | $m^3$ | 22,608 |
| Shotcrete with Fiber Reinforcement | $m^3$ | 45,080 |
| PCC (1:2:4) | $m^3$ | 17,270 |
| Concrete (1:1.5:3) | $m^3$ | 21,399 |
| Steel Reinforcement Grade 60 | Ton | 204,524 |



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## Table 14-2 Quantities of Main Civil Works Items

| Description | Unit | Quantity |
|---|---|---|
| **Earthwork (Excavation)** | | |
| Main Weir | $m^3$ | 1,008,000 |
| Undersluices | $m^3$ | 1,400,000 |
| Power Intake, Low Pressure Headrace Tunnel, Surge Tank and Penstock | $m^3$ | 98,160 |
| Powerhouse and Tailrace Channel | $m^3$ | 87,044 |
| **TOTAL** | **$m^3$** | **2,593,204** |
| **Concrete** | | |
| Main Weir | $m^3$ | 12,570 |
| Undersluices | $m^3$ | 11,028 |
| Power Intake, Low Pressure Headrace Tunnel, Surge Tank and Penstock | $m^3$ | 29,728 |
| Powerhouse and Tailrace Channel | $m^3$ | 13,584 |
| **TOTAL** | **$m^3$** | **66,910** |
| **Reinforcement** | | |
| Main Weir | Ton | 655.20 |
| Undersluices | Ton | 498.50 |
| Power Intake, Low Pressure Headrace Tunnel, Surge Tank and Penstock | Ton | 1,020 |
| Powerhouse and Tailrace Channel | Ton | 820.50 |
| **TOTAL** | **Ton** | **2,944** |



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## Table 14-3 Summary of the Cost Estimate

Price Index – March, 2021

US$ Exchange Rate = Rs. 157

| Sr. No | Description | Local | Foreign | Cost | | Reference |
|---|---|---|---|---|---|---|
| | | Mill.PKR | Mill.PKR | Mill.PKR | Mill.US $ | |
| **A** | **Preliminary Works** | | | | | |
| A-1 | Land Acquisition & Environmental Mitigation | 208.450 | - | 208.450 | 1.328 | Table – 14.4 |
| A-2 | Preparatory Works | | | | | |
| - | Mobilization & De-mobilization | 500.000 | - | 500.000 | 3.185 | Table – 14.5 |
| - | Project Colony and Contractor Camp | 130.310 | - | 130.310 | 0.830 | |
| - | Access Roads to Main Works sites | 134.235 | - | 134.235 | 0.855 | |
| - | Reservoir Slope Stabilization & Construction Risks | 188.400 | - | 188.400 | 1.200 | |
| | **Sub Total A** | **1,161.395** | **-** | **1,161.395** | **7.397** | |
| **B** | **Civil Works** | | | | | |
| B-1 | Main Weir | 2,008.821 | - | 2,008.821 | 12.795 | Table – 14.6 |
| B-2 | Undersluices | 2,326.679 | - | 2,326.679 | 14.820 | Table – 14.7 |
| B-3 | Power Intake | 429.289 | - | 429.289 | 2.734 | Table – 14.8 |
| B-4 | Low Pressure Headrace Tunnel | 1,820.182 | - | 1,820.182 | 11.594 | Table – 14.9 |
| B-5 | Surge Tank | 132.728 | - | 132.728 | 0.845 | Table – 14.10 |
| B-6 | Penstock | 713.256 | - | 713.256 | 4.543 | Table – 14.11 |
| B-7 | Powerhouse | 624.474 | - | 624.474 | 3.978 | Table – 14.12 |
| B-8 | Tailrace Channel | 84.318 | - | 84.318 | 0.537 | Table – 14.13 |
| B-9 | Check Dams at Shimshal Nullah | 392.500 | - | 392.500 | 2.500 | |
| | **Sub Total B** | **8,532.247** | **-** | **8,532.247** | **54.346** | |
| | **Sub Total (A+B)** | **9,693.642** | **-** | **9,693.642** | **61.743** | |
| **C** | **Hydraulic Steel Structures, Mechanical & Electrical Works** | | | | | |
| C-1 | Hydraulic Steel Structures (HSS) | 104.798 | 34.933 | 139.730 | 0.890 | Table – 14.14 |
| C-2 | Mechanical Works | 33.818 | 1,657.072 | 1,690.890 | 10.770 | Table – 14.15 |
| C-3 | Electrical Works | 31.400 | 2,217.939 | 2,249.339 | 14.327 | Table – 14.16 |
| C-4 | Switchyard Works | 4.285 | 424.168 | 428.453 | 2.729 | Table – 14.17 |
| C-5 | Transmission Line (Single Circuit Attabad to Sost & Double Circuit Attabad to Aliabad) | 1,200.108 | 300.027 | 1,500.135 | 9.555 | Table – 14.18 |
| | **Sub Total C-1 to C-5** | **1,374.408** | **4,634.139** | **6,008.547** | **38.271** | |
| C-6 | Transportation Charges of E&M Equipment @ 7% of Sub Total C1 to C-5 | 252.359 | 168.239 | 420.598 | 2.679 | |
| C-7 | Erection & Commissioning Charges @ 8% of Sub Total C1 to C-5 | 144.205 | 336.479 | 480.684 | 3.062 | |
| C-8 | Government Taxes on E&M Equipment @ 16% of Sub Total C1 to C-5 | 961.368 | - | 961.368 | 6.123 | |
| | **Sub Total C** | **2,732.34** | **5,138.86** | **7,871.197** | **50.135** | |
| | **Sub Total (A+B+C)** | **12,425.98** | **5,138.86** | **17,564.839** | **111.878** | |
| **D** | Engineering and Supervision of Project and Review of Feasibility Study by Consultants @ 7%of Sub Total (A+B+C) | 865.819 | 359.720 | 1,225.539 | 7.831 | |
| | Generation Capacity Espansion Plan for GB | 4.000 | - | 4.000 | 0.025 | |
| **E** | Physical and Numerical Modeling (Lumpsum) | 5.000 | - | 5.000 | 0.032 | |



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Price Index – March, 2021

US$ Exchange Rate = Rs. 157

| Sr. No | Description | Local | Foreign | Cost | | Reference |
|---|---|---|---|---|---|---|
| | | Mill.PKR | Mill.PKR | Mill.PKR | Mill.US $ | |
| F | Physical Contingencies @ 3% of Sub Total (A+B+C) | 372.779 | 154.166 | 526.945 | 3.356 | |
| G | Admin, Audit, Accounts, Legal and Client's Expenses @ 2% of Sub Total (A+B+C) | 351.297 | - | 351.297 | 2.238 | |
| H | Authority Overheads @ 1.5% of Sub Total (A+B+C) | 263.473 | - | 263.473 | 1.678 | |
| I | Insurance Costs @ 0.5% of Sub Total (A+B+C) | 62.130 | 25.694 | 87.824 | 0.559 | |
| | **PROJECT BASE COST** | **14,350.479** | **5,678.437** | **20,028.916** | **127.573** | |

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# COST ESTIMATES

## (Preliminary & Civil Works)

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## Table 14-4 Cost Estimate for Land Acquisition and Environmental Mitigation

Price Index – March, 2021
US$ Exchange Rate = Rs. 157

| Sr. No. | Description | Unit | Qty | Rate | Cost | |
|---|---|---|---|---|---|---|
| | | | | (PKR) | (PKR) | (US$) |
| 1 | Permanent Land Acquisition* | | | | | |
| - | Powerhouse Site | kanal | 32 | 750,000 | 24,000,000 | 152,866 |
| - | Weir & Associated Structures | kanal | 120 | 750,000 | 90,000,000 | 573,248 |
| - | Project Colony | kanal | 20 | 750,000 | 15,000,000 | 57,325 |
| - | Miscellaneous | LS | 1 | 16,000,000 | 16,000,000 | 101,911 |
| 2 | Temporary Land Acquisition | LS | 1 | 1,000,000 | 1,000,000 | 6,369 |
| 3 | Building Compensation | LS | 1 | 15,000,000 | 15,000,000 | 95,541 |
| 4 | Spoil Disposal Area Rehabilitation | LS | 1 | 4,000,000 | 4,000,000 | 25,478 |
| 5 | Rehabilitation of Villages | LS | 1 | 2,000,000 | 2,000,000 | 12,739 |
| 6 | Livelihood Allowance for Affectees | LS | 1 | 2,000,000 | 2,000,000 | 12,739 |
| 7 | Monitoring and Evaluation | LS | 1 | 16,500,000 | 16,500,000 | 105,096 |
| 8 | Capacity Building/training | LS | 1 | 2,000,000 | 2,000,000 | 12,739 |
| 9 | Land Conservation | LS | 1 | 2,000,000 | 2,000,000 | 12,739 |
| | | | | **Sub-Total** | **189,500,000** | **1,207,006** |
| 10 | Contingencies 10% | | | | 18,950,000 | 120,701 |
| | | | | **Total** | **208,450,000** | **1,327,707** |

## Table 14-5 Cost Estimate for Preparatory Works

Price Index – March, 2021
US$ Exchange Rate = Rs. 157

| Sr. No. | Description | Unit | Qty | Rate | Cost | |
|---|---|---|---|---|---|---|
| | | | | (PKR) | (PKR) | (US$) |
| A | Mobilization & Demobilization | LS | 1 | 500,000,000 | 500,000,000 | 3,184,713 |
| B | Project Colony & Contractor's Camp | | | | | |
| 1 | Officer, Staff colony and Hostel | $m^2$ | 4,000 | 31,400 | 125,600,000 | 800,000 |
| 2 | Contractor's Camp | LS | 1 | 3,140,000 | 3,140,000 | 20,000 |
| 3 | Equipment and material storage | LS | 1 | 1,570,000 | 1,570,000 | 10,000 |
| | | | | **Sub-Total (B)** | **130,310,000** | **830,000** |
| C | Access Roads & Bridge | | | | | |
| 1 | Roads in Weir Area | m | 1,200 | 39,250 | 47,100,000 | 300,000 |
| 2 | Road to Power Intake | m | 300 | 39,250 | 11,775,000 | 75,000 |
| 3 | Road to Surge Tank | m | 200 | 39,250 | 7,850,000 | 50,000 |
| 4 | Road to Powerhouse | m | 500 | 47,100 | 23,550,000 | 150,000 |
| 5 | Road to Adit | m | 200 | 31,400 | 6,280,000 | 40,000 |
| 6 | Bridge on Hunza river near Powerhouse | m | 80 | 471,000 | 37,680,000 | 240,000 |
| | | | | **Sub-Total (C)** | **134,235,000** | **855,000** |
| D | Reservoir Slope Stabilization & Construction Risks Costs | LS | 1 | 188,400,000 | 188,400,000 | 1,200,000 |
| | | | | **Total (A+B+C+D)** | **952,945,000** | **6,069,713** |



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## Table 14-6 Cost Estimate for Main Weir

Price Index – March, 2021
US$ Exchange Rate = Rs. 157

| Sr. No | Description of Activities | Unit | Qty | Rate | Cost | |
|---|---|---|---|---|---|---|
| | | | | (PKR) | (PKR) | (US$) |
| **A** | **Main Weir** | | | | | |
| 1 | Excavation for Main Weir upto design depth in Medium Hard Soil removing of material from outside of the structure area | $m^3$ | 828,000 | 958 | 792,975,600 | 5,050,800 |
| 2 | Excavation for Main Weir upto design depth in Rock material requiring blasting i/c removing of material from outside of the structure area | $m^3$ | 180,000 | 2,714 | 488,587,140 | 3,112,020 |
| 3 | Free Draining Backfill | $m^3$ | 8,280 | 1,005 | 8,319,744 | 52,992 |
| 4 | Lean Concrete 1:4:8 | $m^3$ | 990 | 14,130 | 13,988,700 | 89,100 |
| 5 | RCC 1:1.5:3 for Main Weir using crushed stone aggregate (screening & ashing) and coarse sand i/c cost of all labour and material and all kinds of form works, moulds, shuttering lifting / pumping, curing, rendering and finishing the exposed surface excluding steel reinforcement | $m^3$ | 10,920 | 21,399 | 233,678,172 | 1,488,396 |
| 6 | Reinforcement Grade 60 | Ton | 655.20 | 204,524 | 134,004,059 | 853,529 |
| 7 | Dewatering | LS | 1 | 15,700,000 | 15,700,000 | 100,000 |
| 8 | Riprap Protection | $m^3$ | 2,160 | 7,850 | 16,956,000 | 108,000 |
| 9 | Protection with Gabions | $m^3$ | 1,000 | 11,323 | 11,322,840 | 72,120 |
| | | | | **Sub-Total (A)** | **1,715,532,255** | **10,926,957** |
| **B** | **Coffer Dams** | | | | | |
| **B1** | **Upstream** | | | | | |
| 1 | Excavation | $m^3$ | 7,200 | 958 | 6,895,440 | 43,920 |
| 2 | Compacted Concrete | $m^3$ | 660 | 14,130 | 9,325,800 | 59,400 |
| 3 | Jet Grout Cutoff | $m^3$ | 1,000 | 28,563 | 28,563,010 | 181,930 |
| 4 | Riprap Face Protection u/s | $m^3$ | 2,500 | 7,850 | 19,625,000 | 125,000 |
| 5 | Rock Fill | $m^3$ | 8,100 | 1,703 | 13,797,945 | 87,885 |
| | | | | **Sub-Total (B1)** | **78,207,195** | **498,135** |
| **B2** | **Downstream** | | | | | |
| 1 | Excavation | $m^3$ | 2,250 | 958 | 2,154,825 | 13,725 |
| 2 | Jet Grout Cutoff | $m^3$ | 700 | 28,563 | 19,994,107 | 127,351 |
| 3 | Riprap Face Protection u/s & d/s | $m^3$ | 500 | 7,850 | 3,925,000 | 25,000 |
| 4 | Rock Fill | $m^3$ | 3,750 | 1,703 | 6,387,938 | 40,688 |
| | | | | **Sub-Total (B2)** | **32,461,870** | **206,764** |
| | | | | **Sub-Total (B)** | **110,669,065** | **704,899** |
| C | Miscellaneous 10% for joints of all types, Drainage, Architectural details, finishes etc. | | | | 182,620,132 | 1,163,186 |
| | | | | **Total (A+B+C)** | **2,008,821,452** | **12,795,041** |



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## Table 14-7 Cost Estimate for Undersluices

Price Index – March, 2021
US$ Exchange Rate = Rs. 157

| Sr. No. | Description | Unit | Qty | Rate | Cost | |
|---|---|---|---|---|---|---|
| | | | | (PKR) | (PKR) | (US$) |
| 1 | Clearing and Grubbing of area 300m upstream of Weir | $m^2$ | 10,875 | 314 | 3,414,750 | 21,750 |
| 2 | Excavation for Undersluices upto design depth in Medium Hard Soil removing of material from outside of the structure area | $m^3$ | 1,120,000 | 958 | 1,072,624,000 | 6,832,000 |
| 3 | Excavation for Undersluices upto design depth in Rock material requiring blasting i/c removing of material from outside of the structure area | $m^3$ | 280,000 | 2,714 | 760,024,440 | 4,840,920 |
| 4 | Compacted Concrete | $m^3$ | 413 | 23,110 | 9,533,040 | 60,720 |
| 5 | Riprap face protection u/s | $m^3$ | 500 | 6,961 | 3,480,690 | 22,170 |
| 6 | Lean Concrete 1:4:8 | $m^3$ | 645 | 14,130 | 9,113,850 | 58,050 |
| 7 | RCC in Undersluices using crushed stone aggregate (screening & ashing) and coarse sand i/c cost of all labour and material and all kinds of form works, moulds, shuttering lifting / pumping, curing, rendering and finishing the exposed surface excluding steel reinforcement | $m^3$ | 9,970 | 21,399 | 213,349,027 | 1,358,911 |
| 8 | Reinforcement Grade 60 | Ton | 498.5 | 204,524 | 101,955,164 | 649,396 |
| 9 | Grout Curtain | LS | 1 | 10,990,000 | 10,990,000 | 70,000 |
| 10 | Dewatering | LS | 1 | 15,700,000 | 15,700,000 | 100,000 |
| 11 | Consolidation Grouting | LS | 1 | 15,700,000 | 15,700,000 | 100,000 |
| 12 | Miscellaneous 5% for joints of all types, Drainage, Architectural details, finishes etc. | | | | 110,794,248 | 705,696 |
| | | | | **Total** | **2,326,679,209** | **14,819,613** |



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## Table 14-8 Cost Estimate for Power Intake

Price Index – March, 2021
US$ Exchange Rate = Rs. 157

| Sr. No. | Description | Unit | Qty | Rate | Cost | |
|---|---|---|---|---|---|---|
| | | | | (PKR) | (PKR) | (US$) |
| 1 | Excavation for Power Intake upto design depth in Medium Hard Rock requiring blasting i/c removing of material from outside of the structure area | $m^3$ | 17,150 | 2,714 | 46,551,497 | 296,506 |
| 2 | PCC in overbreak section including placing, compacting, finishing & curing (Ratio 1:2:4) | $m^3$ | 172 | 17,270 | 2,961,805 | 18,865 |
| 3 | Lean Concrete 1:4:8 | $m^3$ | 271 | 14,130 | 3,824,744 | 24,361 |
| 4 | RCC 1:1.5:3 for Linning using crushed stone aggregate (screening & ashing) and coarse sand i/c costof all labor and material and all kinds of form works, moulds, shuttering lifting / pumping, curing, rendering and finishing the exposed surface excluding steel reinforcement | $m^3$ | 10,405 | 21,399 | 222,666,730 | 1,418,259 |
| 5 | Reinforcement Grade 60 in Lining | Ton | 520 | 204,524 | 106,407,905 | 677,757 |
| 6 | Dewatering | LS | 1 | 7,850,000 | 7,850,000 | 50,000 |
| 7 | Miscellaneous 10% for joints of all types, Piles, Backfill, Drainage, Architectural details, finishes and Gate Control Building etc. | | | | 39,026,268 | 248,575 |
| | | | | **Total** | **429,288,949** | **2,734,325** |

## Table 14-9 Cost Estimate for Low Pressure Headrace Tunnel

Price Index – March, 2021
US$ Exchange Rate = Rs. 157

| Sr. No. | Description | Unit | Qty | Rate | Cost | |
|---|---|---|---|---|---|---|
| | | | | (PKR) | (PKR) | (US$) |
| 1 | Excavation for Headrace Tunnel upto design depth in Medium Hard Rock requiring blasting i/c removing of material from outside of the structure area | $m^3$ | 60,737 | 20,278 | 1,231,655,089 | 7,844,937 |
| 2 | PCC in overbreak section including placing, compacting, finishing & curing (Ratio 1:2:4) | $m^3$ | 4,191 | 17,270 | 72,376,562 | 460,997 |
| 3 | Lean Concrete 1:4:8 | $m^3$ | 1,030 | 14,130 | 14,559,552 | 92,736 |
| 4 | Shotcrete 35mm thick-fiber reinforced | $m^3$ | 1,012 | 44,117 | 44,628,432 | 284,258 |
| 5 | RCC 1:1.5:3 for Lining using crushed stone aggregate (screening & ashing) and coarse sand i/c cost of all labour and material and all kinds of form works, moulds, shuttering lifting / pumping, curing, rendering and finishing the exposed surface excluding steel reinforcement | $m^3$ | 9,935 | 21,399 | 212,605,151 | 1,354,179 |
| 6 | Reinforcement Grade 60 in Lining | Ton | 397 | 204,524 | 81,280,127 | 517,708 |
| 7 | Rock Bolts 4m long with 4m spacing | No. | 1,728 | 24,178 | 41,779,584 | 266,112 |
| 8 | Adits (Access Tunnel) | LS | 1 | 31,481,640 | 31,481,640 | 200,520 |
| 9 | Dewatering | LS | 1 | 3,140,000 | 3,140,000 | 20,000 |
| 10 | Miscellaneous 5% for joints of all types, Drainage, Architectural details, finishes etc. | | | | 86,675,357 | 552,072 |
| | | | | **Total** | **1,820,182,493** | **11,593,519** |



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## Table 14-10 Cost Estimate for Surge Tank

Price Index – March, 2021
US$ Exchange Rate = Rs. 157

| Sr. No. | Description | Unit | Qty | Rate | Cost | |
|---|---|---|---|---|---|---|
| | | | | (PKR) | (PKR) | (US$) |
| 1 | Excavation for Surge Tank upto design depth in Medium Hard Rock requiring blasting i/c removing of material from outside of the structure area | $m^3$ | 3,291 | 22,608 | 74,392,161 | 473,835 |
| 2 | PCC in overbreak section including placing, compacting, finishing & curing (Ratio 1:2:4) | $m^3$ | 329 | 17,270 | 5,682,735 | 36,196 |
| 3 | Shotcrete 35mm thick-fiber reinforced | $m^3$ | 509 | 44,117 | 22,452,814 | 143,012 |
| 4 | RCC 1:1.5:3 for Lining using crushed stone aggregate (screening & ashing) and coarse sand i/c cost of all labor and material and all kinds of form works, moulds, shuttering lifting / pumping, curing, rendering and finishing the exposed surface excluding steel reinforcement | $m^3$ | 360 | 21,399 | 7,714,326 | 49,136 |
| 5 | Reinforcement Grade 60 in Lining | Ton | 22 | 204,524 | 4,423,824 | 28,177 |
| 6 | Rock Bolts 3m long with 2m spacing | No. | 222 | 24,178 | 5,367,516 | 34,188 |
| 7 | Dewatering | LS | 1 | 628,000 | 628,000 | 4,000 |
| 8 | Miscellaneous 10% for joints of all types, Drainage, Architectural details, finishes etc. | | | | 12,066,137 | 76,854 |
| | | | | **Total** | **132,727,512** | **845,398** |

## Table 14-11 Cost Estimate for Penstock

Price Index – March, 2021
US$ Exchange Rate = Rs. 157

| Sr. No. | Description | Unit | Qty | Rate | Cost | |
|---|---|---|---|---|---|---|
| | | | | (PKR) | (PKR) | (US$) |
| 1 | Excavation for Penstock upto design depth in Medium Hard Rock requiring blasting i/c removing of material from outside of the structure area | $m^3$ | 1,382 | 22,608 | 31,235,213 | 198,950 |
| 2 | Excavation for Penstock upto design depth in Medium Hard Soil removing of material from outside of the structure area | $m^3$ | 15,600 | 958 | 14,940,120 | 95,160 |
| 3 | PCC in overbreak section including placing, compacting, finishing & curing (Ratio 1:2:4) | $m^3$ | 110 | 17,270 | 1,897,973 | 12,089 |
| 4 | Shotcrete 35mm thick-fibre reinforced | $m^3$ | 51 | 44,117 | 2,231,422 | 14,213 |
| 5 | Filter Material | $m^3$ | 1,400 | 7,850 | 10,990,000 | 70,000 |
| 6 | RCC 1:1.5:3 for Linning using crushed stone aggregate (screening & ashing) and coarse sand i/c costof all labour and material and all kinds of form works, moulds, shuttering lifting / pumping, curing, rendering and finishing the exposed surface excluding steel reinforcement | $m^3$ | 1,354 | 21,399 | 28,971,539 | 184,532 |
| 7 | Reinforcement Grade 60 in Lining | Ton | 81 | 204,524 | 16,613,891 | 105,821 |
| 8 | Rock Bolts 3m long with 2m spacing | No. | 123 | 24,178 | 2,973,894 | 18,942 |
| 9 | Dewatering | LS | 1 | 603,846 | 603,846 | 3,846 |
| 10 | Miscellaneous 10% for joints of all types, Drainage, Grouting, finishes etc. | | | | 11,045,790 | 70,355 |
| 11 | Penstock | Ton | 802 | 737,661 | 591,751,943 | 3,769,121 |
| | | | | **Total** | **713,255,631** | **4,543,029** |

## Table 14-12 Cost Estimate for Powerhouse



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Price Index – March, 2021
US$ Exchange Rate = Rs. 157

| Sr. No. | Description | Unit | Qty | Rate | Cost | |
|---|---|---|---|---|---|---|
| | | | | (PKR) | (PKR) | (US$) |
| 1 | Excavation for Powerhouse upto design depth in Medium Hard Soil removing of material from outside of the structure area | $m^3$ | 74,451 | 957 | 71,301,723 | 454,151 |
| 2 | Backfilling | $m^3$ | 74,451 | 1,005 | 74,808,365 | 476,486 |
| 3 | Lean Concrete 1:4:8 | $m^3$ | 635 | 14,130 | 8,965,485 | 57,105.00 |
| 4 | RCC for Sub structures and around Draft Tubes using crushed stone aggregate (screening & ashing) and coarse sand i/c cost of all labour and material and all kinds of form works, moulds, shuttering lifting / pumping, curing, rendering and finishing the exposed surface excluding steel reinforcement | $m^3$ | 7,774 | 21,399 | 166,353,180 | 1,059,574 |
| 5 | RCC 1:1.5:3 for walls, columns, slabs and floors using crushed stone aggregate (screening & ashing) and coarse sand i/c cost of all labour and material and all kinds of form works, moulds, shuttering lifting / pumping, curing, rendering and finishing the exposed surface excluding steel reinforcement | $m^3$ | 3,426 | 21,399 | 73,303,636 | 466,902 |
| 6 | Reinforcement Grade 60 | Ton | 715.45 | 204,524 | 146,325,843 | 932,012 |
| 7 | Dewatering | LS | 1 | 1,962,500 | 1,962,500 | 12,500 |
| 8 | Miscellaneous 15% for joints of all types, Drainage, Architectural details, finishes etc. | | | | 81,453,110 | 518,810 |
| | | | | **Total** | **624,473,840** | **3,977,540** |

**Table 14-13 Cost Estimate for Tailrace Channel**

Price Index – March, 2021
US$ Exchange Rate = Rs. 157

| Sr. No. | Description | Unit | Qty | Rate | Cost | |
|---|---|---|---|---|---|---|
| | | | | (PKR) | (PKR) | (US$) |
| 1 | Excavation for Tailrace Channel upto design depth in Medium Hard Soil removing of material from outside of the structure area | $m^3$ | 12,593 | 958 | 12,059,837 | 76,814 |
| 2 | RCC 1:1.5:3 using crushed stone aggregate (screening & ashing) and coarse sand i/c cost of all labour and material and all kinds of form works, moulds, shuttering lifting / pumping, curing, rendering and finishing the exposed surface excluding steel reinforcement | $m^3$ | 1,750 | 21,399 | 37,448,425 | 238,525 |
| 3 | Reinforcement Grade 60 | Ton | 105 | 204,524 | 21,475,010 | 136,784 |
| 4 | Backfill | $m^3$ | 1,440 | 1,021 | 1,469,520 | 9,360 |
| 5 | Dewatering | LS | 1 | 7,850,000 | 7,850,000 | 50,000 |
| 6 | Miscellaneous 5% for joints of all types, Drainage, finishes etc. | | | | 4,015,140 | 25,574 |
| | | | | **Total** | **84,317,932** | **537,057** |



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# COST ESTIMATES

## (HSS, Hydro-Mechanical, Electrical, Switchyard & Transmission Line Equipment)

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## Table 14-14 Cost Estimate for Hydraulic Steel Structures

Price Index – March, 2021
US$ Exchange Rate = Rs. 157

| Sr. No. | Description | Unit | Qty | Rate | Cost | |
|---|---|---|---|---|---|---|
| | | | | (PKR) | (PKR) | (US$) |
| 1 | Power Intake Main Gates | Set | 2 | 11,775,000 | 23,550,000 | 150,000 |
| 2 | Intake Trashrack | Set | 1 | 18,840,000 | 18,840,000 | 120,000 |
| 3 | Power Intake Trashrack Cleaning Machine | Set | 1 | 15,700,000 | 15,700,000 | 100,000 |
| 4 | Powerhouse Draft Tube Gates | Set | 4 | 6,280,000 | 25,120,000 | 160,000 |
| 5 | Gantry Crane | Set | 2 | 28,260,000 | 56,520,000 | 360,000 |
| | | | | **Total** | **139,730,000** | **890,000** |

## Table 14-15 Cost Estimate for Hydro-Mechanical Equipment

Price Index – March, 2021
US$ Exchange Rate = Rs. 157

| Sr. No. | Description | Unit | Qty | Rate | Cost | |
|---|---|---|---|---|---|---|
| | | | | (PKR) | (PKR) | (US$) |
| 1 | Turbine | No. | 3 | 335,980,000 | 1,007,940,000 | 6,420,000 |
| 2 | Governor and Auxiliaries | No. | 3 | 36,110,000 | 108,330,000 | 690,000 |
| 3 | Main Inlet Valves | No. | 3 | 67,510,000 | 202,530,000 | 1,290,000 |
| 4 | Powerhouse Bridge crane (100 Ton) Mobile crane (20 Ton) | L.S | 1 | 78,500,000 | 78,500,000 | 500,000 |
| 5 | Cooling Water System | L.S | 1 | 59,660,000 | 59,660,000 | 380,000 |
| 6 | Drainage and Dewatering System | L.S | 1 | 69,080,000 | 69,080,000 | 440,000 |
| 7 | Compressed Air System | L.S | 1 | 32,970,000 | 32,970,000 | 210,000 |
| 8 | Fire Fighting System | L.S | 1 | 25,120,000 | 25,120,000 | 160,000 |
| 9 | Oil Handling Equipment | L.S | 1 | 28,260,000 | 28,260,000 | 180,000 |
| 10 | Powerhouse Elevators | No. | 2 | 10,990,000 | 21,980,000 | 140,000 |
| 11 | Heating, Ventilation and Air Conditioning (HVAC) System | L.S | 1 | 32,970,000 | 32,970,000 | 210,000 |
| 12 | Workshop Equipment | Lot. | 1 | 17,270,000 | 17,270,000 | 110,000 |
| 13 | Miscellaneous Equipment | | | | 6,280,000 | 40,000 |
| | | | | **Total** | **1,690,890,000** | **10,770,000** |



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## Table 14-16 Cost Estimate for Electrical Equipment

Price Index – March, 2021
US$ Exchange Rate = Rs. 157

| Sr. No. | Description | Unit | Qty | Rate | Cost | |
|---|---|---|---|---|---|---|
| | | | | (PKR) | (PKR) | (US$) |
| **A** | **Generator** | | | | | |
| 1 | 21.20 MVA Generator, complete with Excitation system, cooling system, Control and protection | Set | 3 | 471,000,000 | 1,413,000,000 | 9,000,000 |
| 2 | 11 kV Generator Circuit Breaker | Set | 2 | 39,250,000 | 78,500,000 | 500,000 |
| 3 | Isolated Phase Bus System with associated components | Set | 3 | 15,700,000 | 47,100,000 | 300,000 |
| | | | | **Sub Total (A)** | **1,538,600,000** | **9,800,000** |
| **B** | **Transformer** | | | | | |
| 4 | Power Transformer 22 MVA, 11/132 kV with off-load tap changer, control & protection and other associated components. (A spare transformer shall also be provided) | No. | 3 | 78,500,000 | 314,000,000 | 2,000,000 |
| 5 | Station Service Transformer 2 MVA, 132/11 kV with control and protection and associated components | No. | 1 | 20,410,000 | 20,410,000 | 130,000 |
| 6 | Main Auxiliary Transformer 630 KVA, 11/0.4 kV with control and protection and associated components | No. | 3 | 2,355,000 | 7,065,000 | 45,000 |
| 7 | Main Auxiliary Transformers 400 KVA, 11/0.4kV with control and protection and associated components | No. | 3 | 1,884,000 | 3,768,000 | 24,000 |
| | | | | **Sub Total (B)** | **345,243,000** | **2,199,000** |
| **C** | **MV, LV & DC Equipment** | | | | | |
| 8 | 11 kV switchgears with control & protection & associated components | No. | 8 | 26,690,000 | 213,520,000 | 1,360,000 |
| 9 | Station service Equipment, Low Voltage Installation, 220 V DC & UPS System including batteries, chargers and other associated equipment | LS | 1 | 15,700,000 | 15,700,000 | 100,000 |
| | | | | **Sub Total (C)** | **229,220,000** | **1,460,000** |
| **D** | **Others Equipment** | | | | | |
| 10 | Control System & Protection | LS | 1 | 34,540,000 | 34,540,000 | 220,000 |
| 11 | Lighting and Small Power System | LS | 1 | 2,355,000 | 2,355,000 | 15,000 |
| 12 | Earthing & lightning Protection System | LS | 1 | 5,495,000 | 5,495,000 | 35,000 |
| 13 | Fire Detection & Alarm System | LS | 1 | 3,140,000 | 3,140,000 | 20,000 |
| 14 | Telecommunication(EPABX, PAS, CCTV) | LS | 1 | 3,925,000 | 3,925,000 | 25,000 |
| 15 | Cables(MV, LV, Control, P&I) and Cable trays | LS | 1 | 14,915,000 | 14,915,000 | 95,000 |
| 16 | D.G Set | LS | 1 | 17,270,000 | 17,270,000 | 110,000 |
| 17 | Electrical Workshop | LS | 1 | 5,181,000 | 5,181,000 | 33,000 |
| 18 | Spare Parts | LS | 1 | 47,100,000 | 47,100,000 | 300,000 |
| 19 | Maintenance Tools & Plants | LS | 1 | 2,355,000 | 2,355,000 | 15,000 |
| | | | | **Sub Total (D)** | **136,276,000** | **868,000** |
| | | | | **Total (A+B+C+D)** | **2,249,339,000** | **14,327,000** |



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## Table 14-17 Cost Estimate for 132 kV Switchyard Equipment

Price Index – March, 2021
US$ Exchange Rate = Rs. 157

| Sr. No. | Description | Unit | Qty | Rate | Cost | |
|---|---|---|---|---|---|---|
| | | | | (PKR) | (PKR) | (US$) |
| 1 | 132 kV SF6 Circuit Breakers, with associated components | Set | 12 | 3,140,000 | 37,680,000 | 240,000 |
| 2 | 132 kV Disconnecting Switch, three pole, motor operated with associated components | No. | 27 | 1,099,000 | 29,673,000 | 189,000 |
| 3 | 132 kV Communication System including Line Matching Units, Digital Power Line Carrier, SCADA equipment, etc. | LS | 1 | 141,300,000 | 141,300,000 | 900,000 |
| 4 | Other Switchyard Equipment required for complete functioning like Bus Bars, SA, CT, CVT, CCVT, earthing & Lightening system etc. | LS | 1 | 94,200,000 | 94,200,000 | 600,000 |
| 5 | Protection & Control Equipment | LS | 1 | 86,350,000 | 86,350,000 | 550,000 |
| 6 | Spare Parts | LS | 1 | 39,250,000 | 39,250,000 | 250,000 |
| | | | | **Sub Total** | **428,453,000** | **2,729,000** |

## Table 14-18 Cost Estimate for 132 kV Transmission Line

Price Index – March, 2021
US$ Exchange Rate = Rs. 157

| Sr. No. | Description | Unit | Qty | Rate | Cost | |
|---|---|---|---|---|---|---|
| | | | | (PKR) | (PKR) | (US$) |
| **A** | **132 kV Transmission Line (Double Circuit from Powerhouse to Aliabad) - 27 km** | | | | | |
| 1 | Towers (ZM1, ZM30, ZM60) | No. | 135 | 1,413,000 | 190,755,000 | 1,215,000 |
| 2 | Conductor Twin Bundle (Rail) | Km | 180 | 785,000 | 141,300,000 | 900,000 |
| 3 | Optical Ground Wire (OPGW) | Km | 30 | 314,000 | 9,420,000 | 60,000 |
| 4 | Insulators | LS | 1 | 34,540,000 | 34,540,000 | 220,000 |
| 5 | Hardware | LS | 1 | 34,540,000 | 34,540,000 | 220,000 |
| 6 | Grounding Sets | LS | 1 | 4,710,000 | 4,710,000 | 30,000 |
| 7 | Protection Equipment | LS | 1 | 15,700,000 | 15,700,000 | 100,000 |
| 8 | Land & Right of Way | LS | 1 | 21,980,000 | 21,980,000 | 140,000 |
| 9 | Excavation & Foundation | LS | 1 | 31,400,000 | 31,400,000 | 200,000 |
| | | | | **Sub Total (A)** | **484,345,000** | **3,085,000** |
| **B** | **132 kV Transmission Line (Single Circuit from Powerhouse to Sost) - 70 km** | | | | | |
| 10 | Towers(ZM1, ZM30, ZM60) | No. | 350 | 1,413,000 | 494,550,000 | 3,150,000 |
| 11 | Conductor Twin Bundle (Rail) | km | 210 | 785,000 | 164,850,000 | 1,050,000 |
| 12 | Optical Ground Wire (OPGW) | km | 75 | 314,000 | 23,550,000 | 150,000 |
| 13 | Insulators | LS | 1 | 89,490,000 | 89,490,000 | 570,000 |
| 14 | Hardware | LS | 1 | 89,490,000 | 89,490,000 | 570,000 |
| 15 | Grounding Sets | LS | 1 | 7,850,000 | 7,850,000 | 50,000 |
| 16 | Protection Equipment | LS | 1 | 15,700,000 | 15,700,000 | 100,000 |
| 17 | Land & Right of Way | LS | 1 | 51,810,000 | 51,810,000 | 330,000 |
| 18 | Excavation & Foundation | LS | 1 | 78,500,000 | 78,500,000 | 500,000 |
| | | | | **Sub Total (B)** | **1,015,790,000** | **6,470,000** |
| | | | | **Total (A+B)** | **1,500,135,000** | **9,555,000** |



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## Table 14-19 Phasing of Cost Estimate

| Sr. No. | Description | Total | | | | 1st Year | | 2nd Year | | 3rd Year | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Local (Mill. PKR) | Foreign (Mill. PKR) | Total (Mill. PKR) | Total (Mill. US$) | Local (Mill. PKR) | Foreign (Mill. PKR) | Local (Mill. PKR) | Foreign (Mill. PKR) | Local (Mill. PKR) | Foreign (Mill. PKR) |
| A | **Preliminary Works** | | | | | | | | | | |
| A-1 | Land Acquisition & Environmental Mitigation Cost | 208.450 | - | 208.450 | 1.328 | 156.338 | - | 20.845 | - | 31.268 | - |
| A-2 | Preparatory Works | | | | | | | | | | |
| - | Mobilization & De-mobilization | 500.000 | - | 500.000 | 3.185 | 350.000 | - | - | - | 150.000 | - |
| - | Project Colony & Contractor's Camp | 130.310 | - | 130.310 | 0.830 | 130.310 | - | - | - | - | - |
| - | Access Roads to the Main Works Sites | 134.235 | - | 134.235 | 0.855 | 134.235 | - | - | - | - | - |
| - | Reservoir Slope Stabilization and Construction Risks | 188.400 | - | 188.400 | 1.200 | 188.400 | - | - | - | - | - |
| | **Sub Total A** | **1,161.395** | **-** | **1,161.395** | **7.397** | **959.283** | **-** | **20.845** | **-** | **181.268** | **-** |
| B | **Civil Works** | | | | | | | | | | |
| B-1 | Main Weir | 2,008.821 | - | 2,008.821 | 12.795 | 1,519.856 | - | 651.367 | - | - | - |
| B-2 | Undersluices | 2,326.679 | - | 2,326.679 | 14.820 | 2,548.564 | - | - | - | - | - |
| B-3 | Power Intake | 429.289 | - | 429.289 | 2.734 | - | - | 436.692 | - | - | - |
| B-4 | Low Pressure Headrace Tunnel | 1,820.182 | - | 1,820.182 | 11.594 | 398.062 | - | 1,194.187 | - | 398.062 | - |
| B-5 | Surge Tank | 132.728 | - | 132.728 | 0.845 | - | - | 179.911 | - | - | - |
| B-7 | Penstock | 713.256 | - | 713.256 | 4.543 | - | - | 89.692 | - | - | - |
| B-8 | Powerhouse | 624.474 | - | 624.474 | 3.978 | - | - | 455.416 | - | 190.893 | - |
| B-9 | Tailrace Channel | 84.318 | - | 84.318 | 0.537 | - | - | 34.817 | - | 52.226 | - |
| B-10 | Check Dams at Shimshal Nullah | 392.500 | - | 392.500 | 2.500 | 78.500 | - | 235.500 | - | 78.500 | - |
| | **Sub Total B** | **8,532.247** | **-** | **8,532.247** | **54.346** | **4,544.982** | **-** | **3,267.584** | **-** | **719.681** | **-** |
| | **Total (A+B)** | **9,693.642** | **-** | **9,693.642** | **61.743** | **5,504.265** | **-** | **3,288.429** | **-** | **900.949** | **-** |
| C | **Hydraulic Steel Structures, Mechanical & Electrical Works** | | | | | | | | | | |
| C-1 | Hydraulic Steel Structures (HSS) | 104.798 | 34.933 | 139.730 | 0.890 | 20.960 | 6.987 | 62.879 | 20.960 | 20.960 | 6.987 |
| C-2 | Mechanical Works | 33.818 | 1,657.072 | 1,690.890 | 10.770 | - | - | 6.764 | 331.414 | 27.054 | 1,325.658 |
| C-3 | Electrical Works | 31.400 | 2,217.939 | 2,249.339 | 14.327 | - | - | 6.280 | 443.588 | 25.120 | 1,774.351 |
| C-4 | Switchyard works | 4.285 | 424.168 | 428.453 | 2.729 | - | - | - | - | 4.285 | 424.168 |
| C-5 | Transmission Line (Single Circuit Attabad to Sost & Double Circuit Attabad to Aliabad) | 1,200.108 | 300.027 | 1,500.135 | 9.555 | - | - | - | - | 1,200.108 | 300.027 |
| | **Sub Total for C-1 to C-5** | **1,374.408** | **4,634.139** | **6,008.547** | **38.271** | **20.960** | **6.987** | **75.922** | **795.962** | **1,277.526** | **3,831.191** |
| C-6 | Transportation Charges of E&M Equipment @ 7% of Sub Total C1-C5 | 252.359 | 168.239 | 420.598 | 2.679 | 1.174 | 0.782 | 36.619 | 24.413 | 214.566 | 143.040 |
| C-7 | Erection & Commissioning Charges @ 8% of Sub Total C1-C5 | 144.205 | 336.479 | 480.684 | 3.062 | - | - | 57.682 | 134.591 | 86.523 | 201.887 |
| C-8 | Government Taxes on E&M Equipment @ 16% of Sub Total C1-C5 | 961.368 | - | 961.368 | 6.123 | 4.471 | - | 139.501 | - | 817.395 | - |
| | **Sub Total C** | **2,732.339** | **5,138.857** | **7,871.197** | **50.135** | **26.605** | **7.769** | **309.725** | **954.966** | **2,396.010** | **4,176.122** |
| | **Sub Total (A + B + C)** | **12,425.982** | **5,138.857** | **17,564.839** | **111.878** | **5,530.870** | **7.769** | **3,598.153** | **954.966** | **3,296.959** | **4,176.122** |
| D | Engineering and Supervision @ 7% of Sub Total (A+B+C) | 865.819 | 359.720 | 1,225.539 | 7.806 | 383.161 | 0.540 | 251.871 | 66.848 | 230.787 | 292.329 |
| | Generation Capacity Expansion Plan for GB | 4.000 | - | 4.000 | 0.025 | 4.000 | - | - | - | - | - |
| E | Physical and Numerical Modeling (Lumpsum) | 5.000 | - | 5.000 | 0.032 | 3.500 | - | 1.500 | - | - | - |
| F | Physical Contingencies @ 3% of Sub Total (A+B+C) | 372.779 | 154.166 | 526.945 | 3.356 | 165.926 | 0.233 | 107.945 | 28.649 | 98.909 | 125.284 |
| G | Admin, Audit, Accounts, Legal and Client's Expenses @ 2% of Sub Total (A+B+C) | 351.297 | - | 351.297 | 2.238 | 110.773 | - | 91.062 | - | 149.462 | - |
| H | Authority Overheads @ 1.5% of Sub Total(A+B+C) | 263.473 | - | 263.473 | 1.678 | 83.080 | - | 68.297 | - | 112.096 | - |
| I | Insurance Costs @ 0.5% of Sub Total (A+B+C) | 62.130 | 25.694 | 87.824 | 0.559 | 27.654 | - | 17.991 | 4.775 | 16.485 | 20.881 |
| | **PROJECT BASE COST** | **14,350.478** | **5,678.440** | **20,028.916** | **127.573** | **6,308.964** | **8.585** | **4,136.819** | **1,055.237** | **3,904.698** | **4,614.615** |



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# Annexure-A

# Equipment, Material & Labor Rates

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS



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**Summary of Major Construction Equipment Operating Cost**

| Sr. No. | Description | Monthly Rent (PKR) | HourlyRent (PKR) |
|---|---|---|---|
| 1 | Bulldozer D6 / Equivalent | 1,352,000 | 6,500.00 |
| 2 | Dump Truck 10-Wheeler | 1,040,000 | 5,000.00 |
| 3 | Excavator CAT 220 / EX 100 / Equivalent | 1,456,000 | 7,000.00 |
| 4 | Excavator CAT 225 / EX 200 / Equivalent | 1,560,000 | 7,500.00 |
| 5 | Motor Grader 12 Ft Blade | 1,352,000 | 6,500.00 |
| 6 | Front End Loader CAT 950 / Equivalent | 1,040,000 | 5,000.00 |
| 7 | Roller Vibratory 12.5 Ton (Plane) | 936,000 | 4,500.00 |
| 8 | Roller Vibratory 12.5 Ton (Pad Foot) | 1,040,000 | 5,000.00 |
| 9 | Water Tank /Bouzar Water 10000 litre | 728,000 | 3,500.00 |
| 10 | Tractor 78 HP | 520,000 | 2,500.00 |
| 11 | Crane 28/33 Ton | 1,248,000 | 6,000.00 |
| 12 | Concrete Batching Plant, 30 Cum/hr | 936,000 | 4,500.00 |
| 13 | Concrete Batching Plant, 60 Cum/hr | 1,560,000 | 7,500.00 |
| 14 | Concrete Transit Mixer Mobile 2.5 Cum | 312,000 | 1,500.00 |
| 15 | Concrete Transit Mixer Mobile 6.0 Cum | 624,000 | 3,000.00 |
| 16 | Concrete Pump 60~110 Cum / hr | 520,000 | 2,500.00 |
| 17 | Placement Machinery | 312,000 | 1,500.00 |
| 18 | Vibrator | 416,000 | 2,000.00 |
| 19 | Power Generator 1MW | 6,240,000 | 30,000.00 |
| 20 | Bar Cutting Machine | 62,400 | 300.00 |
| 21 | Bar Bending Machine | 31,200 | 150.00 |
| 22 | Tractor trolly | 249,600 | 1,200.00 |
| 23 | Drilling Jumbo | 6,240,000 | 30,000.00 |
| 24 | Loader 2.5 cum | 1,040,000 | 5,000.00 |
| 25 | Dumper 20T | 1,664,000 | 8,000.00 |
| 26 | Jack hammer | 108,160 | 520.00 |
| 27 | Dozer 100HP | 1,456,000 | 7,000.00 |
| 28 | Ventilator Blowers | 3,120,000 | 15,000.00 |
| 29 | Tipper | 1,248,000 | 6,000.00 |



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## Summary of Material Costs

| Sr. No. | Description | Unit | Rate (PKR) |
|---|---|---|---|
| 1 | Ordinary Portland Cement (OPC) | Per Bag | 950.00 |
| 2 | Coarse Sand | Cum | 2,600.00 |
| 3 | Aggregate | Cum | 4,000.00 |
| 4 | Rubble Stone | Cum | 2,600.00 |
| 4 | Water | 1000 litre | 1,000.00 |
| 5 | Admixture | litre | 1,200.00 |
| 6 | Formwork (average) | Sq. m | 200.00 |
| 7 | Reinforcing Steel Grade 60 | Ton | 150,000.00 |
| 8 | Reinforcing Steel Grade 40 | Ton | 120,000.00 |
| 9 | Cold steel wire AASHTO M-32 | Kg | 300.00 |
| 10 | Explosives | Kg | 1,800.00 |

## Summary of Labour Wages

| Sr. No. | Description | Monthly Wage (PKR) | Hourly Wage (PKR) | Daily Wage (PKR) |
|---|---|---|---|---|
| 1 | Foreman for Batch/Mix Plant | 65,000 | 312.50 | 2,500 |
| 2 | Plant Operator | 58,501 | 281.26 | 2,250 |
| 3 | Forman for Excavation / Concrete Placing / Rebar | 65,000 | 312.50 | 2,500 |
| 4 | Mechanics | 65,000 | 312.50 | 2,500 |
| 5 | Electrician | 58,500 | 281.25 | 2,250 |
| 6 | Masons | 52,000 | 250.00 | 2,000 |
| 7 | Carpenter | 45,500 | 218.75 | 1,750 |
| 8 | Dresser | 32,499 | 156.25 | 1,250 |
| 9 | Steel Binder Cutter | 32,499 | 156.25 | 1,250 |
| 10 | Helpers/Oilers/Muckers/Beldaar | 26,000 | 125.00 | 1,000 |
| 11 | Drivers | 32,499 | 156.25 | 1,250 |
| 12 | Labourers | 26,000 | 125.00 | 1,000 |
| 13 | Explosives Inspector | 64,999 | 312.49 | 2,500 |
| 14 | Explosives Chargeman | 52,001 | 250.00 | 2,000 |
| 15 | Drillers | 52,000 | 250.00 | 2,000 |
| 16 | Wireman | 31,200 | 150.00 | 1,200 |



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# 15 CONSTRUCTION PLANNING AND COST ESTIMATES

## 15.1 GENERAL

This section covers the construction planning aspects of Attabad Lake Hydropower Project (ALHPP) in detail. The implementation schedule for the Project has been prepared taking into account the anticipated construction methods and planning. Following areas are covered in the subject section of the report:

- Project geographic location and access to the Project Area.
- Availability of manpower.
- Planning of effective working periods.
- Required Construction Materials, Storage and Major Equipment.
- Detailed Construction Planning and Methodology for different Project components.
- Project Implementation Schedule.
- Mode of Construction Supervision.

## 15.2 PROJECT LOCATION

ALHPP is proposed on Attabad Lake along Karakuram Highway (N-35) in Hunza Valley. The Weir Site has been proposed at existing spillway of Attabad Lake. The Powerhouse site is about 2.5 km downstream of the Weir Site, along the left bank of Hunza River.

## 15.3 ACCESSIBILITY TO PROJECT AREA

### 15.3.1 Roads Access

The ALHPP is approachable from all major cites of Pakistan, primarily Islamabad and Gilgit along the existing N-35 Karakoram Highway (KKH). KKH is 806 km long and starts at Hassanabdal in province Punjab. It passes through Khyber Pakhtunkhwa and the Northern areas and terminates at Khunjerab Pass in the Karakoram Range on the Pakistan – China border. The maintenance of the Karakoram Highway now is the responsibility of the National Highways Authority (NHA) who operates and maintains this road through Frontier Works Organization (FWO). The KKH is two lane all-weathered mountainous road. Landslides on KKH are frequently experienced during the rainy seasons, blocking the vehicular traffic ranging from a few hours to a number of days and can even extend up to a few weeks occasionally.

No major rehabilitation or upgrading has been carried out on the KKH since its completion in 1978, although some maintenance has been undertaken and its condition from Gilgit to Chilas city is good however, the condition of road from Chilas to Besham is not satisfactory. It shall be necessary to rehabilitate the existing structure of KKH to serve the construction of ongoing Dasu Hydropower Project & Diamer Basha Dam Project and proposed upstream projects including Shyok Dam, Bunji Hydropower Project and ALHPP Lake Hydropower Project etc., to



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allow transport of construction materials, heavy construction equipment and the permanent plant and equipment.

The route from Islamabad to Thakot via KKH is through Mansehra via Haripur and Abbottabad. From Mansehra, KKH moves towards Shinkiari, Battal, Batgram and Thakot. With the construction of Motorways, Thakot can now easily be accessed through Motorways. From Thakot Bridge, the access onward to Gilgit and Hunza continues as a part of KKH:

- Islamabad to Burhan Interchange near Hassanabdal via M-1 (Islamabad-Peshawar Motorway):
- The transportation from Islamabad to Burhan Interchange near Hassanabdal via Islamabad-Peshawar Motorway (M-1) comprised of 6 lanes is 44 km.
- Burhan Interchange to Thakot via M-15 (Hazara Motorway):
- The transportation from Burhan Interchange to Thakot via Hazara Motorway (M-15) is also 6 lanes upto Haripur, 4 lanes upto Mansehra and 2 lanes upto Thakot with five Tunnels, two at Abbottabad & one each at Battal, Karmong & Mansehra, with route distance of 180 km.
- Thakot to Gilgit via N-35 (KKH);
- KKH (N-35) from Thakot to Dasu is in good condition whereas from Dasu to Chilas, the road condition is not good and requires improvements. From Chilas onwards to Gilgit, the road is in good condition. The route distance is 390 km.
- Gilgit to Project Area via N-35 (KKH) along Hunza River.
- KKH (N-35) from Gilgit to Project Site at Attabad Lake is good condition metaled road with 2 lanes. The route distance is 120 km.

There is another route from Islamabad to Gilgit and Project area via Babusar Pass, through National Highway (N-15). This route with good condition metaled road is although shortest than national highway to reach upto Chilas but due to high altitude mountains, many sharp turns and route closure for about six months in a year because of heavy snowfall during winter, the transportation through this route is not suitable for heavy vehicles.

The distances between Project Site and major landmarks are as follows;

| Major Landmark | Distance (km) | Importance |
|---|---|---|
| Gilgit | 120 | Capital of Gilgit Baltistan and nearest airport |
| Khunjerab Pass | 150 | Pak-China border, trade route between the two countries |
| Islamabad | 735 | Capital of Pakistan |
| Lahore | 1,100 | Capital of Province Punjab |
| Karachi | 2,300 | Sea Port |



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### 15.3.2 Access by Air

Gilgit, the capital of Gilgit-Baltistan is the closest airport at a distance of 120 km from the Project Site. Air time to reach Gilgit from Islamabad is about 1 hour subject to weather. Helipads are also available which can be used in case of extreme urgency situations.

## 15.4 MANPOWER AVAILABILITY

### 15.4.1 Unskilled

Unskilled labour including drivers, guards, clerical staff, etc. will be all indigenous and mostly available from Gilgit Baltistan Region.

### 15.4.2 Unskilled

Adequate number and variety of skilled labour will be required for the Project. Skilled labour will mainly consist of masons, carpenters, mechanics, electricians and technicians for operating various construction equipment, batching plant, aggregate processing plant, surveying alongwith the execution of various construction activities including production and laying of concrete, rock blasting, quality control, testing of construction materials, welding, heavy equipment repair and installation of E&M equipment etc. The Project Area will not be able to provide significant number of skilled labours. However, sufficient number of manpower is available in other parts of Pakistan.

## 15.5 FACTORS AFFECTING PROGRESS OF CONSTRUCTION WORKS

### 15.5.1 Non-Productive Periods

The climate of the Project are is characterized by moderate summers and severe winters with maximum daily temperatures in summer often exceeding 30 °C and about −10 °C in winters. The Project Area receives precipitation in the form of rain in summers and snow in winters. During severe cold weather with temperature falling below freezing point, the cement and reinforcing bars cannot be stored for long periods due to deterioration in their quality. The storage of cement below freezing point will lead to its setting. Moreover, it would be difficult for supervisory and working staff to work in cold season and snowfall, therefore, the above ground construction works are expected to be suspended for about 60 days every year during January & February.

Sunday is a weekly holiday in Pakistan. Therefore, six days work in each week is expected at Project from Monday through Saturday but normally, Sundays are not observed as holiday at Projects in remote areas and the labours are allowed to avail more holidays on Eid festivals. It is traditional to close the Project Site for 7 to 10 days on Eid-ul Fitr and Eid-ul-Azha as most of the labour, who would be hailing from distant places visit their families to celebrate these festivals with them. There are 14 official public holidays in Pakistan, as shown on Table 15-1. Depending on the lunar calendar, dates of some are subject to variation.



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**Table 15-1 Public Holidays**

| Occasion | Date | No. of Days |
|---|---|---|
| Kashmir Day | 05th February | 1 |
| Pakistan Day | 23rd March | 1 |
| Labour Day | 01st May | 1 |
| Independence Day | 14th August | 1 |
| Eid-ul-Fitr* | 1st to 3rd Shawal | 3 |
| Birthday of Quaid-e-Azam & Christmas | 25th December | 1 |
| Eid-ul-Azha* | 9th to11th Dhul-Hijjah | 3 |
| Youm-e-Ashur* | 9 &10th of Muharram | 2 |
| Milad-un-Nabi* | 12th Rabi Ul Awal | 1 |
| Total Official Holidays | | 14 |

(*) Dates of religious holidays are defined by the lunar calendar

### 15.5.2 Procurement and Storage of Materials

**Cement**

The Cement is abundantly available in Pakistan. During snowfall and rainy season, there is risk of supply hold-up due to inclement weather for 8 to 10 days. To ensure continuity of construction works, it is assumed that 02 to 03 weeks storage of cement at site in weatherproof warehouses will be essential. It has been estimated that about 31,485 tons cement would be required to meet the project construction activities. Mostly Ordinary Portland Cement (OPC) will be used. Sufficient production capacity of cement per day is available with the existing cement factories in Pakistan and cement can be transported to the project site using trucks or long trailers.

The Table – 15-3 indicates the present daily production of five factories in nearest locations to the project. It is evident from production rates of these factories that any of these factories can furnish the requisite quantity of cement for concrete works at the project site.

**Table 15-2 Cement Production Capacities in various Factories**

| No. | Manufacturer | Production (tons/day) / Distance (km) |
|---|---|---|
| 1 | Bestway Cement (Farooqia) | 8,155 / 675 |
| 2 | Askari Cement (Wah) | 3,020 / 685 |
| 3 | Fauji Cement (Fateh Jhang) | 9,407 / 710 |
| 4 | Askari Cement (Nizampur) | 4,662 / 755 |
| 5 | Cherat Cement (Nowshera) | 12,427 / 790 |



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**Coarse Aggregate**

As mentioned in Volume-2 Geology and Geotechnical Investigations, rock quarries have been identified at Passu and Powerhouse area. The marble present in Passu area and Rounded Boulder Gravel Silt (RBGM) at Powerhouse Area can be used as coarse aggregate by certain amount of processing, i.e. crushing, washing, screening and blending. The muck material from underground excavations cannot be used as coarse aggregate with OPC due to potential of Alkali Silica Reaction.

**Sand**

High quality of large sand deposits are available in the tail end area of Attabad Lake near Shishkat Bridge for use in the ALHPP.

**Reinforcing Steel**

The quantity of reinforcing steel required for the Project will be about 3,300 tons, with a monthly average consumption of about 155 tons. Several factories in the country produce small quantities of reinforcing steel, in the form of both plain and deformed bars. There is no factory producing reinforcing steel bars in the vicinity of the Project Site. The nearest location from where the reinforcing steel bars of the desired specification are available is Islamabad. Both hot and cold rolled reinforcing steel bars are available in desired quantity from Islamabad, about 735 km from the Project Site. The storage of reinforcing steel sufficient for one month peak consumption 155 tons will not require large areas.

**Explosive Materials**

In the main weir and flushing channel areas, extensive volume of excavation is of slided materials having large size boulders, which may require blasting. There are certain areas, where rock excavation would also be involved like power intake, headrace tunnel and surge tank etc. The consumption of explosives and blasting consumables is generally difficult to assess. However, a sustainable inventory will have to be maintained for which adequate storage depot will be essentially required at Project Site. The Wah - Bofors factory in Wah (near Rawalpindi) is capable of supplying all the explosives and blasting consumables required for the Project.

**Steel Plates and Steel Formwork**

Steel sheets of various thicknesses are produced at the Steel Mills at Karachi, which can be used to fabricate steel formwork. These can also be used for fabricating steel liners and other miscellaneous items required in connection with the construction activities. Alternatively, steel items can be imported from abroad. Most likely source of steel plate could be nearby countries such as China and Iran.

**Petroleum Products**

Petroleum products will be mainly diesel with comparatively minor quantity of gasoline and lubricants, which can be procured directly from the source i.e. the oil refineries, spread in the country, for the operation of machinery and vehicles. The storage tanks would be established at the Project site with total capacity of around 40,000 litres, sufficient for around one month of



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operation, to cope with extraordinary conditions like land sliding on the KKH or fuel shortages, etc.

**Water and Stone for Riprap and Fill Material**

The Hunza River water will be used in the making of concrete at ALHPP. The results of water samples taken from Hunza River indicate that water is suitable for mixing & curing of concrete.

The large boulders with sufficient quantity present in the slided mass can be used as riprap material to control the erosion by water. Silty sand, sandy silt and gravelly sand available in the river bed and in slided mass (in ample quantities) can be used as fill material for the protection of slopes and construction of coffer dam etc.

### 15.5.3 General Construction Equipment

The economic life for most of the construction plant and equipment is five 5 to 7 years, therefore brand new equipment should be deployed on the Project. Most of the construction plant and equipment required for the execution of the works will have to be imported from international sources like excavators, dumpers, graders, crawlers, cutters, drilling jumbos, drilling and grouting equipment, batching and concrete plant, vibrators, mixers, graders, rollers, dump trucks, power generator etc.; the same applies to most of the spare parts and construction plant and equipment-related consumable supplies.

Due to the difficult KKH haulage conditions through mountainous terrain, the size of equipment will generally be smaller, with most units weighing less than 40 tons when prepared for transportation. Large items of equipment may be brought to the Project site in knock-down condition for assembling at the site.

## 15.6 PRE-CONSTRUCTION PHASE

Upon the completion of Feasibility Study, a number of preliminary works are required to be completed as pre-requisites for starting the construction phase of the Project including approval of PC-I, land acquisition, procurement of Consultant, preparation of EPC tender documents and the selection of EPC Contractor.

Immediately after the approval of PC-I of the Project, the Consultant will be hired for the review of Feasibility Study, preparation of EPC tender documents and construction supervision. Simultaneously, land would be acquired for project components and access roads. The Consultant, after the award of Consultancy Contract will immediately commence their pre-construction phase tasks; however the supervision period will proceed after the award of Main Contract. After the completion of tender documents by the Consultant, the EPC Contractor shall be hired to commence the preparatory works at project site. The Pre-construction activities are planned to be completed within 14 months.

### 15.6.1 Land Acquisition

Permanent Acquisition

No major problem is envisaged in acquisition of land. It is anticipated that land required for the Project on permanent basis will be acquired / purchased. To streamline the Project implementation and to avoid delays, it is desirable that the land acquisition process is



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accomplished and possession of the land for temporary and Project main structures is taken at least one month before start of construction work.

Temporary Acquisition

The land required for the establishment of contractor camps, stores and workshops will be acquired on temporary basis by direct negotiation and agreement with the owners. Temporary acquisition will principally be the responsibility of the Contractor.

### 15.6.2 Contract Award on EPC Basis

International Competitive Bidding (ICB) has been proposed for execution of the project works for award to the contractor on EPC basis detailed hereunder:

XIII. Detailed engineering design of the Project components.

Construction of infrastructure works, civil works, procurement & installation of electrical and mechanical equipment etc.

## 15.7 PREPARATORY WORKS

Preparatory works includes access roads, contractor's camps & site installations and, infrastructure works, etc. It is envisaged that the EPC Contractor will mobilize its personnel and equipment to the site within 60 days after signing of Contract. The main activities to be undertaken by the EPC Contractor under preparatory works are briefly outlined below:

- Establishment of Contractor's camp and other facilities.
- Construction of Residential Colony.
- Construction of access roads to main work sites.
- Additional survey and investigations required by the Contractor.

The detailed design of temporary works and permanent structures by EPC Contractor shall also be commenced in parallel with the preparatory works.

### 15.7.1 Contractor's Camp

About 300~350 work force together with the supervisory staff of the Contractor will be required for the Project construction. The workforce will be originated from Gilgit Baltistan and different regions of Pakistan and from oversees. The Contractor will be responsible for the construction of adequate accommodation and temporary facilities for his workforce before the start of the main works. The Contractor also will carry out proper and adequate maintenance of such facilities to provide neat, well-kept, pleasant, healthful surroundings and conditions for all occupants.

All utilities including electricity, water supply, sewerage system and approach roads will be provided by Contractor at construction camps & offices and in residential area. The Contractor will ensure that all these facilities fulfill the requirements for residential camps, site offices, yards, construction sites etc.



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### 15.7.2 Construction Plant Facilities

The Contractor will require work areas for various functions including space for stockpiling aggregates, aggregate manufacturing, and concrete batching and mixing plants.

Aggregate Processing System

The Aggregate Processing System for preparation of coarse and fine aggregates is proposed at the Powerhouse site due to easy access and the availability of wide area of land. The estimated requirement of aggregates of different sizes is 63,790 $m^3$. In accordance with the demand of finished aggregates, consideration of the losses during transportation, processing and pouring and counting the non-uniform coefficient of production, the system's overall raw material processing capacity is assumed to be 50 $m^3/h$.

The Aggregate Processing System mainly consists of raw material stock yard, coarse screening plant, pre-screening plant, coarse crushing plant, storage area for the semi-finished products, intermediate crushing plant, main screening plant, fine crushing plant, sand making plant, storage area for the finished product, water processing system, power supply system and belt conveyor system, etc. Aggregate processing system shall adopt the three-stage crushing and closed production workmanship. Main equipment includes jaw crusher, cone crusher, vertical shaft impact crusher, vibrating feeder, vibrating screen classifier, screw sand washer, etc.

#### 15.7.2.1 Concrete Production System

The estimated total quantity of concrete in this project is about 73,600 $m^3$. Two independent units are proposed to meet the requirement of concrete and shotcrete for the Project structures. One concrete mixing batching plant of 30 $m^3/hr$ capacity is proposed on left bank side, downstream of the Weir site to cater for the needs of Main Weir, Undersluice / flushing channel, Power Intake and Access Tunnel / Adit to Headrace Tunnel near Power Intake.

Another Concrete Batch of 60 $m^3/hr$ capacity is planned to be install at Powerhouse site as suitable area is available here. This batch plant will cater for the needs of Headrace Tunnel, Surge Tank, Powerhouse, Tailrace Channel, Access tunnel / Adit to Headrace Tunnel near Surge Tank. The Temporary roads may be constructed to transport concrete at desired site location from these batch plants.

Concrete system consists of automobile receiver bin, finished charging bucket, belt conveyor, concrete mixing plant, screw conveyer, cementing material tank, air compressor room, cooling system etc. This facility need not be on level ground and it can be installed on a series of cut benches with delivery access with bins, cooling system, batch and mix plant possibly on three separate levels.

### 15.7.3 Other Site Facilities

The other site facilities that will be required by the Contractor for the construction of ALHPP are described below. Most of these facilities are planned near Powerhouse site where suitable wide land is available.

- Materials Laboratory equipped with the equipment for test on soil, rock, concrete, aggregates, bricks, embankment materials and filter materials.



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- Temporary facilities / buildings such as steelwork and carpenter's workshops, mechanical equipment repairing workshop, fabrication workshop, storage yards for storing equipment, machinery, aggregate, sand, cement, steel reinforcement, scaffolding, bricks, chemicals, explosives to be used during blasting operations and fuel tanks etc.

- Temporary roads connecting camp & other temporary facilities with the sites of main structures in the project area, other than the access roads.

- Religious facilities within the camp areas for performing religious activities.

- Health facilities including portable First Aid Station equipped to provide primary care for emergencies relating to injuries, burns, broken bones etc. Arrangements shall be made with the closest major hospital to cater for accident and hospitalization cases.

- Emergency fire protection facilities in all offices and buildings to cater for any fire hazard including hose, fire extinguishers, pails and shovels etc.

- Wireless communication system for communication between site personnel, site offices and the working areas.

- Security facilities including security check posts at main entrance of camp/site. All the work areas, storage areas and such other area where construction activity is proceeding shall be guarded by the security guards and watchmen for security.

Spares and standby equipment to ensure continuity and proper completion of operations, including diesel power generating sets, earthwork plant, concrete mixing and transportation plant, grouting equipment, dewatering plant and other key plant and equipment required to ensure work progress.

### 15.7.4 Residential Colony

Residential accommodation for the Project Executing Agency and Consultant's staff is also an important requirement, which must be made available prior to the start of the main works. The construction of Residential Colony will be started simultaneously with the construction of access roads.
An area of 2.5 Acres will be required for the construction of office, residential block for O&M Staff including Engineers, supervisory and lower staff, rest house, mosque, basic health unit, shops and other allied services including roads, water supply / sewage disposal system and the electricity arrangement etc. The Colony once completed will be utilized for the management personnel of the Employer and Consultant till the project construction completes, to facilitate the communication and management. After the completion of the project the colony will be utilized by Operation & Maintenance (O&M) staff.

Area for both the Residential Colony & Contractor's Camp are planned at one place near Powerhouse Site as a wide area of land is available here and also other plants / workshops are to be installed here.

### 15.7.5 Access Roads to Main Work Sites

Access road is the most important structure to effectively start the construction activities; therefore, the construction of access roads to the Project structure's sites shall be taken up immediately after the mobilization of Contractor at Project site.



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From transportation tunnel - 1 inlet of existing KKH, a stretch of old KKH first slopes down from El. 2400 masl to El. 2360 masl and then slopes up to El. 2500 masl with few sharp turns to approach existing spillway of Attabad lake. This stretch of old KKH within the Project Area will be improved / upgraded to provide access to the various Project structures and to serve as carriage for material and equipment required for the Project structures.

From El. 2360 masl, the old KKH path branch off to a track which slopes down to El. 2310 to approach Sarat and Salmanabad Villages through a bridge on Hunza River near proposed Powerhouse site. The track will be improved alongwith the construction of access roads to approach Powerhouse, Residential Colony, Construction camp and utilities to be established. Another track branch off from old KKH which slopes down from El. 2480 masl to El. 2420 masl near existing spillway. This track was developed at the time of creation of existing spillway of Attabad Lake and requires improvement to access Weir and Power Intake sites.

Besides the improvement / upgradation of old KKH and tracks, the access roads to access tunnels / adits for Headrace Tunnel and Surge Tank will also require to be constructed.

### 15.7.6 Additional Survey & Investigations

Based on review of existing survey and investigations, the requirements for additional field investigations will be identified by EPC Contractor and then be carried out as required for Detailed Engineering Design by the EPC Contractor.

### 15.7.7 Detailed Engineering Design

The EPC Contractor will be responsible for the Detailed Engineering Design and will be approved by Project Consultants engaged for construction supervision. Its objective is to achieve an effective design to enable the construction of hydropower plant that meets Project requirements for safety, availability & operability / maintainability with no adverse environmental impact and within the agreed cost and schedule. The EPC Contractor will design all Permanent works and all necessary Temporary works.

The design of access roads, Contractor’s camp & related facilities, Civil and E&M design of all the Project components will be commenced in parallel with the preparatory works. The design of access roads, Contractor’s camp & related facilities will be completed within one month for early construction of access road and Contractor camp & facilities. However, detailed Civil and E&M design of the Project will be presented by the EPC Contractor step by step for later work execution.

## 15.8 CONSTRUCTION PLANNING AND METHODOLOGY

The ALHPP involves execution of considerable quantities of excavation and concreting for structures. Considering the magnitude and nature of construction activities, mechanized construction has been considered for all type of construction job so as to achieve consistent quality at a faster rate for timely completion of the Project.



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The Project involves overflow weir, sediment flushing channel / undersluice, power intake, low pressure headrace tunnel, surge tank, penstock, powerhouse and tailrace channel. The location arrangement and structural details of the above components are shown in Volume-5 (Drawings). The work on all these components can be carried out simultaneously.

The construction of low pressure headrace tunnel is very significant item in order to have early completion of the ALHPP. Diversion works are mandatory for the commencement of the works on sediment flushing channel and overflow weir. The construction of the access tunnels to the headrace tunnel near power intake and surge tank areas will help to make an early start on excavation of headrace tunnel which lies on the critical path. Rock mechanics tests of tunnel and surge tank will also help in determining the kind of support system required in the crowns and walls of these underground structures. Timely rock geology identification will facilitate in design, procurement and manufacturing of support systems and will help in timely completion of the Project.

The construction methodology described in this section of Feasibility Report show techniques for main structural units of ALHPP and is based on the assumption that the construction work will be executed by an experienced EPC Contractor selected through competitive bidding, who will be fully capable of employing modern construction methods, managing proper / sufficient manpower and equipment for timely completion of the Project. However, these construction methods should not restrict the EPC Contractor using other acceptable approaches and methods to achieve desired quantity & quality of works in scheduled time and cost.

### 15.8.1 Care and Handling of Water

It is envisaged that two temporary coffer dams will be constructed in 02 stages. Stockpiling of adequate material and mobilization of suitable equipment will be made well in time before the construction of coffer dams. The construction of Stage-I coffer dam at upstream of sediment flushing channel / undersluice with crest level at El. 2422 masl, will be initiated as soon as possible after the improvement / upgrading the access path to Weir Site. On the completion of the Stage-I coffer dam, the excavation of sediment flushing channel / undersluice will be commenced and the Hunza River / Attabad Lake water will continue flowing through the existing spillway.

The construction of Stage-II coffer dam at upstream of overflow weir section with crest level at El. 2422 masl, will be initiated after the completion of works of sediment flushing channel / undersluice. On the completion of Stage-II coffer dam, the Hunza River / Attabad Lake water will be diverted through sediment flushing channel. The Stage-II coffer dam is envisaged to prevent entry of water into the working area for construction of overflow weir in dry portion.

### 15.8.2 Sediment Flushing Channel / Undersluice

The suspended sediments transported by Hunza River and entering the power intake will unavoidably result in a certain wear and tear. The extent of the abrasion depends largely on the concentration, size and mineralogical characteristics of the sediment particles on one hand and the turbine type and runner speed on the other. This abrasion and the resulting need for overhaul and replacement of runners cannot be avoided; however, the frequency of repair works can be reduced by arrangement of flushing facilities.

For this purpose, the sediment flushing channel will be constructed at the left side of overflow weir section, consisting of low level outlets with gated arrangement (three bays each having 05



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m width) and during construction of overflow weir will be used as diversion channel. The invert level of sediment flushing / undersluice section is planned at El. 2402 masl.

The sediment flushing channel would be founded on overburden / slided mass. The excavation work of sediment flushing channel will begin after the slope stabilization of left bank slopes. During its excavation, water will be diverted through existing spillway. Upon the completion of coffer dam (Stage-I), the sediment flushing channel will be excavated below its planned invert level. The occurrence of large size boulders within the sediment flushing channel area must be anticipated by the Contractor, for which proper methodology needs to be applied for removal of such boulders.

During the excavation, high moisture content materials can be encountered. The Contractor must ensure that his excavation methods ensure for the additional and unseen difficulties associated with removing this material, such as efficient transport of high moisture content material and complex care of water issues. The excavated material will be disposed-off at spoil areas planned near the Powerhouse site.

After the completion of excavation, vertical concrete cut off walls upto the required depth will be provided on upstream and downstream edge of sediment flushing section, followed by the concrete works of channel. Concrete will be poured up to the invert level, at which point where gate will be rested. Concrete placements will be temporarily diverted to flushing channel, until the completion of grouting and drainage curtain works in each bay. When the concrete works have been sufficiently progressed, the gate guides will be installed, aligned, and measured for tolerance. When the survey of these guides will confirm their position, second stage concrete will be placed. It is anticipated that the radial gates will be fabricated offsite in manageable sections. A test assembly of the gates would be undertaken at the fabrication yard, following which the gates would be dismantled to their transportable sections for mobilization to site.

At site, the gates would be preassembled into larger sections, such as trunnion arms and full height skin plate sections. These gate components would then be hoisted into place and fixed into final position. The exact process for undertaken this complex task would need to be developed in detail by the Contractor, in collaboration with the gate supplier. Once the flushing section gates are installed, the remainder of the M&E equipment i.e. gate hoists would be installed. Stop logs would also be fabricated and brought to site in full width segments. Dry commissioning of both the radial gates and stop logs would occur. Wet commissioning will follow when an appropriate level of lake is reached.

The stone apron will provided at the upstream side. Before placing stone apron, the ground will be properly adjusted and compacted and if required covered by a filter fabric. The sediment flushing channel is envisaged to be completed in 8 months period.

Upon the completion of sediment flushing channel, lake water will be diverted through this structure, to commence construction activities on power intake and overflow weir section.

### 15.8.3 Power Intake

A two bay intake structure shall be constructed on left bank of Attabad Lake upstream of main weir for passing the design discharge. The Intake level will be 4m above the invert level of sediment flushing channel section to keep the area upstream of the intake sediment free. It shall be equipped with a trashrack to prevent intrusion of debris (like timber, leaves, trees etc.)



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into the waterways and with a hydraulically operated gate for emergency closure and for isolating the waterways for inspection and maintenance.

After the completion of sediment flushing channel in all respects and drawdown of water level in Lake below El. 2400 masl, the construction work on intake structure will commence. The excavation of intake has to be made at El. 2404 masl. To access the power intake area, access road has to be constructed first and after the construction of intake structure, it will be removed. Concrete and other materials will be brought to the structure via the same route.

The excavation for the power intake shall be open cut rock excavation and will be done from top to bottom. The slope protection and support measures will be installed after each excavation step and prior to the next excavation step. The excavation will be done in a manner that the remaining rock slopes are not damaged, rock properties are maintained and rock is not loosened. The rock strengths shall be maintained by using adequate blasting techniques. The excavation beyond the theoretical rock contour shall be backfilled with concrete or shotcrete.

After completion of excavation works at intake, the erection of formwork of suitable length for pouring concrete will be done with concrete pumps to expedite the work. The excavation and concreting activities at intake structure are envisaged to be completed in 12 months period. After the completion of intake structure, a trashrack cleaning machine (TRCM) will be installed for removal of debris infront of trashracks. A gantry will be installed for placement and removal of the stoplogs.

### 15.8.4 Overflow Weir / Ungated Spillway

The overflow weir is a concrete gravity type, un-gated section (60 m wide) with downstream stilling basin. The weir would be founded on overburden / slided mass. The weir crest (El. 2414 masl) will be of ogee type which will transfer the water from Attabad Lake reservoir in a smooth decline to the downstream. A stilling basin downstream of weir will dissipate the energy by creating a hydraulic jump and shall prevent downstream erosion.

Once the construction of coffer dam (stage-II) will be completed, the work on the overflow weir section will be commenced with its excavation to required level with excavators. The occurrence of large size boulders within the main weir area must be anticipated by the Contractor, for which proper methodology needs to be applied for removal of such boulders.

During the excavation of overflow weir section, high moisture content materials can be encountered. The Contractor must ensure that his excavation methods ensure for the additional and unseen difficulties associated with removing this material, such as efficient transport of high moisture content material and complex care of water issues. The muck generated from the excavation of main weir will be disposed-off along right bank downstream of the weir site

After the completion of excavation, vertical concrete cut off walls upto the required depth will be provided on upstream edge and center of weir.

For overflow portion, the crest of the weir will be 2412.0 masl and downstream basin at El. 2400.10 masl. After completion of the excavation up to the required level, the construction of weir will be commenced in form of monoliths by erecting formwork. The concrete hauling trucks with vibrating drum will be used for pouring concrete. The specified strength of concrete in lifts usually one meter in height will be poured into formwork of the various monoliths. After pouring



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the concrete, chipping or green cutting with water and air pressure on the top of the laid concrete lift will be carried out for preparation of a proper bond required for placing the next lift of the concreting. PVC water-stop will be provided between the two monoliths at u/s of contraction joints to stop the seepage, if any. In this way, concreting up to the crest level 2412.0 masl will be completed.

The stone apron will be provided at the upstream and downstream side. Before placing stone apron, the ground will be properly adjusted and compacted and if required covered by a filter fabric. The overflow weir is envisaged to be completed in 9-month period. Upon completion of overflow weir, the working area will be re-flooded to match the lake water level.

### 15.8.5 Access Tunnels / Adits for Headrace Tunnel

The biggest portion of the underground works is the excavation of the headrace tunnel, which is approximately 2.3 km long. The headrace tunnel covers about 95% of the total underground works excavation volume. Since the main objective of the project planning is time and cost minimization, the total of these works have to be split up into reasonable portions to enable simultaneous work at several sections. In accordance with the study of local geographical and environmental conditions, the provision of 02 access tunnels has been proposed. Nevertheless, the tunneling will remain the critical path for the civil works. The following access tunnels will be constructed to access the headrace tunnel:

| Access Tunnel Adit | Length |
|---|---|
| Near Power Intake | 450 m |
| Near Surge Tank | 202 m |

The excavation of these access tunnels will be done using the drill and blast technique as explained below for the low pressure headrace tunnel.

### 15.8.6 Low Pressure Headrace Tunnel

From power intake, approximately 2,300 m long low pressure headrace tunnel (horseshoe shape), having 5.5 m width & 5.5 m height would run along the left bank of Hunza River leading to surge tank. The upstream level of tunnel is El. 2,402.5 masl whereas downstream level is El. 2,385 masl.

After the completion of access tunnels / adits, the underground works for the headrace tunnel will be commenced immediately because the construction of headrace tunnel is connected with the dependent works of surge tank structure. Taking into account the geological and execution conditions, the “Drill and Blast method” is proposed for the excavation of the headrace tunnel. The underground works of headrace tunnel are assumed to be the most critical part of the Project.

The headrace tunnel will be sub-divided into two sections. With this division in construction sections, it will be possible to work simultaneously at two fronts basically independently from each other. However, due to limitations of space for spoil areas near the power intake site, major excavation will be executed through the section near surge tank for disposal of muck at spoil areas near Powerhouse site. Accordingly, the headrace section # 01 will be from its start



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at power intake upto about 700 m length. The headrace section # 02 will be from 700 m to 2300 m (1600 m long)

The surface geological mapping of the tunnel area has been carried out. A good to poor quality rocks are present in headrace tunnel area. The tunnel length for each rock classification and its quantity are used for tunnel progress rate calculation & for establishing the tunnel scheduling.

The headrace tunnel will be constructed in three main phases; the top heading, benching and invert. The drill and blast method using a jumbo drill will be used for the top heading excavation, and the front-end loaders and articulated trucks for mucking out the excavated material. The benching will be carried out by drilling a pattern of vertical charge holes through the floor of the top heading. The holes will be charged and shot as the excavation of the bench proceeds. The rock shot will be removed with front end loaders and trucks. Similarly, invert will be excavated at the end of tunnel excavation.

Depending on the type of rock, the advance rate for the top headings is assumed as 2 to 3 m per day based on two 10-hour shifts. This advance rate is adopted after reviewing data derived from standard guides as well as ongoing projects of similar nature within Pakistan, and is used for establishing the tunnel scheduling. It has been estimated that the excavation of tunnel will be carried out in 533 days.

Support measures comprising rock bolts, shotcrete, wire mesh, steel sets and drainage holes will be adopted depending on the condition of the rock strata. After completing the excavation and temporary supports in whole length of headrace tunnel, the erection of steel sliding forms of suitable length will be applied for pouring concrete with concrete pumps to expedite the concrete lining. A standard progress assumes at 120 m/month for arch and wall applying steel sliding form and 500 m/month for inverts. The backfill grout will follow the concrete lining.

After the completion of construction activities of headrace tunnel, the access tunnels/adits will be plug with the concrete. Total time of around 25 months has been estimated for the excavation, rock support measures and concrete lining of headrace tunnel.

### 15.8.7 Surge Tank

A circular surge tank having 10 m diameter and 45 m high will be constructed at the intersection of the headrace tunnel and penstock to prevent the adverse effect of water hammer pressure or flow variation due to turbine load fluctuation on the headrace and other structures.

For approaching surge tank, an access road and access tunnel / adit will be constructed upto its crown. The construction of access road will be commenced simultaneously with the other access roads to the work sites. The excavation work for access tunnel will be started from its outlet and mucking of excavated material will also be done from the same end. Rock bolting and shotcreting on excavated faces of access tunnel shall be done depending on the condition of the rock strata.

The work for surge tank will be done more or less independently from the other works. Dependence exists to the construction of 2$^{nd}$ section of the headrace tunnel because it will be used for mucking of excavated material from the surge tank structure.

After the completion of access tunnel / adit, the manpower and equipment shall be mobilized and downward excavation shall be done by raise boring to the full diameter of the surge tank.



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Prior to raise boring activities, the excavation will be done to prepare the staging area and platform for the surge tank. Once the boring machine is set, drilling of pilot hole will commence. Drilling of pilot hole will be done until breakthrough with the tank bottom at headrace tunnel. After breakthrough, widening the pilot hole by raise boring will be done. The spoil generated shall be mucked out from the tank bottom off the headrace tunnel using wheeled loader that will load the spoil to dump trucks for transport to spoil areas near powerhouse site. Upon completion of raise bore, the boring equipment will be dismantled and removed from the site.

The raise bore will then be widened to the full diameter of the tank. After initial excavation, collaring of the tank will be done by applying the support measures. Suitable hoisting equipment and related accessories will be installed to transport equipment, supplies and personnel from the tank collar to the work area. After advancing downwards, the sinking platform will be installed to facilitate the work of the tank construction.

Main excavation will be by drill and blast method, starting from the top and progressing downward. The explosives charge will be limited to ensure that the pilot raise bore is not deteriorated or damaged by the blasting operations. After each blast, spoil will be dropped to the tank bottom through the pilot raise bore which shall then be loaded by a wheeled loader into dump trucks that will transport the spoil to the spoil area through the access tunnel / adit to headrace tunnel near surge tank.

After completion of excavation, the concrete lining in this structure will be taken up immediately by starting from its bottom to top with slip forms moving in an upward direction towards the tank collar. A total of 12 months have been allocated for completion of the underground excavation and concrete works of the surge tank.

### 15.8.8 Penstock

A Penstock of 3.6 m dia will be laid under the left bank slopes for conveying water from headrace tunnel to 03 Vertical Shaft Francis Turbines to be housed in Powerhouse. At the end, the penstock shall be trifurcated into penstock manifolds with reduced dia. In the first section upto 80 m, the penstock will cross horizontally the rock starting from the bottom of surge tank. This section can be considered as an extension of headrace tunnel, lined with an embedded steel lining. The second section, 455 m long will be the embedded penstock descending towards the powerhouse.

For the excavation of first section, the similar method of excavation as for headrace tunnel i.e. drill and blast method will be applied. For the second section, the alluvium will be excavated upto the required depth over which concrete will be placed for penstock to be laid. Excavation from the penstock trench will be stockpiled in the area near to the powerhouse site.

The penstock steel liner will be manufactured in the workshop at the Project site from the steel plates and welded into 4 to 6 m long sections, which after testing will be transported to their places of installation using trailers. The installation of penstock will be started from the upstream side moving downwards towards the powerhouse. The penstock will be placed on a bedding of blinding concrete. After laying in final position, the penstock sections will be welded, followed by the concreting of 8 no. anchor blocks and backfilling. The construction of penstock will be taken up alongwith the powerhouse construction. Total time envisaged for the construction of penstock is 10 months.



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### 15.8.9 Powerhouse Civil Works

The Powerhouse is proposed 63 m long, 20 m wide and 35 m high with four floors at different levels. Machine Hall floor would be at El. 2306.2 masl and powerhouse top shall be at El.2314.5 masl. The main hall would accommodate three vertical Francis units, each of 18 MW, alongwith generators, switch cabinets, trifurcation of penstock pipe and erection bay.

The construction of powerhouse structure will be taken up independently after the construction of access road to powerhouse site. The powerhouse will be excavated upto the lowest El 2292 masl of the powerhouse pit. The muck generated from the excavation will be disposed off at the spoil areas near powerhouse site.

Upon completion of powerhouse excavation, the steel reinforced base concrete will be poured and subsequent concrete works for sub-structure and super-structure of powerhouse will be commenced in accordance with the planned sequence. The sloping trussed roof will be constructed along with the installation of powerhouse crane. Backfilling around powerhouse will be done upon the completion of powerhouse substructure. All these activities related to powerhouse construction will be completed in 15.5 months. The powerhouse architectural works will be completed parallel to testing and commissioning of units.

### 15.8.10 Unit Erection

The three generating units will be housed in the powerhouse, with the operating floor at El. 2,306.2 masl. A large erection bay is provided to maximize the ability to work on multiple units at a time to save time. Each turbine is connected via a main inlet valve to a steel penstock.

It is intended that the EPC Contractor will have three complete teams of workers on site, enabling the erection of three units in parallel. In addition, the workforce will be divided so that a team that installs and welds embedded components, such as the draft tube and spiral casing, will be separate from a team that installs the rotating plant (head cover, guide vanes etc.). There will also be separate generator teams, able to work on stators and rotors in parallel. The main inlet valves (MIV) for 03 turbines will be installed for commissioning of units when headrace tunnel is watered.

In draft tube construction, civil and mechanical teams will work continuously without impeding the each other. Once the draft tube liner has been installed for a particular unit, the mechanical team will move on to the next unit while the civil team undertakes draft tube embedment. Once the next draft tube liner is installed, and the concrete of the current unit is sufficiently cured, the team will move back to the initial unit to install and weld the spiral casing, and so on. In this way the mechanical and civil teams will be continuously employed without hindering each other.

### 15.8.11 Mechanical & Electrical Installations

The installation of the mechanical and electrical equipment can be broken down into the following major stages, excluding the civil works that are required to support these works, such as pouring the floor columns, beams, floors and plinths:

- Installation and embedment of the turbine embedded parts, comprising the draft tube liner, spiral casing, stay ring, and turbine pit liner.

- Installation and alignment of the turbine and covers to the stage where work can commence on the generators such as head cover, regulating ring, servomotors, runner



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and turbine shaft. These items are large and heavy and need to be lowered into the turbine pit using the powerhouse crane, and hence no work in the generator enclosure can take place before these works are complete.

- Installation of the generator lower bracket (which is then covered over and used as a working platform) to allow generator stator building in parallel with installation of the remaining turbine components, which will need to be taken into the turbine pit via the pit entrance on the turbine floor.

- Installation of 03 spherical Main Inlet Valves (MIV). Each valve will be taken to its plinth and aligned with the penstock stub and spiral inlet, a potentially time consuming process depending on the accuracy of alignment of those components. The upstream stub pipe of the MIV will be welded to the penstock manifold stub. A stub piece will be welded to the spiral end, and the remaining gap filled with an adjustable make-up ring. The servomotor(s) will be installed as well as control pipework and fittings to enable the valve to be dry commissioned.

- Generator stator building. The stator frame will be brought to the erection bay in three sections. They can then either be assembled on the erection bay and taken as one assembly to the generator enclosure or taken as separate items and assembled in the enclosure. The method used would be that preferred by the manufacturer. Once in position and aligned the stator core will be built. The core will consist of layers of punched magnetic sheets of steel lowered over retaining rods to form a complete ring with no vertical joints. The layers will be built up and clamped to predetermined pressures at a number of stages to ensure the build is progressing satisfactorily. Care will be required to ensure the stator core is completely circular. Resistance temperature detectors will be embedded within the core to provide temperature information during unit operation. Once the core layers are complete the competed core will be clamped to ensure it does not move during operation. Upon tests to ensure the core is satisfactory, the stator winding will commence. There will be two layers of windings in each slot, but the exact dimensions and construction arrangements will be to the manufacturer’s standard design.

- Generator rotor building. This work will be undertaken on the erection bay and as such can take place in parallel with the stator building. The rotor spider (the frame upon which the rotor pole rim is mounted) will be of forged construction and brought into the powerhouse as one item. It will be lowered over the generator shaft, and then the rim and brake track will be fitted, followed by the rotor poles.

- The upper bracket, bearings and slip-rings will be installed once the fully assembled and tested rotor has been lowered into the generator onto the thrust bearing (which will be mounted on the lower bracket). The rotor will be the heaviest single item to be lifted within a powerhouse, and will require two overhead cranes to operate in tandem (i.e. controlled as a single device) using a specially designed lifting beam.

- The generator transformers will be installed in transformer bays outside powerhouse at its back. During the erection stage, the transformers will be delivered directly to the transformer bays. The transformers will be delivered as complete tanks (that is, the core will be installed in the tank and the assembly sealed), but the internal voids will be filled with nitrogen rather than oil and most other items will be sent separately (such as the



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conservator) to reduce transportation weight. The transformers will have to be drained on the nitrogen, fitted out with all the remaining components and then filled with oil and tested. Upon completion of generating units, the transformers will be connected to Insulated Bus Pipes (IPBs) and HV switchgear for on-line commissioning.

- Main electrical equipment comprising excitation system, control boards, isolated phase busbars, gas insulated busbars (GIB) and the switchyard electrical equipment. All these items can be installed as civil works are finished and time allows.

- The turbine and generator auxiliary systems, comprising the cooling water system, lubrication system, compressed air system, braking and jacking system, shaft seal system, drainage and dewatering system and others can be installed in parallel with the main installation works, timed to finish at the same time.

- Lighting and small power equipment will need to be installed on a unit basis to provide the required amenities for the station operations and maintenance personnel once each unit is commissioned.

The total time for excavation, concreting in powerhouse and installation of vertical Francis turbines, generators, transformers and auxiliary systems is estimated to be 21 months.

### 15.8.12 Tailrace Channel

The draft tube of each turbine unit will drain water in the 20 m long tailrace channel and it finally will be discharged into Hunza river. The tail water level is therefore maintained to retain the minimum setting for turbines. The excavation of tailrace channel can be started and completed independent of the other activities in parallel with the excavation of Powerhouse starts.

### 15.8.13 Switchyard

A surface 132 kV switchyard will be located near Powerhouse. The civil works of the switchyard area will be started after the construction of powerhouse superstructure. The switchyard equipment will be transported to its location through access road to Powerhouse. The erection of switchyard equipment will be done using the 5 ton mobile crane. Cabling for instrumentation, monitoring and controls alongwith cable terminations will be completed before the start of unit testing. It is envisaged that the construction and installation of the equipment in switchyard will take 07 months.

### 15.8.14 Transmission Lines

The two double circuit 132 kV transmission line will be erected, each between ALHPP and grid station at Aliabad (70 km) and Sost (27 km) for transfer of power generated at Attabad to the local grids. The construction of transmission lines is critical for commissioning and commercial operation of the powerhouse units. This activity can proceed independently and does not have any link with the other project construction activities. But it is important that transmission line construction should be planned in such a way that at least one circuit must be available before commissioning of first generating unit, so that the energy generated can be transmitted to the local grid.

The construction activities include construction of foundations, fixing of towers, installation of equipment, stringing, etc., and other activities include transportation of construction materials and equipment. It is estimated that construction of transmission lines will take 23 months.



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Another significant aspect for on time completion of the transmission lines is the marking of route corridors and acquisition of land prior to commencement of the construction activities.

Diligent planning will be required to complete the geotechnical and other investigations, route alignment, acquisition of right of way, identification of access road routes and crossings over the Hunza River etc., before the actual start of construction of the transmission lines.

### 15.8.15 Transportation, Assembly of Electro-Mechanical Equipment

All the Electrical & Mechanical equipment, which includes main inlet valve, turbine and generator parts, transformers, gate equipment, HV & LV switchgear, crane and other auxiliaries, will be transported from port to site on trailers and containers via National highway / Motorway and KKH. The largest pieces of equipment will be transported to site in parts and will be assembled at site. This equipment will be stored at site in the work yards / storage areas, with sensitive parts stored in covered areas for protection against rain, dust and weather action.

The first item of equipment to be installed in the powerhouse is the crane, for which the EPC Contractor will complete the civil works in erection bay and complete the erection of crane rails. The crane will be tested for travelling and carrying of the designed load with all protections in place, after completing installations of all parts.

### 15.8.16 Testing and Commissioning

After installation of all electro-mechanical equipment, two months will be required for testing and commissioning of the installed equipment before the start of commercial operation.

## 15.9 PROJECT IMPLEMENTATION SCHEDULE

The proposed implementation schedule takes account of the preliminary design of each structure and facilities, work quantities and site conditions. It is prepared on the basis of the construction plan, estimated construction progress, rate of each activity and work sequence. The Project Implementation Schedule spans over a period of 50 months, which includes 36 months for construction activities and 14 months for pre-construction activities. It is anticipated that the construction of the entire project shall be completed within this time frame. The Project Implementation Schedule is presented as Annexure-A.

During detailed design and execution of actual works, EPC Contractor may develop his own schedule in such a way that most of the work can be taken up simultaneously on various project components in order to complete the project in the shortest possible time.

## 15.10 CONSTRUCTION MANAGEMENT

### 15.10.1 Project Executing Agency

Pakistan Water and Power Development Authority (WAPDA) will execute the Project as Project Executing Agency. WAPDA in close liaison with the Consultants will provide supervision of all the Project works by EPC Contractor and will facilitate all staff permits, authorizations, licenses, customs clearance of imported equipment, materials & personal effects required for the execution of the Project. WAPDA will also coordinate with Gilgit Baltistan's authorities and departments for any issues arising about the project, which require resolution by inter-departmental interaction.



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### 15.10.2 Consultants

The supervision of construction activities by EPC Contractor will be carried out by independent Consultants, comprised of a Joint Venture of local and international engineering firms with proven track records on such projects. The Consultants will be reporting to the Project Executing Authority.

During the Pre-Construction phase, the Consultants will prepare EPC Tender Documents of the Project. After approval of the Tender Documents, the Consultants will assist Project Executing Agency in the procurement of EPC Contractor.

During the Construction Phase of the Project, the Consultants will in general review & monitor the detailed design, construction, manufacturing, procurement, installation, commissioning & testing of works by the EPC Contractor. The Consultant's services will be in close coordination with the Project Executing Agency. The Consultant's major tasks for EPC implementation of the Project will be:

- To monitor additional field investigations, review of procedures adopted and types of tests performed by the Contractor.
- To examine the basis of design by the Contractor and review of design reports, detailed construction drawings, specifications, construction schedules, quality assurance / quality control manuals and health, safety & environmental manuals by the Contractor.
- To monitor the manufacturing and procurement of equipment by the Contractor for timely delivery and supervision of all quality control tests at manufacturer's workshops.
- To monitor Contractor's progress of work and coordination of construction activities of various civil and E&M works to ensure execution of the project within time and according to applicable standards.
- To monitor Contractor's compliance with construction management & environmental management plans.
- To verify the works executed by the Contractor for the purposes of making interim payments and the final payment.
- To review variations and claims by the Contractor and provide assistance to Project Executing Agency in processing the claims.
- To review Contractor's As-Built documentation / drawings, operation & maintenance manuals and project completion reports.



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# ANNEXURE - A

# IMPLEMENTATION SCHEDULE



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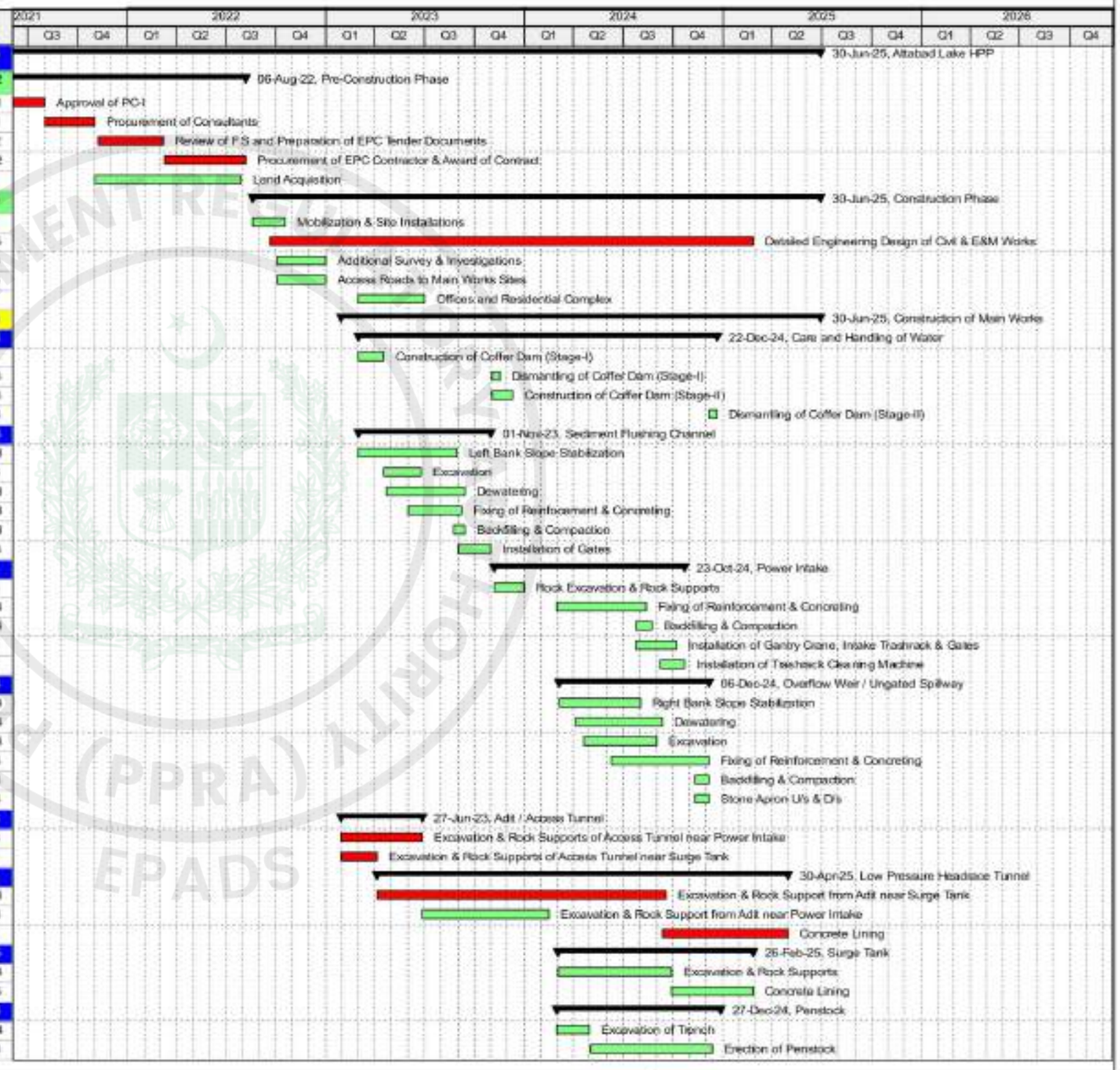
# ATTABAD LAKE HYDROPOWER PROJECT

## IMPLEMENTATION SCHEDULE

| Activity ID | Activity Name | Original Duration | Start | Finish |
|---|---|---|---|---|
| **Attabad Lake HPP** | | 1519 | 03-May-21 | 30-Jun-25 |
| **Pre-Construction Phase** | | 460 | 03-May-21 | 06-Aug-22 |
| A1000 | Approval of PC-I | 90 | 03-May-21 | 01-Aug-21 |
| A1010 | Procurement of Consultants | 90 | 03-Aug-21 | 01-Nov-21 |
| A1020 | Review of F.S and Preparation of EPC Tender Documents | 120 | 08-Nov-21 | 08-Mar-22 |
| A1030 | Procurement of EPC Contractor & Award of Contract | 150 | 09-Mar-22 | 06-Aug-22 |
| A1040 | Land Acquistion | 270 | 01-Nov-21 | 29-Jul-22 |
| **Construction Phase** | | 1045 | 20-Aug-22 | 30-Jun-25 |
| A1050 | Mobilization & Site Installations | 60 | 20-Aug-22 | 19-Oct-22 |
| A1060 | Detailed Engineering Design of Civil & E&M Works | 890 | 20-Sep-22 | 26-Feb-25 |
| A1070 | Additional Survey & Investigations | 90 | 04-Oct-22 | 02-Jan-23 |
| A1080 | Access Roads to Main Works Sites | 90 | 04-Oct-22 | 02-Jan-23 |
| A1160 | Offices and Residential Complex | 120 | 03-Mar-23 | 01-Jul-23 |
| **Construction of Main Works** | | 864 | 28-Jan-23 | 30-Jun-25 |
| **Care and Handling of Water** | | 660 | 03-Mar-23 | 22-Dec-24 |
| A1700 | Construction of Coffer Dam (Stage-I) | 45 | 03-Mar-23 | 17-Apr-23 |
| A1710 | Dismantling of Coffer Dam (Stage-I) | 15 | 02-Nov-23 | 17-Nov-23 |
| A1720 | Construction of Coffer Dam (Stage-II) | 40 | 02-Nov-23 | 12-Dec-23 |
| A1730 | Dismantling of Coffer Dam (Stage-II) | 15 | 07-Dec-24 | 22-Dec-24 |
| **Sediment Flushing Channel** | | 243 | 03-Mar-23 | 01-Nov-23 |
| A1090 | Left Bank Slope Stabilization | 180 | 03-Mar-23 | 30-Aug-23 |
| A1100 | Excavation | 70 | 17-Apr-23 | 26-Jun-23 |
| A1110 | Dewatering | 145 | 22-Apr-23 | 14-Sep-23 |
| A1130 | Fixing of Reinforcement & Concreting | 100 | 01-Jun-23 | 09-Sep-23 |
| A1140 | Backfilling & Compaction | 20 | 25-Aug-23 | 14-Sep-23 |
| A1150 | Installation of Gates | 60 | 02-Sep-23 | 01-Nov-23 |
| **Power Intake** | | 350 | 08-Nov-23 | 23-Oct-24 |
| A1260 | Rock Excavation & Rock Supports | 55 | 08-Nov-23 | 02-Jan-24 |
| A1280 | Fixing of Reinforcement & Concreting | 165 | 02-Mar-24 | 14-Aug-24 |
| A1290 | Backfilling & Compaction | 30 | 25-Jul-24 | 24-Aug-24 |
| A1300 | Installation of Gantry Crane, Intake Trashrack & Gates | 75 | 25-Jul-24 | 08-Oct-24 |
| A1500 | Installation of Trashrack Cleaning Machine | 45 | 08-Sep-24 | 23-Oct-24 |
| **Overflow Weir / Ungated Spillway** | | 275 | 06-Mar-24 | 06-Dec-24 |
| A1190 | Right Bank Slope Stabilization | 150 | 06-Mar-24 | 03-Aug-24 |
| A1200 | Dewatering | 160 | 05-Apr-24 | 12-Sep-24 |
| A1210 | Excavation | 135 | 20-Apr-24 | 02-Sep-24 |
| A1230 | Fixing of Reinforcement & Concreting | 180 | 09-Jun-24 | 06-Dec-24 |
| A1240 | Backfilling & Compaction | 25 | 11-Nov-24 | 06-Dec-24 |
| A1370 | Stone Apron U/s & D/s | 25 | 11-Nov-24 | 06-Dec-24 |
| **Adit / Access Tunnel** | | 150 | 28-Jan-23 | 27-Jun-23 |
| A1310 | Excavation & Rock Supports of Access Tunnel near Power Intake | 150 | 28-Jan-23 | 27-Jun-23 |
| A1320 | Excavation & Rock Supports of Access Tunnel near Surge Tank | 67 | 28-Jan-23 | 05-Apr-23 |
| **Low Pressure Headrace Tunnel** | | 756 | 05-Apr-23 | 30-Apr-25 |
| A1330 | Excavation & Rock Support from Adit near Surge Tank | 533 | 05-Apr-23 | 19-Sep-24 |
| A1340 | Excavation & Rock Support from Adit near Power Intake | 234 | 27-Jun-23 | 16-Feb-24 |
| A1660 | Concrete Lining | 230 | 12-Sep-24 | 30-Apr-25 |
| **Surge Tank** | | 360 | 03-Mar-24 | 26-Feb-25 |
| A1350 | Excavation & Rock Supports | 210 | 03-Mar-24 | 29-Sep-24 |
| A1360 | Concrete Lining | 150 | 29-Sep-24 | 26-Feb-25 |
| **Penstock** | | 300 | 02-Mar-24 | 27-Dec-24 |
| A1380 | Excavation of Trench | 60 | 02-Mar-24 | 01-May-24 |
| A1390 | Erection of Penstock | 225 | 02-May-24 | 13-Dec-24 |




Remaining Work | Critical Remaining Work | summary

Page 1 of 2

AFS-CP-478

**Annex - A**



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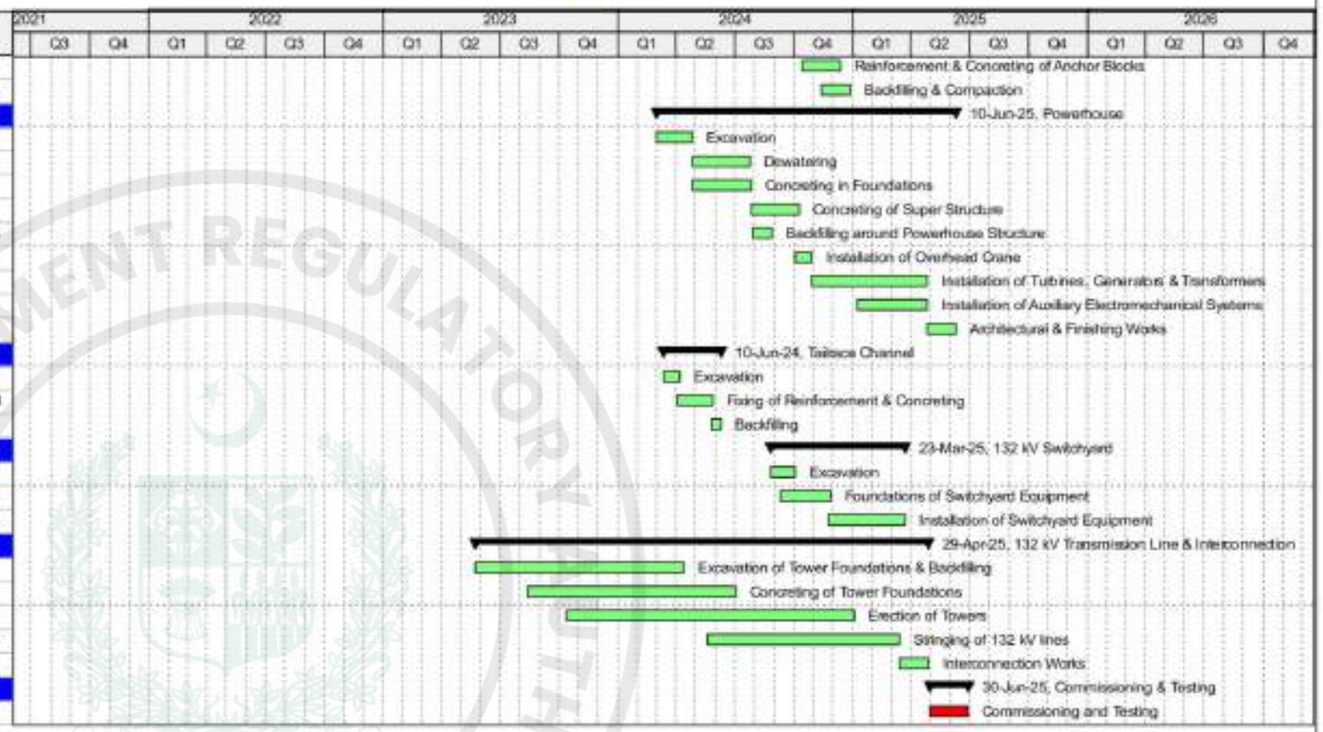
# ATTABAD LAKE HYDROPOWER PROJECT

## IMPLEMENTATION SCHEDULE

| Activity ID | Activity Name | Original Duration | Start | Finish |
|---|---|---|---|---|
| A1400 | Reinforcement & Concreting of Anchor Blocks | 60 | 14-Oct-24 | 13-Dec-24 |
| A1410 | Backfilling & Compaction | 45 | 12-Nov-24 | 27-Dec-24 |
| Powerhouse | | 465 | 02-Mar-24 | 10-Jun-25 |
| A1420 | Excavation | 55 | 02-Mar-24 | 26-Apr-24 |
| A1430 | Dewatering | 90 | 26-Apr-24 | 25-Jul-24 |
| A1440 | Concreting in Foundations | 90 | 27-Apr-24 | 26-Jul-24 |
| A1450 | Concreting of Super Structure | 75 | 26-Jul-24 | 09-Oct-24 |
| A1460 | Backfilling around Powerhouse Structure | 30 | 29-Jul-24 | 28-Aug-24 |
| A1470 | Installation of Overhead Crane | 25 | 03-Oct-24 | 28-Oct-24 |
| A1480 | Installation of Turbines, Generators & Transformers | 180 | 29-Oct-24 | 27-Apr-25 |
| A1490 | Installation of Auxiliary Electromechanical Systems | 110 | 07-Jan-25 | 27-Apr-25 |
| A1520 | Architectural & Finishing Works | 45 | 26-Apr-25 | 10-Jun-25 |
| Tailrace Channel | | 90 | 12-Mar-24 | 10-Jun-24 |
| A1530 | Excavation | 25 | 12-Mar-24 | 06-Apr-24 |
| A1550 | Fixing of Reinforcement & Concreting | 55 | 03-Apr-24 | 28-May-24 |
| A1560 | Backfilling | 15 | 26-May-24 | 10-Jun-24 |
| 132 kV Switchyard | | 210 | 25-Aug-24 | 23-Mar-25 |
| A1570 | Excavation | 40 | 25-Aug-24 | 04-Oct-24 |
| A1580 | Foundations of Switchyard Equipment | 80 | 09-Sep-24 | 28-Nov-24 |
| A1590 | Installation of Switchyard Equipment | 120 | 23-Nov-24 | 23-Mar-25 |
| 132 kV Transmission Line & Interconnection | | 705 | 25-May-23 | 29-Apr-25 |
| A1600 | Excavation of Tower Foundations & Backfilling | 325 | 25-May-23 | 14-Apr-24 |
| A1620 | Concreting of Tower Foundations | 325 | 13-Aug-23 | 03-Jul-24 |
| A1630 | Erection of Towers | 450 | 12-Oct-23 | 04-Jan-25 |
| A1640 | Stringing of 132 kV lines | 300 | 19-May-24 | 15-Mar-25 |
| A1650 | Interconnection Works | 45 | 15-Mar-25 | 29-Apr-25 |
| Commissioning & Testing | | 60 | 01-May-25 | 30-Jun-25 |
| A1670 | Commissioning and Testing | 60 | 01-May-25 | 30-Jun-25 |




Remaining Work | Critical Remaining Work | summary

Page 2 of 2

AFS-CP-478



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# 16 ENVIRONOMENTAL IMPACT ASSESSMENT

## 16.1 GENERAL

Administratively, the Gilgit-Baltistan (Gilgit-Baltistan) is divided into 10 districts: Gilgit, Ghizer, Hunza, Nagar, Skardu, Ghanche, Shigar, Kharmang, Diamer and Astore. Previously there were seven districts in the Region. In 2016, the number of districts increased from seven to ten after the addition of 2 districts in Baltistan Region and the bifurcation of the Hunza-Nagar to 2 districts. in 2021, there are 10 districts in the entire region, 4 in the Baltistan Division, 4 in the Gilgit Division and two in the Diamer Division. In 2019, Darel, Tangir, GupisYasin and Roundu has been announced as new districts by the Gilgit-Baltistan Cabinet, but so far these are not notified officially

**Figure 16-1 District and Tehsil Boundaries of Gilgit-Baltistan**

Hunza Valley was composed of two independent kingdoms: Hunza and Nagar in the early 1600s. Hunza is located on the branch of the ancient Silk Route from Kashgar to Kashmir and is linked to Turkistan/western China since ancient times.

Attabad Lake was created due to a massive land slide in January, 2010. Water and Power Department (W&P Dept.) of Gilgit-Baltistan intends to utilize this storage as an opportunity to develop Hydropower Project of appropriate capacity utilizing this potential in order to meet the ever increasing demand of Hunza District and its suburbs.



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## 16.2 ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT (ESIA)

The ESIA is the planning tool developed in recent years to foresee the environmental and social impacts of human intervention in nature arising from development projects. Major hydropower and storage dam projects invariably result in many far-reaching environmental, ecological and socio-cultural changes. Some of these changes benefit human population, while others threaten the natural resource base on a short or long term basis.

The negative environmental and social impacts of a development project are avoided or minimized through the ESIA and where adverse impacts cannot be avoided, the mitigation measures and resettlement activities are conceived and executed as part of the project.

The overall objectives of an ESIA in accordance with the Pakistan Environment Protection Act (PEPA 1997), and the World Bank guidelines (OP 4.0) include the following:

- Help to ensure the environmental and social soundness and sustainability of projects.
- Support integration of environmental and social aspects of projects into the decision making process.
- Promote environmentally sustainable development by supporting the protection, conservation, maintenance, and rehabilitation of natural habitats and their functions.
- Avoid or minimize involuntary resettlement and if not feasible, to assist displaced persons in improving or at least restoring their livelihoods and standards of living in real terms relative to pre-displacement levels or to levels prevailing prior to the beginning of project implementation, whichever is higher.
- Design and implement projects in a way that fosters full respect for indigenous peoples' dignity, human rights, and cultural uniqueness and so that they: (a) receive culturally compatible social and economic benefits; and (b) do not suffer adverse effects during the development process.
- Assist in preserving physical cultural resources and avoiding their destruction or damage.
- Assure quality, health and safety in the design and construction of new dams and the rehabilitation of existing dams, and in carrying out activities that may be affected by an existing dam.
- Enable vulnerable and disadvantaged stakeholder groups to participate in an informed manner.

## 16.3 PROJECT CATEGORIZATION

According to Pakistan Environment Protection Agency (PEPA) regulations for review of IEE and EIA, hydroelectric projects with a generation capacity of over 50 MW and power transmission lines with a capacity more than 11 kV fall into Schedule-II, i.e. projects requiring EIA. Similarly, in accordance with the guidelines of the World Bank, the Asian Development Bank and the Japan Bank for International Cooperation Environmental guidelines, the AALHPP (with a planned generating capacity of 54 MW and 132 kV power transmission lines) would fall within the category 'A' projects could be having significant impacts on the environment and requiring a full scale EIA.



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## 16.4 SCOPE AND LIMITATIONS OF ESIA

### 16.4.1 Scope

The scope of the study includes this ESIA which only covers the dam site, reservoir, powerhouse areas and transmission systems. Resettlement Action Plan (RAP) is not under consideration as there is no displacement of people involved. Team of Engineers from Hydro Planning Organization (HPO) have envisaged the following statement of work related to environmental studies:

a. Review of national and local guidelines, laws and policies;

b. Review of all relevant existing data, studies, reports and drawings;

c. Avoid, minimize, mitigate and the potential significant environmental and social impacts due to the proposed intervention;

d. Collection of baseline data related to physical, ecological and social environmental aspects;

e. Identification, evaluation and categorization of the potentially significant adverse physical, ecological and socio-economic impacts on the local environment during the construction and operational stages of the proposed Hydropower Project;

f. Recommend appropriate environmental and social mitigation measures for the identified adverse impacts and monitoring plans to address them;

g. Preparation of Environment Monitoring Management Plan (EMMP);

h. Cost estimate for environmental setup;

i. Public consultation and disclosure;

### 16.4.2 Limitations

The baseline information documented in the present report reflects the prevailing physical, biological and socio-economic conditions of the Project Area. The Project is at Feasibility Stage and the detailed design and tender documents preparation stages will follow during the execution. If the Project is implemented after two years of completion of the Feasibility Stage then certain variables such as development of infrastructure, population growth, increase or decrease in the forest, land use, cropping patterns and economic conditions could be changed significantly.

## 16.5 APPROACH AND METHODOLOGY

### 16.5.1 Review of Previous Studies

ALHPP was conceived by W&P. Dept. of Gilgit-Baltistan. Consequently, a Feasibility Study was conducted by the W&P. Dept. of Gilgit-Baltistan through Consultants with a designed capacity of Project for 32.5 MW. Therefore, only IEE was carried out to fulfill the requirement of the PEPA by the consultants engaged by govt. of GILGIT-BALTISTAN because ESIA was not required for projects less than 50 MW. Later on the request of govt. of Gilgit-Baltistan, HPO,



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WAPDA updated the Feasibility Study of the Project with enhanced capacity of 54 MW and therefore, detailed ESIA was required.

The following earlier project reports have been reviewed to assess their applicability in the prevailing environmental conditions specially in GILGIT-BALTISTAN Region:

- Bunji Hydropower Project: Feasibility Study Report (Vol-III), Environmental Impact Assessment by Bunji Hydropower Consultants (March, 2005).
- Detailed Engineering Design Report of Phander Hydropower Project.
- Feasibility Study Report of Shyok Dam Project, Environmental Impact Assessment Study.
- And Various Other Reports Related to Gilgit-Baltistan.

### 16.5.2 Acquisition of Secondary Data

The secondary data have been collected from various offices and published reports of different organizations in the Gilgit-Baltistan. These organizations included W & P Dept., Education, Forest, Agriculture, Fisheries, Sanitation, Wildlife, Environmental Protection Agency, District Administration, Tehsil Offices, Local Councils and others. The studies are carried out on the information received during field visits of Project Area, data received from some NGOs, water samples collected from Project Area at various places and tested in Environmental Protection Agency Laboratory, Gilgit, climate data received from Metrological Department, and other data taken from earlier conducted Feasibility Study and other reports of projects.

### 16.5.3 Collection of Primary Data

The primary data have been collected and assessed with reference to different project components, i.e. dam site, reservoir area, powerhouse, construction camps etc. The data regarding climate, hydrology, geology, seismology, neo-tectonics and other physical features of the Project Area has also been obtained as part of the preparation of this Feasibility Study

#### I. Vegetation and Wildlife Fauna Studies

The assessment area for terrestrial flora and fauna encompasses the terrestrial environments upstream and downstream of the dam and adjacent areas that may be affected by the project activities, specifically from the dam to the upper end of the reservoir impoundment and from the dam to the powerhouse.

Since the lake was formed in January 2010 and no new area would be submerged with the Project except the powerhouse site, therefore, there would be no new threat to plants with the construction of hydropower project. However, concentration has been given to study the rare species and special emphasis has given to the economic species such as medicinal plants.

Information on wildlife fauna species (mammals, amphibians, reptiles, birds etc.) in the assessment area has compiled based on opportunistic observation, gathering the existing information and consultation with local experts, community members and government and non-government organizations.



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### II. Aquatic Ecology and Environmental Flow Study

Generally Northern Area is blessed with great water resources comprised of rivers, streams, and alpine lakes fed by the snowmelt and glacier waters. These freshwater resources harbor several fish species, which are the important component of the biological diversity. The fish fauna in Hunza Valley is relatively poor due to high turbidity, low water temperature and high water speed.

An environmental flow study has been carried out to determine the optimum environmental flow downstream of the proposed dam for sustainability of the aquatic ecosystem.

### III. Social Surveys

The purpose of social survey is to record the present conditions of the people living in the Project Area and to assess the expected Project impacts on their life, subsistence systems, and social and cultural conditions. Prior to conducting the field surveys, the following steps have been taken:

- Geographic boundaries of the Project Area has been identified and listed existing villages and settlements.
- Decided the sampling procedure in order to draw a representative sample size of the target population and households.
- Developed the tools for data collection i.e. questionnaires for household sample survey, village profile, women sample survey, community participation and water use.

In order to obtain comprehensive and detailed information, the following techniques and tools of data collection has been used.

### IV. Sampling Design

A stratified proportionate random sampling technique has been applied to select adequate and representative samples to generalize survey findings at the Project level. The stratification variables have been taken into consideration for enhancing the representation level for adopting appropriate sampling design.

### V. Stratification Variables

The major objective of the study has to establish baseline socio-economic conditions for the inhabitants near the existing reservoir upto original extent of lake formed in 2010, powerhouse and adjacent areas of the Project. The following factors have been taken into consideration for enhancing the probability of every household being selected in the sample size:

Each village has been included in the sampling frame because of the heterogeneity of socio-economic characteristics between villages and relatively homogeneity within a village.



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### VI. Sampling Unit

The primary sampling unit for the socio-economic survey is the head (male or female) of the household falling within the nine sample villages of proposed ALHPP Area.

### VII. Basic Unit of Study

The basic unit of study and analysis for the purpose of socio-economic investigation is nine villages of Project Area for ALHPP.

### VIII. Questionnaires

In order to test the validity and reliability of the proposed questionnaires, interviewing guides have been pre-tested in the area and then the questionnaires have reviewed to assess whether questions needed to be clarified, changed or re-sequenced and then a final editing of questionnaires has been conducted prior to their subsequent application in the real sample areas.

List of Respondents of socio-economic survey is attached at **Appendix-A** of **Volume-6** of Feasibility Study. The different questionnaires used for the social survey are included in **Appendix-B** of **Volume-6** of Feasibility Report.

### IX. Field Investigators

A team of experts of Hydro Planning Organization (HPO) moved to Project Area for field investigations. The team hired services of one local graduate female and one local graduate man for questioning and answering with local people in their language. Additionally, the services of a local well educated female hired for the interviews and data collection covers the subjects of gender and women empowerment. The team spent more than three weeks to visit seven villages of upstream and two villages of downstream side of the Project Area. In this exercise both genders have been covered in field visits of Project Area. The field investigators (team) with interviewing skills minimize the sampling error and wrongly asked or interpreted or recorded answers to finalize a report with the respondents.

### X. Interviewing Guide for Community Participation

Well informed persons in the village has been interviewed by using a questionnaire to obtain information about village and their perceptions about the Project.

### XI. Household Sample Survey

Household heads of total sample size from each sample village of the Project Area have been interviewed by using structured questionnaires. Detailed information about the socio-economic status of the family and household has been obtained from the respondents.

### XII. Village Profile

A comprehensive village profile has been prepared to document the socio-economic and demographic data of each sample village in Project Area.



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### XIII. Gender Survey

The experts developed a separate questionnaire covering various aspects and issues of women in the area. The services of a qualified local female hired for this survey. Women from all the villages have been interviewed. Respondent women have been selected by applying the technique used for socioeconomic survey.

### XIV. Data Editing

The filled-in questionnaires and interviewing guides have been edited by the same field investigators, who are involved in the data collection. This has been done immediately after completing the field investigations.

### XV. Data Analysis

Data sets have been processed after the completion of the field survey and editing of socio-economic information. Analysis of this diversified data and preparation of conclusions in the minimum possible time has achieved using statistical techniques of data analysis.

All questionnaires sample are included in **Appendix-B** of **Volume-6** of Feasibility Report.

## 16.6 BASELINE CONDITIONS

This section provides baseline data (physical, biological and socio-economic parameters) related to the Project Area. Information provided is both quantitative and qualitative and is based on secondary and primary data collected, site field visits and desk studies. A baseline consists of the existing environmental and socio-economic and cultural status of the Project Area. The baseline information and indigenous knowledge is required for scoping potential environmental issues associated with the implementation of the Project. On the basis of baseline information, the Project interventions are assessed and mitigation measures are proposed. The baseline information also helps to indicate the specific issues to be monitored during Project execution as well as during operational phase.

## 16.7 PHYSICAL ENVIRONMENT

### 16.7.1 Physiography.

The site of the Project is located on Hunza River at Attabad Lake about 15 km upstream from Ganish Bridge of Hunza. Its distance is about 20 km from Hunza and 115 km from Gilgit. The powerhouse location is on the left bank of river and easily accessible from KKH. The intake weir/dam site is selected at current exit point of Attabad Lake which was formed in the year 2010 due to a huge slide from right bank mountain, however, some left bank mountain portion was also damaged.

### 16.7.2 Demography

Hunza Valley is mainly divided in three parts with different tribal structure. The people living in Gojal had migrated to this part of Hunza from Wakhan, Pamir and Badakhshan before the end of 18th century. They are mostly Wakhis (from Wakhan, a strip of land between Central Asia and Pakistan), an ethic group staying in the mountainous areas of the Karakoram and the



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Pamirs in the border land of Pakistan, China and Afghanistan. The language and culture distinguish them from Brush and Shina speaking people, who live in central and lower Hunza.

### 16.7.3 Climate

The climatic parameters that influence the climate of an area include temperature, precipitation, humidity and evaporation. Situated in the western most arm of Karakoram Range, Hunza is found within semi-arid and rugged mountain landscape (mountain desert). The climate varies widely from monsoon-influenced moist temperate to arid and semi-arid cold deserts in the North. In general, two seasons prevail in the Project Area: winter (October to March) and summer (April to September).

### 16.7.4 Precipitation

Rarefied air, intense solar radiation, strong winds, and vast ranges of temperature are the characteristic climate of the Area. Below 3000 m a s l, precipitation is less than 200 mm per annum while there is a sharp precipitation gradient along the altitude, and over 2,000 mm annual snow fall above 6000 m.a.s.l. Average Monthly and annual rainfall recorded at WAPDA High Altitude Weather Station has been given in Table 16-1

The Hunza River catchment upstream of the dam site is highly mountainous generally with low precipitation. The low precipitation particularly during the hot (monsoon) season coupled with less catchment area likely to experience rainfall are the factors responsible for low runoff or poor contribution to flood producing mechanism source. Hunza like other areas in extreme North-West of Pakistan receives only 136 mm precipitation of which 40% occurs in Winter and Spring.

### 16.7.5 Temperature

Temperatures in the valley bottoms can vary from extremes of 35°C in summer to less than –15°C in winter. The summer season in Hunza Valley is cool while winter is chilly. Wide spread snow fall occurs in winter. During winter the northern winds blow constantly bringing the temperature down considerably. At Hunza, the mean maximum temperature is 23.8□C in July, the hottest month and the coldest month is January with an mean minimum average temperature of -1.9□C. The Gilgit Meteorological Station is the nearest station to Hunza Valley that has a sound historical record covering more than five decades



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**Table 16-1 Average Max & Min Monthly Temperature and Mean Precipitation at Gilgit**

| Month | Mean Min Temp ($^{O}$C) | Mean Max Temp ($^{O}$C) | Mean Prec. (mm) |
|---|---|---|---|
| Jan | 2.4 | 9.4 | 4 |
| Feb | 0.7 | 12.6 | 6.8 |
| Mar | 5.7 | 18.2 | 0.14 |
| Apr | 9.5 | 24.1 | 23.8 |
| May | 12.1 | 28.6 | 24.5 |
| Jun | 15.1 | 34 | 8.8 |
| Jul | 18.4 | 36.1 | 14.6 |
| Aug | 17.8 | 35.3 | 14.6 |
| Sep | 12.7 | 31.7 | 7.6 |
| Oct | 6.8 | 25.5 | 6.9 |
| Nov | 0.9 | 18.2 | 2.4 |
| Dec | -1.9 | 11.5 | 5.1 |
| **Annual Mean** | **7.9** | **23.8** | **133.1** |
| | | | |

### 16.7.6 Geology

Tectonically, Project Area lies in the Karakoram Block towards the North of the Main Karakoram Thrust (MKT) and Main Mantle Thrust (MMT) which are considered to be the manifestation of the tectonic collision between Indian Plate (Continent) with the Kohistan Island Arc and then with the Eurasian Plate (Continent). This continent to continent collision has given rise to three most famous orogenies in the world. The Himalaya, Karakorum and Hindukush are considered to be the highest mountainous ranges in the world.

The Glacio fluvial deposits forming the site of Attabad Village consist of boulders, cobbles and gravels with some silt and sand as cementing material. The rocks exposed at the crown and toe; are highly fractured, sheared, jointed and weathered. A fault on the eastern side of the village is passing through Hunza River trending almost North-South. The re- sediment till deposits flank both sides of Hunza River in the powerhouse area. These tills comprise extremely fine grained (powder) soapy-touch clays.

### 16.7.7 Seismology

The Project Area lies in the Northern Region of Pakistan which has high frequency of earthquakes especially in the Himalayan orogenic belt. This belt represents the contact between Indo-Pak and Eurasian plates, which has always been the source of moderate to large earthquakes including Kangra (1905), Bihar-Nepal (1934), Assam (1897) and 2005 Kashmir earthquakes with significance consequences.

In October 2005, an earthquake of very high intensity (7.8) hit the area near Muzaffarabad and disturbed the ground to a significant extent in that area. The geological, tectonic and geodynamic conditions of the Project Area have been assessed and detailed mapping of the ground surface has been done to define the geology and tectonic features of the Area.



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### 16.7.8 Landslides, Erosion and Sedimentation

Landslides are very common features in the Project Area because of the high steep terrain. Erosion and sediment input to the river is a function of landslides and riparian erosion processes. There are frequent talus accumulations along the side slopes of the river. These are typically in a state of stable equilibrium at their current slope angle and environment but become unstable when the equilibrium is disturbed. Excess water and earthquakes often trigger landslides.

### 16.7.9 Land Use

There are nine villages located on alluvial fans and terraces on both sides of the Hunza River and its tributaries where water is available for human consumption and agriculture. The nallahs span out near the confluence of the river, forming some cultivable land masses as can be witnessed near Passu Village. The available flat land is used for residential purposes as well as for agriculture, orchards and grazing for cattle, goats and sheep etc. The total geographic area of the Hunza Valley is about 8,920 km2. Summary of land use in the Gilgit-Baltistan is shown in Table 16-2

**Table 16-2 Summary of Land Use in Gilgit-Baltistan**

| S.No. | Type of land | Area Million (Hectares) | Percentage (%) |
|---|---|---|---|
| **1** | Mountain/Lakes/Rivers/Glaciers | 4.810 | 66.3 |
| **2** | Protective Forests | 0.065 | 0.89 |
| **3** | Private Forests | 0.219 | 1.78 |
| **4** | Social/Agricuture Forests | 0.368 | 5.07 |
| **5** | Range lands | 1.626 | 22.4 |
| **6** | Cultivable Area | 0.078 | 1.1 |
| **7** | Cultivable Waste | 0.090 | 1.2 |
| **Total** | | 7.250 | 100% |

Source: Statistical Unit GILGIT-BALTISTANP & DD 2013

### 16.7.10 Mining

Mining is one of the common professions in small parts of the Project Area. The area near the lake is rich in mineral resources however their exploitation as commercial use is still not being done. People use to explore the mines by their own resources without any support of Government.

### 16.7.11 Agriculture

The area under agriculture is approximately 112,688 ha or 1.6% of the total area Gilgit-Baltistan. Because the climate is arid, agriculture depends on irrigation through water channels locally known as (kuhls) - that bring water through gravity flow from streams fed by glacier or snow melt. Agricultural in Gilgit-Baltistan can be divided into two broad cropping zones depending on the elevation. At elevations between 1200 and 2000 m a s l both summer and winter crops are grown, however, in areas situated in between 2000 and 3000 m a s l a single summer crop can be grown.

In Hunza District, the general combination of crops, livestock and other farm related activities are more or less the same. Wheat, barley and vegetables are the main Rabi crops. Whereas



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Maize, potato, millet and pulses are Kharif crops. Shaft all and Lucerne or Alfalfa is grown as a perennial crop which is the most popular fodder for livestock throughout the year. District wise Agriculture Land of Gilgit-Baltistan is shown in table 16-3.

**Table 16-3 District Wise Agriculture Land of Gilgit-Baltistan**

| District | Agriculture Land (ha) | Percentage Cover |
|---|---|---|
| Astore | 8133.43 | 1.51% |
| Diamer | 9058.52 | 1.26% |
| Ghanche | 11966.75 | 1.35% |
| Ghizer | 16431.94 | 1.34% |
| Gilgit | 10167.94 | 2.44% |
| Hunza-Nagar | 12013.87 | 0.8% |
| Skardu | 30589.88 | 1.56% |
| **Total** | **98362.33** | **10.26%** |

### 16.7.12 Fruits

Gilgit-Baltistan is producing many fruits like apple, cheery, walnut, and apricot. But apricot is more famous for its test and quality. Pakistan produces approximately 300,000 tons of fresh apricot, making it the world's fourth largest producer. Gilgit-Baltistan and Baluchistan are the two main apricot growing regions in Pakistan, with Gilgit-Baltistan alone producing 114,286 tons in 2007. Planting density is only 230 trees/ha, which is much less than the recommended 750 trees/ha, due to apricots being planted around field edges, rather than orchards. Average yields of fresh fruit are 38 kg/ tree which are good considering the limited use of inputs, although yields of 50 kg/tree can be achieved through improved management.

At higher altitudes there are no fruit trees, but in lower portion of Hunza Valley several types of fruit are grown. Major fruits are apricot, apple, mulberry, grapes, almond and walnut. It has been calculated on average that every household has 22 trees out of which 15 are fruit bearing trees. The average production of fruit by each tree is 50 kg.

### 16.7.13 Livestock

The people of entire Hunza River the livestock reared by almost all households. Usually with the snow melt, goat, sheep and cows giving no milk are taken to the Alpine Pastures for grazing. They stay there during the summer season and are brought back with the onset of snow on the top of the hills. When the animals are brought to the village they are grazed in the agricultural fields of maize crop residues. All the milking animals are kept in the houses and stall fed.

Livestock contributes a great deal to the local economy. However, physical condition and general health of the animals is not satisfactory, especially in winter due to the shortage of fodder. Bullocks are the main source of farm power, but they are hardly capable of drawing plough due to poor health. Cows, sheep and goats are also lean and thin. Animal diseases cause considerable losses to the livestock. Productivity of cattle is generally low because of severe winter and lack of proper feed. Meat, milk, butter and eggs are the main animal /poultry products but most of these are consumed at the household level. At some places milk, meat, animal hides, wool and poultry are sold.



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### 16.7.14 Hydrology

The main tributaries of Hunza River are; Chapursan, Kilik, Bola Das joining the Hunza River from the west and Khunjerab along with Ghujerab, Simshal and Hispar Rivers joining river from the east of the valley. The river flows of Hunza are usually maximum in the month of July when snow and glacier melt is at its peak while these are minimum in the month of March when snow and ice melting is insignificant.

There is only one hydrological gauging station on Hunza River at Danyor Bridge being operated by SWHP-WAPDA. This station is located at about 107 km downstream of Attabad Landslide Dam. The catchment area of Hunza River upto Danyor gauging station is 13,157 km2, whereas it is 14,083 km2 upto its confluence with Gilgit River. Hunza River catchment area is 8,901 km2 upto Attabad Landslide Dam. Therefore, river flows are transposed and estimated from documented discharge data from hydrological station at Danyor. Daily discharge data from 1966 to 2015 is available and processed for the calculations. Data for year 2016 was incomplete, missing the values of high flow months, and there was no record of hydrological data for the period 2017 to 2018 at SWHP therefore, it was not used in the calculations. Mean annual flows are calculated and drawn in the figure below for the period 1966-2015. Average value for mean annual flow has been calculated as 208.36 $m^3/s$.

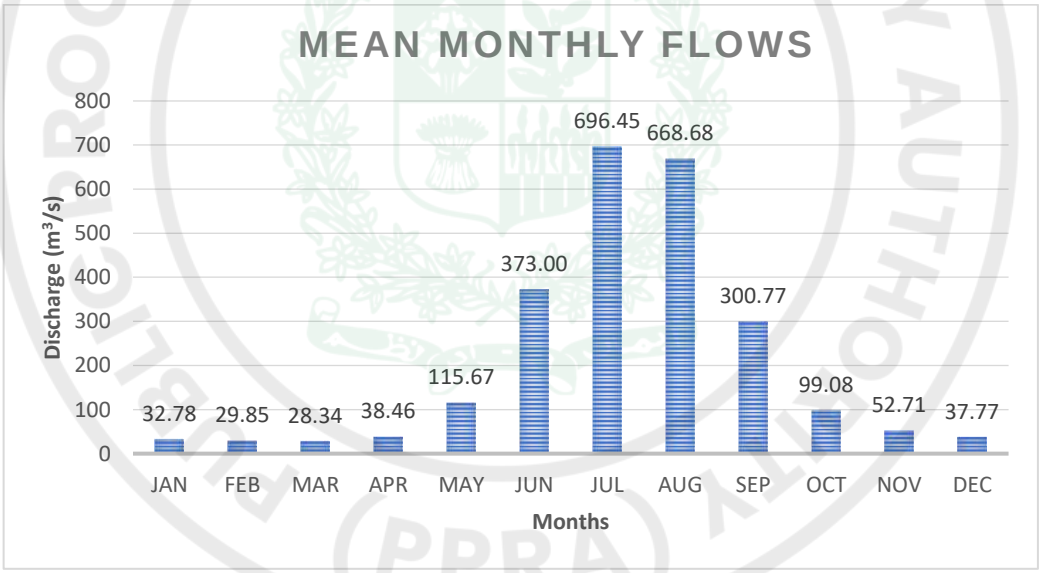


**Figure 16-2 Mean Monthly Flows**

Flows are generally maximum in July and August almost reaching 700 $m^3/s$. Whereas, flows are low from December to April each year when snow falls in the catchment. The record shows that design discharge of 60 $m^3/s$ is available for about half year (almost 6 months). Graph shows that flows are exceeding the design discharge from June to mid-December which shows the potential of hydropower generation.

The maximum peak discharges of mean daily for every year recorded. The instantaneous peaks will definitely be higher than the measured daily flows and can be enhanced while execution accordingly. Instantaneous peak flows for the period 1966 to 2015 has been calculated and plotted as well.



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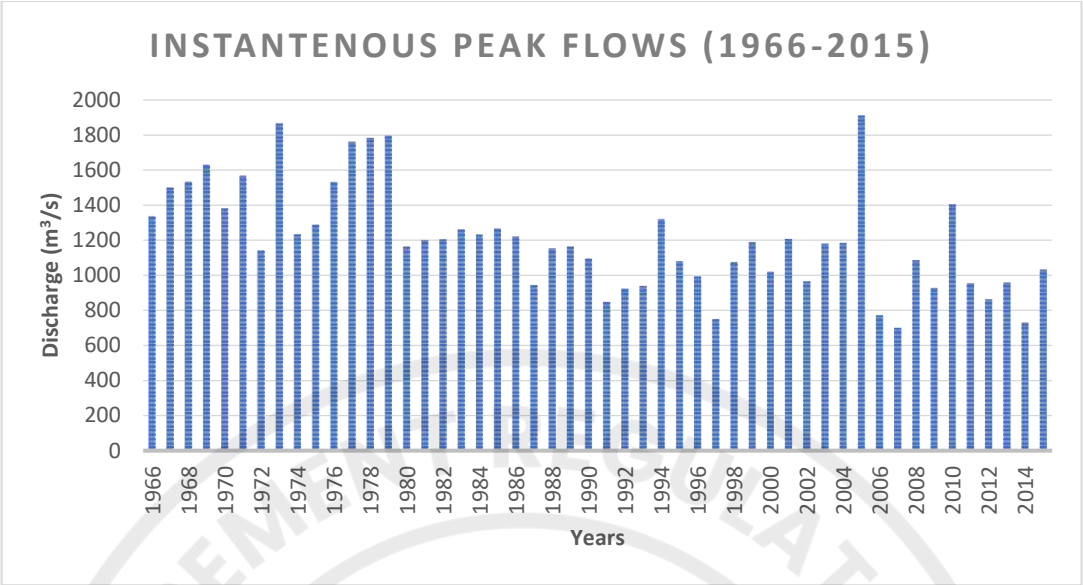


**Figure 16-3 Instantaneous Peak Flows at ALHPP**

### 16.7.15 Surface Water Availability & Quality

In the Project Area, the Hunza River carries water of various streams (nallahs)of snowmelt, and rainwater fall. The people use the water of these nallahs for drinking, household and agriculture purposes. Generally, there is no shortage of clean potable water in the Project Area as it is very difficult to fetch the water of river and nallahs due to the very steep slopes. People mostly use water from nallahs for drinking, washing and other domestic purposes. During the socio-cultural survey of the Project Area, many of the respondents from the villages reported stomach, skin, bones, diseases. Initially, rainwater as well as snowmelt water do not contain significant impurities. As these waters flow over land they pick up sediments, salts, toxic elements, pulverized organic matter and bacteria from the surface. Water samples were taken in November, 2020 covering the complete affected area within the project area. The laboratory results of these samples summarized in Tables given in volume 6and detail at Appendix-C reveal that all the parameters are within the permissible limits when compared with drinking water quality standards of WHO, except the presence of Escherichia Coli Pathogenic Bacteria which causes gastroenteritis in human beings.

Piped water supply that covers only 40% of the total population of the Gilgit-Baltistan does not provide safe/ clean drinking water to urban and rural settlements in the Region. In upper Hunza Region, drinking water is obtained from glacier melt and piped water only in summer season.

### 16.7.16 Groundwater

The Project Area consists of rocky mountainous terrain. The water originated from rainfall and snowmelt flows through streams and enters into river. Only a small quantity of water has the chance to percolate and form a groundwater reservoir.

### 16.7.17 Air Quality and Noise

The air quality of the Project Area and its vicinity is very fresh and clear under normal condition. Air and noise pollution has not yet emerged as an environmental issue owing to operation of a



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small number of vehicles increasing by a fair degree during the tourist season. Based on a number of observations on ambient air quality in rural areas the following range of concentration of gaseous pollutants is estimated on the roadside at Gulmit

**Table 16-4 Range of Gaseous Pollutant Concentration & Noise Emission Level**

| Range of Variation | CO ppm | $SO_2$ ppb | $NO_x$ ppb | SPM $\mu g/m^3$ | Noise dB(A) |
|---|---|---|---|---|---|
| Minimum | 0.65 | 05 | 05 | 45 | 40 |
| Maximum | 0.9 | 10 | 12 | 90 | 70 |
| Average | 0.7 | 07 | 07 | 70 | 55 |

The noise level near the river is fairly high and range between 50 to 65 dB without traffic, mainly due to the flowing water colliding against rocks and boulders. There is normal traffic on the KKH which runs through the Hunza Valley. So traffic noise has negligible contribution to the noise level in the Project Area.

### 16.7.18 Greenhouse gases

Greenhouse gases are those gases (CO2, CH4, O2, CFCs and NO) which contribute to global warming. The main sources of these gases are industries and vehicles using fossil fuel as fuel. At present there is no industry in the Project Area that emits greenhouse gasses (GHG) and vehicles intensity is also very low. The main sources of carbon and nitrogen oxide emissions are due to automobiles in the Project Area.

### 16.7.19 Waste

The villages within the Project Area do not have any drainage, sewerage or treatment system for sewerage collection and disposal. More than 50 percent of the houses have improvised pour flush pit latrines. The remaining 50 percent of the house hold use locally made toilets. Waste water(sludge) from kitchen, bathing and washing is discharged into small drains/water courses leading to the nallah or directly to small fields outside the houses. Animal waste especially cow dung is used for farm manure or used for burning after drying (though rarely).

## 16.8 BIOLOGICAL ENVIRONMENT

Habitat loss is considered as the leading cause of loss of world's biodiversity. Most species need undisturbed habitat to find food, water, shelter, and mates. But people are altering habitats all over the world. In such areas, the activities causing habitat loss include commercial logging (not based on technical and sustainable basis), land development, over-grazing, fuel wood collection, construction of roads, and building new settlements. All these actions change landscapes, natural water flows, and the species composition in the area. Moreover, changes in climate and land use patterns also reducing the amount of snowfall and rain upon which the habitat depends.

### 16.8.1 Flora

A study was carried out on the Biodiversity of Khunjerab National Park (KNP) during May and June, 2006 to establish baseline information about existing plant wealth and wildlife including



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flora, reptiles, bird, sand mammals in order to make some vantage points for future monitoring of key wildlife species. Using different direct and indirect investigation techniques, 14 different valleys and Nullahs of KNP were surveyed and observations on various habitats were recorded.

Four types of vegetation zones were identified including Dry Alpine Scrub, Moist Alpine Pastures, Dry Alpine Plateau Pastures and Sub Alpine Scrub and Birch Forests. So far, 62 plant species belonging to 45 genera and 25 families were identified. Of them, 4 grasses and one species of Liliaceae were determined. Details of flora zones and further types are described in the **Volume-6** of this report.

### 16.8.2 Forestry

Forestry is important for fuel, timber, in addition to control of the soil erosion and reduction silt load in lakes and rivers. In the Gilgit-Baltistan only Diamer district is rich in forest while the other five districts including Hunza have nominal forest of Juniper. The forests consist of blue pine, spruce, willows and shrub consist of rosa species.

### 16.8.3 Fauna

This diverse range of vegetation and ecological zones also supports a rich faunal diversity, including an estimated 54 species of mammals and 230 species of birds. About 23 species of reptiles and 6 of amphibians have been reported from Gilgit-Baltistan. Among reptiles 9 species are of lizards and 14 of snakes, while among amphibians 2 species of frogs and 4 of toads. Very little information is available on insect diversity in Gilgit-Baltistan, however, about100 species of butterflies have been reported from Gilgit-Baltistan.

Several globally threatened species – including the snow leopard and Markhor – continue to survive in Gilgit-Baltistan in significant numbers. The flora and fauna belong to Palearctic region. Fifty-four species of mammals have been reported in Gilgit-Baltistan, which comprise 1 shrew, 10 bats, 18 carnivores, 6 artiodactyls, 3 lagomorphs, and 16 rodents. The region is also home to a few globally threatened species like Snow Leopard, Himalayan lynx, Marco polo sheep, Blue sheep, Ladakhurial, Markhor, Musk deer, and Woolly Flying Squirrel. The resident avifauna includes Monal pheasant, Snow Partridge, Himalayan Snow Cock, and several birds of prey species.

Occurrence of some rare species has been reported in Gilgit-Baltistan. These include species like Lammergeyer and Golden eagle. Few sightings of Lesser Kestrel have also been reported in lower Hunza near Hunza river. The main diverse group of birds in NA is the Passeriformes species. These are mostly Warblers, Tits, Flycatchers, and Buntings. Some of the restricted range species like Snow Partridge and Himalayan Monal pheasant are extremely rare and may be at the verge of extinction from many of their earlier strongholds. According to Birdlife International (2001) report there are 27 species of Pakistan, which are threatened internationally out of which 7 species are found in Gilgit-Baltistan.

Hunza is very scattered settlement with meager population. Considering its wildlife resources to be protected and preserved. Shooting, trapping of wild animals is not allowed except with a special permit. The number of animals or birds killed or captured is also restricted and specified in the permit. Snow leopard and Ibex are already declared as endangered and other species of mammal are also scarce. But trophy hunting is allowed which is beneficial to the local



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community as the 70% of the funds go to local community which is used for the development of the local area.

**Table 16-5 Fauna available in Gilgit-Baltistan**

| English Name | Urdu Name | Scientific Name |
|---|---|---|
| Ibex | Kill or Kil | Capra ibex sibirica |
| Snow Leopard | Cheeta | Pantherauncia |
| Red fox | Lombrei | Vulpesvulpes |
| Lynx | Seaa gosh | Felis lynx |
| Wolf | Bharia or Bahdia | Canis lupus |
| Maramot | Barfanichoh Tershoon | MaramotaCandata |
| Alpine weasel | Gilhari | Mustelaaltacia |
| Musk rat | Chachondar | Mustelaaltacia |
| Himalayan snowcock | Ramchakur | Mustelaaltacia Tetraogallushimalayencis |
| Chukor | Chukor | AlectorisChukor |
| Eagle | Shaheen | Aquila Chrysaetos |
| Hawk | Gid | - |
| Falcon | OoqaaborOoqabaa | - |
| Pie | Jample | UrocissaEryphrohyncha |
| Hopoe | Hodhodh | Upepaepaps |
| Pigeon | Kabutar | - |

### 16.8.4 Insects

The Project Areas is rich in biodiversity of insects including butterflies found in the Project Area, particularly during the humid months of July and August. In addition, caterpillars, bugs, beetles, black bees, weevils, mosquitoes, ants, green aphids, codling moths, leaf miners, mitts, fruit flies, woody aphids, stray grass hoppers, leaf hoppers, mealy and woolly bugs, peach leaf curling aphids, scale insects, walnut weevils, blister mites, and dusky veined aphides are all found in the Northern Areas including the Project sites.

### 16.8.5 Protected Area

In order to safeguard the biodiversity of key ecological systems, Government of Gilgit-Baltistan has declared four National Parks to protect and conserve bio-diversity of Gilgit-Baltistan. These include Handarb National Park, KNP, Deosai National Park and Central Karakorum National Park. In the protected forest, the forest owned by Government as per Forest Act-1927, all activities are prohibited until and unless permitted by the government. Usually, removal of fallen, dying, and dead trees is not banned, however, grazing, sometimes, is regulated to ensure regeneration. In GILGIT-BALTISTAN, designated protected forests cover an area of 445,712 ha and are mostly found in Ghizer, Astore, Skardu and Gilgit Districts. Out of that 64,512 ha is conifer forests while 3, 81,200 ha are scrub forests (IUCN, 2003).

Aga Khan Rural Support Programme (AKRSP), International Union for Conservation of Nature (IUCN), Wildlife Conservation Society (WCS) and World Wide Fund (WWF) are the main international organizations who over the last two decades have played a crucial role in creating awareness among communities for sustainable management of biodiversity resources. The



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then Ministry of Environment also implemented a Program for Mountain Areas Conservation (PMAC) to promote biodiversity conservation in Gilgit-Baltistan through community participation. This program was completed in 2011. As a result of these efforts the GILGIT-BALTISTAN offers a model for community based management of forestry resources.

Despite of all these conservation initiatives and efforts by government and international organization, fast depletion of forest ecosystems has been observed in the last two decades. The following strategies and actions will be taken to achieve the objectives of conservation, sustainable use and equitable sharing of benefits.

### 16.8.6 Aquatic Ecology

GILGIT-BALTISTAN is blessed with highest potential of cold and clean water resources in shape of lakes, canal, reservoirs, rivers, and water logged areas that offer ideal habitat for trout and other cold water fish species. There is dire need to get maximum benefit from these resources through technological advancement in production, processing and marketing. Both the public and private sector are fully involved in order to judicially exploit this potential both in natural waters as well as its development in culture conditions. The fish fauna in Hunza Valley is relatively poor due to high turbidity, low water temperature and high water speed.

### 16.8.7 Fisheries

Fisheries department Hunza was established in the year 2012 with the core aim to develop and promote Fisheries and aquaculture activities in newly created district. District Hunza has very rich aquatic resources of aquaculture and fisheries in forms of bluish lakes, gashing rivers, torrential streams, seasonal and perennial springs etc. Fisheries department Hunza has come up with novel approach and ideas to get maximum benefit from wise use and sustainable exploitation of natural resources in multiple ways with special focus on introduction and installation of cage culture system in Attabad Lake under controlled environment to enhance production with stocking and multiplication of fine verities of fish in nature. At the same time, it has also been planned to promote sport fishery providing enabling environment and other related facilities for tourists and fish anglers.

For this the Attabad Lake having crystal clear water offers as natural gene pool reserve, ideal for excessive multiplication and better growth of many indigenous and exotic fish species



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**Table 16-6 Potential Fisheries Resources in District Hunza**

| S.No | Name of River | Name of Lakes | Name of Nallas |
|---|---|---|---|
| 1 | Hunza River | Attabad Lake | MisgarNallah |
| 2 | | Borith Lake Gojal | KhunjarabNallah |
| 3 | | Shimshal Lake I | Dee Nallah |
| 4 | | Shimshal Lake II | ChoporsunNallah |
| 5 | | Bathora lake Gojal | GojarabNallah |
| 6 | | Pasho Lake | Khyber Nallah |
| 7 | | | Shimshal Nallah |
| | | | Hassan Abad Nallah |
| Total | 01 | 06 | 08 |

#### 16.8.7.1 EXOTIC FISH SPECIES OF HUNZA

I. Salmo TruttaFario (Brown Trout)

II. Onchorynchus Mykiss (Rainbow Trout)

#### 16.8.7.2 INDEGENOUS FISH SPECIES

Among the 15 identified indigenous fish species in Gilgit-Baltistan the following six fish species found in District Hunza:

I. Shizothoraxplagiostomus

II. ShizothoraxNasus

III. PtychobarbusConirostris

IV. TriplophysaTerwasae

V. TriplophysaYasinensis

VI. DiptychusMaculatus

## 16.9 SOCIAL AND ECONOMIC ENVIRONMENT

### 16.9.1 Population

The population in Gojal consists of 51% male and 49 % female; it has a population density of 17 persons/acre. The child-women ratio of the study area is 345 children per 1000 women. The dependency ratio is 142 % in Hunza Valley, which shows that there are about 3 dependents on every two earning members. The average size of household is 7.26 persons. The average size of family is 7 persons per household, while the density of room is 4 rooms per household.



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In the study area of Gulmit, Shishkat and Passu total number of households according to the census 2017 is 8697 people, these are the areas surrounding the Attabad Village. The detail of population is shown in table

**Table 16-7 Population of the Area (2017)**

| Name of Jamatkhana | No. of household registered | Actual Population |
|---|---|---|
| Gulmit central | 142 | 963 |
| Kamaris | 42 | 319 |
| Odver | 42 | 320 |
| Dalgiram | 44 | 307 |
| Chamangul | 131 | 858 |
| Ghulkin | 158 | 1178 |
| Hussaini | 89 | 670 |
| Passu | 89 | 771 |
| Janabad | 24 | 169 |
| Muradabad | 4 | 49 |
| Nazimabad central | 117 | 989 |
| Nazimabad-I- Bala | 76 | 638 |
| Nazimabad II Darmiyan | 142 | 1417 |
| Borithpayeen | 6 | 49 |
| Borithbala | 2 | 1 |
| **Total** | **1108** | **8697** |

Source: Gulmit Local Council

### 16.9.2 Languages

Burushasky and Wakhi are the main languages of Hunza Valley. There are some other languages in the region are

- Shina.
- Burushasky.
- Khowar.
- Balti.
- Domaaki.
- Wakhi.
- Gojri.



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### 16.9.3 Ethnic Groups and Religions

Almost, 95% of the people living in Hunza Valley and 100% in Upper Hunza belong to Ismaili faction with his highness Prince Karim Aga Khan as their spiritual leader. 5% in Hunza Valley are members of Shia Imami faction which is concentrated in the village Ganish and surrounding settlements.

### 16.9.4 Administrative Setup

Hunza remained an independent state after 1947 while still staying under the control of the Islamic Republic of Pakistan. The last Mir (Jamal Khan) and his family were retired and the Mirdom was abolished, and Hunza became a subdivision of the Northern Area in 1974. The government tried to establish administrative structure in the valley. The abolition of the traditional institutions left a gap that was partly filled by institutions established under projects of the Aga Khan Development Net Work (AKDN), which started operation in 1979.

### 16.9.5 Health Facilities and Common Diseases

The villages in the Hunza Valley have somewhat better healthcare facilities than rest of the Gilgit-Baltistan except Gilgit and Skardu. Aga Khan Health Service (AKHS) and Government health workers are providing health facilities in the area. They provide first aid facilities and also give family planning guidance to the people. Gulmit Government hospital was established in 1980.

### 16.9.6 Education and Literacy

Almost all the settlements in Hunza Valley have a high literacy rate. There was no school before 1946 in the villages of Gojal. Diamond Jubilee School for Boys was established in the Gulmit on the occasion of the Diamond Jubilee Ceremony of Sir Sultan Mohammad Shah, Aga Khan III in 1946. At present there is one Government High School for Boys and one D. J. High School for Girls, besides one public high school: Al-Amin Model School for boys and girls. There are two primary schools in Hussaini village. Literacy rate in Hunza is almost 95% which is higher than other districts of Gilgit-Baltistan. Girls in Hunza are enthusiastic about their future so they prefer to have higher education. For higher education students go to KIU Hunza Campus in central Hunza; a number of boys and girls are studying in Gilgit, Islamabad, Peshawar, Lahore, and Karachi for higher studies.

### 16.9.7 Infrastructure and Recreation

Infrastructure facilities including health, education and transportation are available in Hunza Valley to those near the KKH. Construction of Karakoram Highway (KKH), the Silk route or Pak China Friendship Highway, was started in 1965 and was completed in 1986. The KKH starts from Thakotin KPK and continues up to Khunjerab Pass; it has over one hundred bridges. The length of KKH is 1300 km and width is two lanes. KKH has played an important role in the development of Hunza Valley. Buses and vans are used for traveling in Gojal from and to Gilgit and down areas of the country. Public transport is provided by both Private vans and Government buses (NATCO). The impact of the KKH is very conspicuous on the socio-economic condition of the villages. KKH provides an important link between Pakistan and China. This road serves the tourist traffic and acts as supply route for the mountaineers to the down country and other neighboring countries.



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Recreation and tourism has grown in the area rapidly, which in future can become an important source of income.

### 16.9.8 Professions and Source of Income

The people of the area are linked with different professions like tourism sector, business, livestock, dry fruits, trade and government jobs.

### 16.9.9 Tourism and Cultural Heritage

Hunza is the tourism and business hub of Gilgit-Baltistan thus a large number of residents from this area directly or indirectly involves either in business or work in tourism sector

## 16.10 ESIA AND MITIGATION MEASURES

Determining the significance of impacts identified is one of the main purposes of an ESIA and it enables the identification of necessary mitigation and a determination of environmental and social costs associated with the Project. Environmental and social impacts of any Project are identified taking into account all phases of the project cycle, including planning, construction, operation and decommissioning. The environmental issues and impacts of a project depend upon the nature of the project activities, and the types and extent of interventions involved. It is not easy to predict the future and assign a relative value or overall significance to an impact, since every impact has a different and multi-dimensional nature, and also because it involves personal and subjective judgment for many attributes. An environmental or social impact can be either beneficial or adverse and is assessed by comparing the quality of the existing environment with the predicted quality of the environment once the project is in place. This ESIA identifies the impacts likely to arise as a result of construction and operational activities and assesses the likely magnitude of the impact in order to provide some indication as to which impacts are likely to be most significant. The impact assessment has been based on that environmental checklist developed by the Asian Development Bank (ADB).

## 16.11 IMPACT ASSESSMENT PROCEDURE

In order to describe the significance of an impact it is important to distinguish between two concepts: sensitivity and magnitude. As far as possible the sensitivity and magnitude of the impact are described with reference to legal requirements, accepted scientific standards or accepted impact assessment practice, and/or social acceptability. Where no known published ‘standard’ criteria exist for determining the magnitude of effects, established professional criteria and best practice techniques are used and clearly described.

### 16.11.1 Sensitivity

Sensitivity is generally sites pacific and criteria are developed from baseline conditions. The sensitivity of are captor is determined based on review of the population (proximity/ numbers/vulnerability), presence of biological features of the site or the surrounding area, soil, agricultural suitability, geology and geomorphology, existing air quality, presence of any architectural and historic heritage, landscape etc. Sensitivity, relates to the value, importance and tolerance of an environmental resource or receptor and should take into account where possible stake holders views and public acceptability. Sensitivity can be categorized as high, medium, low, and negligible to the assessment of receptor sensitivity.



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### 16.11.2 Magnitude

The assessment of magnitude is undertaken in two steps. Firstly, the key issues associated with the Project are categorized as being either adverse or beneficial. Secondly, beneficial and adverse impacts are then further sub divided into major, moderate, minor or negligible based on consideration of the parameters listed below:

- Duration of the impact
- Spatial extent of the impact
- Reversibility
- Likelihood; and
- Legal standards and established professional criteria.

In order to make the report as meaningful and useful as possible, an attempt has been made to describe each impact in the following terms: positive impacts refer to beneficial effects and negative impacts refer to harmful effects on e.g. natural resources, human beings and economy

## 16.12 IMPACTS DURING CONSTRUCTION AND OPERATIONAL STAGE

During the construction phase of the project most of the impacts identified are of a negative nature but some of them will be temporary and will vanish with the completion of Project.

### 16.12.1 Impacts on Topography

The interventions of the ALHPP are not likely to impact the topography of the area on a large scale except for those areas where the physical activities of excavation, digging and movement of the heavy machinery will take place Similarly, areas where excavated material from tunnels will be disposed, dumped or stored will be negatively affected. This impact can be considered as a negative impact with moderate magnitude during construction while there will be no impact on topography during operational stage.

**Mitigation**

To reduce the negative impacts of excavated material: firstly, the emphasis should be to reduce the volume of material requiring disposal and secondly, to dispose it in environmental friendly way. The following measures are proposed in this respect:

- As far as disposal on the dam site area is concerned, some of the spoil can be used for construction project related structures.
- Some of the spoil can be used for widening of the roads. Part of the excavated material on the powerhouse site can be used for making aggregate required for project construction and for the development of infrastructure such as roads and filling of natural depressions.



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### 16.12.2 Impact on Seismicity

The area is well known to consist of active landslide zones as more than 33 damaging events have occurred in the region during the period from the year 1830 till January 2010 (Kreutzmann,1994). In addition to this, according to the Geological Survey of Pakistan (GSP) a fault line also passes through the area. During the devastating 2002 earthquake in Astore that hit Attabad, the process of crack evolution in the mountains of Attabad Region was observed, which worsened during the subsequent strong earthquake (7.5 on Richter scale) in 2005. With the passage of time, cracks began to widen slowly and gradually on January 4, 2010, slope failure occurred in the Attabad Region resulting in the establishment of a natural dam that completely blocked the Hunza River. According to the initial estimates, a slide mass of approximately 30 million $m^3$ fell from the northern valley wall.

**Mitigation**

All structures to be built must be designed giving maximum allowance to seismic factors. A very careful analysis of the situation will be required during the design stage of the project by specialist consultants.

Continuous monitoring of the behavior of faults will be required during the operation stage and contingency plans to deal with such a situation must be part of the project management. Instruments to monitor seismic activity must be installed at the time of construction

### 16.12.3 Impact on Geology

Almost all project interventions involve excavation of natural rocks, cutting of formations, moving and dumping of spoil. During tunnel excavation and some other operations, blasting of the formation will be required. All these activities will disturb the existing geological formations and consequently physical features of the local geological formations of the project area will be damaged at some places, which is a negative impact of moderate magnitude.

During operation of the Project the seepage from the reservoir will significantly impact the geology of the area. The seepage water will saturate the formation below and along the reservoir and soluble minerals from the rocks will dissolve in the water. Some solution channels may develop in the formation making the formation more pervious.

**Mitigation**

All these activities are an integral part of the project interventions and cannot be avoided. Blasting should be minimized where possible (near the surface) and, if unavoidable low power explosive should be used and a greater number of blasts with low power material may be preferred instead of high intensity single blasting.

It is difficult to check or reduce the seepage from the reservoir. A continuous monitoring system will be required during operation of the project to monitor the changes in groundwater level and chemistry of ground water.

### 16.12.4 Impacts on Landslides

As the natural dam had been a result of a major landslide, therefore, special emphasis should be given to this aspect. Landslides are common in the project area due to the high steepness,



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unstable geological formations on both sides of the river and common seismic activities. Due to the Project activities, especially blasting of rocks in some areas, the formation will become loose and the risk of landslides will increase in the immediate vicinity of the construction sites specially at the right bank of Hunza River, which may be considered as a moderate negative impact of the Project.

**Mitigation**

To avoid the major risks, all structures are proposed on the left bank of Hunza River. Further, to minimize blasting of formations and, if unavoidable, then use low intensity explosive if possible.

It is expected that landslides could increase due to construction activities. Further the seepage of water will make the formation loose and unstable and the chances of sliding due to rainfall, abnormally high and low temperatures and due to seismic activities will increase. The sloughing and slippage of saturated formation during regular flushing of the reservoir may also enhance the sliding potential of the area. This impact may be considered as a major negative impact.

As no mitigation is possible to check either the seepage or any resulting landslide, however, as after a few years of Project operation most of the rocks along the weir site will become stable.

### 16.12.5 Impacts on Land Use

There will be no major impacts on the land use of the area as the lake has already been formed and changes has already been taken place long before this Project. However, new infrastructure will be built in the area which would have positive impacts on the land use.

### 16.12.6 Impacts on Infrastructure

As there would be no resettlement involved in the project, therefore, impacts on infrastructure would be rather positive.

### 16.12.7 Impact on Climate

Project construction involves large scale activities including the movement of different types of light and heavy traffic, working of heavy machinery, blasting of rocks, operation of batching and mixing plants and the presence of large numbers of people in the area. Due to all these activities, it is expected that the microclimate of the project area (surrounding the dam site and powerhouse site) will suffer significantly. However, no impact on climate of the whole project area is expected, either positive or negative, during the construction phase.

The lake has already been there since 2010, therefore no major changes would occur to the climate after Project has been completed.

**Mitigation**

The deterioration in the local climate during the construction phase will be of a temporary nature and will disappear with the completion of the project.



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### 16.12.8 Impacts on Hydrology

During the construction and operational, stage there will be no change in the hydrology of the river. The flow from the reservoir will be diverted to downstream of the weir through diversion channel.

**Mitigation**

To conserve the aquatic life (flora and fauna) of the river downstream of the weir (2 km patch), minimum flow of 3 $m^3/s$ has been calculated as the environmental flow. It will be obligatory for Project Operating Agency to release 3 $m^3/s$ in the river throughout the year as environmental flow.

### 16.12.9 Impacts on Sedimentation

During the construction stage, the overall sedimentation rate will remain almost the same upto the dam site, but it may change because of movement of heavy traffic, dumping of the excavated material and other Project related activities. The impact is considered as negative but of short duration and of minor magnitude.

The Hunza River water always contains huge sediments of around 20-21 Million Tons annually on average. Diversion Channel will be used for flushing of sediments during high flow months. It is expected that release of sediments in moderate quantity could change the morphology of the river d/s of dam. However, as sediments will be released during high flow months with relatively high velocity of water and the river in this section has a high gradient, it is expected that sediment will move far away from the downstream of the weir site.

**Mitigation**

The silt clearance (flushing) mechanism has been provided in the Project design through channel/sluices. It is proposed to flush the reservoir regularly during high flow months.

### 16.12.10 Impacts on Flooding

Flooding of the river at the dam site is not a common feature although some floods of high intensity are recorded in the past e.g. the glacial lake outburst floods of 1929. As river water from the upper cofferdam will be passed through diversion channels, there is chance that these tunnels could not accommodate the flows in any abnormal year. In such cases, floodwater can overtop or breach the cofferdam and damage the partially constructed civil works and lower cofferdam. Thehas significant positive impact.

**Mitigation**

The design of the weir has considered the design flood of 1 in10,000- year flood of 3,250 $m^3/s$

### 16.12.11 Impacts on Groundwater

During construction stage, no impact on groundwater is envisaged as the flow of water will continue as such without any storage. The lake has already been formed, therefore, there will be no change to the groundwater.



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### 16.12.12 Impacts on Air Quality

The project activities during construction at both weir and powerhouse sites will involve large movements of heavy diesel operated machinery and vehicles which produce more noise and emit more smoke. Similarly, various levels of noise and air pollution are expected to be generated from construction machinery and equipment, working of heavy earth moving machinery, drilling, blasting operations, concrete mixing, pouring equipment and stone crushers etc. The impact on air quality is considered as short duration negative impact of moderate magnitude.

**Mitigation**

The contractors and sub-contractors must be held responsible through special clauses in the tender documents to strictly follow precautionary measures.

### 16.12.13 Impacts on Terrestrial Flora and Fauna

The Project Area has very thin vegetation cover due to the special features of the terrain i.e. poor rainfall and steep mountains with very little soil cover. During construction stage, the damages to flora can be done by vehicles and machinery, establishment of camps and permanent structures etc. The construction activities will generate impacts of negative nature on all types of fauna but of moderate magnitude.

**Mitigation**

Dumping of construction materials should be avoided where large number of terrestrial trees, shrubs, herbs, grasses and fruit trees are found. where mammals, amphibians, reptiles and birds settle.

There would be no significant impacts on Flora and Fauna of the micro environment of the Area during operation stage.

### 16.12.14 Impacts on Employment Opportunities

At present employment opportunities in the Project Area are limited to few fields which would increase with the construction and operational activities. Majority of local employees will be engaged in the unskilled and semi-skilled sectors. Employment generation is a major positive impact of the Project.

**Enhancement**

The contractors of the project components shall be bound legally through contract agreements to engage 100% unskilled labor from Project Area of Hunza Region. Preference should also be given to local skilled and semi-skilled manpower if available.

### 16.12.15 Impacts on Regional Safety and Health

People of Hunza used to interact with people from different areas, cultures and communities. However, when there is sudden influx and congestion of people at any place from other areas for a longer period of time, it may contribute to adverse effects on the community health, safety and security of locals. There is always potential for such social impacts as incidences of accidents, social conflicts, theft and spread of communicable diseases.



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**Mitigation**

The contractors must be bound to establish workers camps sufficiently away from the settlements of local people. During construction, the Project working sites need to be bordered by a fence to safeguard life and property. As appropriate, any warning signs related to safety and security should be displayed in local languages. An appropriate security system must be in place to control all access routes to the site.

### 16.12.16 Impacts on Occupational Health and Safety

There is a tendency for the construction sector to be unregulated with respect to occupational health and safety. Additionally, unskilled and even some skilled construction workers may be illiterate and not necessarily informed or familiar with the protective measures to be adopted during work.

**Mitigation**

The contractors will need to carry out risk assessments and then develop site and Project specific Health and Safety Management Plans to prevent accidents, injuries and work-related diseases.

### 16.12.17 Impacts on Resources

Construction workers will need their daily supplies in the Project Area. This could potentially negatively affect the existing resource base and cost for firewood, food, goods, water and fish as well as create considerable amounts of waste. Both community members and construction workers will be affected by resource constraints and changing prices and are considered sensitive socio-economic receptors, because of their limited purchasing power and state of poverty which could be affected by these impacts. These impacts are considered to be negative and of minor magnitude.

**Mitigation**

Mitigation measures will be needed to ensure that the Project site is managed in a manner that is socially responsible and reflect sound environmental management practices. With respect to resource use, the Contractors will be expected to develop a plan and budget for providing workers with fuel for cooking and heating, water for cooking and cleaning, food supplies, and hygienic sanitation facilities for collecting and disposing rubbish, including construction waste.

### 16.12.18 Impacts on Cultural Heritage and Archaeology

No site of archaeological and historical importance has been identified in the Project Site. Some carving on stones were found near the powerhouse site regarding the incident of 2010 landslide but these carvings are outside the Project construction area.

**Mitigation**

Appropriate community relations have to be maintained for social respect between the local people and labor coming from other parts of the country.



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### 16.12.18.1 Water Pollution

Heavy machinery and equipment will be used during construction and operational phases of the project with huge quantity of explosives for blasting of rocks. Resultantly heaps of leftovers of explosives, grease, chemicals, lubricants, and other harmful materials will be produced on daily basis. These pollutants through run off rain water enter into the lake and river course increase toxicity of water causing rapid destruction of fish population and riverin ecology.

### 16.12.18.2 Fish Migration

Fish usually migrate from one place to another for search of food, shelter and spawning/breeding. Due to construction of the Project fish migration might be affect up to some extent.

**Mitigation**

Rapid mechanism of dispose-off of such kinds of hazardous materials will be required on urgency basis by dumping the extracted hazardous materials selecting safe landfill areas away from the main river course and its watershed, so that contaminated water in form of runoff could not enter directly into the main course.

Land sliding and soil erosion are also the main factor to contribute silt load on river bed manifold causing damage to resting and nesting grounds of fishes. Construction of protective walls and gabions at certain points to make sure the stoppage of sliding debris. Plantation and vegetation cover can also be helpful for slope stabilization. Plants, herbs and shrubs reduce the level of pollution and toxicity at a great extent as bio-filter and carbon suckers.

- Fish screening system should be developed so that fish may not be trap at intake, penstock pipe or channel.
- Sewage water treatment discharged from all labour camps and toilet facilities must be treated before disposal into the river.
- Tanks of fuel, oil and other liquids to be placed quite distant from any water body.
- Washing of vehicles or other machinery in the river or nullah is to be strictly prohibited.
- Oil changes for engines and other machinery to be only allowed in workshops.
- All vehicle and machinery to be maintained properly in order to avoid any leakages

### 16.12.18.3 Impacts on Power

The most significant impact of the Project will be the power generation as the Region is presently facing acute shortage of power. The power generating capacity of the Project is estimated as 54 MW, which is enough to remove the power shortage from the area. The power generated will help to establish new industries to boost commercial activities and to enhance job opportunities in the valley. Electricity generation impacts are considered to be most significant positive impact of the Project.



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## 16.13 CONFIDENCE BUILDING MEASURES (CBM)

People of Hunza are well educated and support development of projects, especially when it comes to power projects. However, in addition to satisfying the needs and requirements of locals, certain measures shall be taken in the form of CBM. During the social survey of the region, it was desired by the local communities to provide facilities where they could play sports and organize sporting events. For the said facility. Land would be acquired by the amount kept near Karimabad and Ganish for CBM, further infrastructure development can be developed with the help of involvement of NGOs.

## 16.14 ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN

This section of the ESIA report provides an overall approach for managing and monitoring the environmental and social issues raised by the construction and operation of the ALHPP .The objective is to provide an overall frame work for implementing the mitigation measures that adequately address the identified adverse impacts and also the enhancements for predicted positive impacts. In addition, the items that require monitoring of the environment are also identified. All of these measures are to be put into a coherent Environmental Management and Monitoring Plan (EMMP), complete with the institutional arrangements and resources required to successfully implement the required actions.

The main objectives of an EMMP areas under:

- Provide the details of the Project impacts, along with the proposed mitigation and enhancement measures.
- Define the roles and responsibilities of the Project stakeholders, including the Project proponent, contractor, supervisory consultants and other key players.
- Identify the training requirements needed for the key role players in order for them to effectively implement the EMMP.
- Provide a mechanism in the form of an environmental monitoring program, that outlines which key parameters (both for the natural and social environment) will need to be monitored and the frequency that each of these has to be carried out.
- The objective is to ensure that mitigation measures are being effective in keeping environmental conditions within prescribed limits and if they are not, then making sure that there is an effective response mechanism that allows corrective action to be implemented.

## 16.15 MITIGATION MANAGEMENT MATRIX

The Mitigation Management Matrix (MMM), a preliminary out line is considered to be one of the main elements of the EMMP. The MMM shall be prepared during detailed design keeping in view the required functions and responsibilities and is to be used as the management tool for the implementation of mitigation measures. The mitigation management matrix should include:

- The required mitigation measures recommended in the ESIA Report.



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- Identification of the person or institution/organization directly responsible for adhering to or executing the required mitigation measures.

- The person or institution/organization responsible for ensuring and monitoring adherence to the mitigation measures.

- The parameters that will be monitored to ensure compliance with environmental standards and also with the requirements and objectives of the mitigation measures.

- The timing at which the mitigation or monitoring has to be carried out.

## 16.16 MANAGEMENT OF DIRECT CONSTRUCTION IMPACTS

Construction programs and management of construction impacts shall be included by drafting appropriate environmental management clauses into the construction contracts. Once a master check list of direct construction impact issues has been finalized then a monitoring checklist can be created for use by the supervising engineers during the construction period. It is crucial to clearly define the responsibilities of each of the parties in the construction works (contractors, supervisors and the Project Proponent).

## 16.17 SITE RESTORATION PLAN

The main areas that will require site restoration include the main construction site area, workers' accommodation sites, land used for vehicle and material workshops and stores along with material excavation and storage areas and temporary access roads and tracks. These areas will need to be restored to their original condition as far as possible and where there has been significant change then landscaped to fit with the surrounding area. The restoration work includes the removal of all temporary construction works and materials, followed by the landscaping and planting of the areas, including provision of adequate surface drainage to ensure that there will be no erosion and particularly sedimentation into the reservoir. The following procedures will be adopted for the restoration of the site:

- All temporary constructions built for the site development will be removed.

- Areas used for construction camps will be restored to their previous condition as far as is possible and where this is not then appropriately landscaped and planted to an agreed plan.

- All toxic and hazardous chemicals and materials will be totally removed from the site followed by treatment and environmentally appropriate disposal.

- During the construction program efforts will be made to minimize the risk of oil and chemical spills and an effective clean-up program should be in place to remove these as soon as they happen.

- All debris from construction activities should be removed from the site and appropriately separated, reused, recycled and composted with the residual material appropriately incinerated.



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- All redundant fencing and gates will be removed and excavated pits will be appropriately backfilled.

## 16.18 RESERVOIR MANAGEMENT PLAN

Reservoir area will need to be managed during both the construction and operation of the project. The risk of debris entering the intakes also has to be considered. Once a clear idea of the construction program has been agreed then an appropriate reservoir management plan can be drawn up. This should also include the fisheries development plan for the reservoir, along with a recreation and tourism management program for the area.

The reservoir management plan will also have to consider the need for upstream catch management measures in the watercourses that directly discharge into the reservoir, based upon the results of water quality monitoring that will be carried out. The quality of the reservoir water will also need to be monitored to ensure that there is not a buildup of nutrients that could cause problems with algal growth. If this should start to occur, then adequate measures will needtobetakentopreventnutrientloadedwaterfromflowingintothereservoir.

## 16.19 IMPACT MONITORING PROGRAM

### 16.19.1 Objectives of the Impact Monitoring Plan

The objective of the environmental monitoring activities to be carried out during the construction and operation stages of the project will be as follows:

- To monitor the actual project environmental impact on the physical, biological and socioeconomic indicators that will be selected to be appropriate for such work in order to compare appropriate indicators with the situation before the start of the Project.

- To provide information that will allow recommend mitigation measures to be drawn up for any unforeseen impact or where the adverse impact level exceeds that anticipated.

- Ensure compliance with legal regulatory requirements and also community obligations, including health and safety at both the construction and operational stages of the Project.

- Ensure the safe and environmentally sound disposal of excess construction materials, solid waste and effluents, along with the adequate management of noise and dust emissions.

The main objectives of environmental monitoring during the operation phase will be to:

- Appraise the adequacy of the ESIA with respect to the predicted long-term impacts of the project on the physical, biological and socio-economic environment of the area.

- Evaluate the effectiveness of the mitigation measures proposed in the EMMP and recommend any improvements in the EMMP if they are found to be required.

- Compile periodic incident and accident data to support analyses that will help to minimize future risks.



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- Monitor the survival rate of the proposed vegetation planting program and make appropriate proposals to ensure that balanced mixed age and species stands develop in the area that provide sustainable supplies of fruit, fuel- wood and fodder for the local population.

### 16.19.2 Monitoring Strategy

All the compliance monitoring will be executed by the Contractor during the construction stage of the Project to ensure that they operate according to the regulatory framework. Supervision of the compliance environmental monitoring work during the construction stage will be carried out by the Supervisory/Management Consultants(SC).

### 16.19.3 Monitoring Parameters and Frequency

#### I. Natural Environment

For the physical environment the following parameters will need to be regularly monitored both before and during construction:

- Ambient air quality (mainly NOx, Sox and CO)
- Batching and crushing plant emissions (smoke, dusted.) during operation
- Ambient noise levels
- Water quality (drinking, surface and groundwater), for both chemical composition and also sediment

#### II. Socio-Economic Environment

The impacts on the socio-economic environment will be monitored by the SC using changes in house hold economic livelihoods as a major indicator in the longer term. Other key aspects that will need to be monitored include environmental and community health, safety issues, employment availability and generation, along with physical mobility and access, especially for women. At the construction stage of the Project the Supervisory Consultant will maintain a Social Complaints Register. This is an open public document that allows anybody to register a complaint which must then be thoroughly investigated and a judgment made as to its justification and the action need to address the issue.



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## 16.20 CONSTITUTION OFPROJECTENVIRONMENT MANAGEMENT COMMITTEE

| Sr. No. | Agency | Representative | Status |
|---|---|---|---|
| 1 | WAPDA | Project Director | Chairman |
| 2 | Government of Gilgit-Baltistan | DC/ AC (Concerned) | Member |
| 3 | Consultant | Resident Engineer | Member |
| 4 | Main Contractor | Designated Engineer | Member |
| 5 | Environment Department | Director, EPA Gilgit-Baltistan Representative | Member |
| 6 | Local Government | Chairman District Council | Member |
| 7 | NGO | Representatives of two functional NGOs of the Region | Member |

## 16.21 LAND REQUIREMENTS FOR THE PROJECT

Resettlement, land requirements and acquisition for any Mega Project is a sensitive task, however, for this Project these issues are not as critical as in other projects. Attabad Lake was formed in 2010 as a result of a natural disaster and it still recovers about 4.5 km2 of land which includes lands of Ainabad, Shishkat, Gulmit and Gulkin. Shishkat, Gulmit and Gulkin were partly damaged but Ainabad was completely submerged.

Land will be acquired for mostly powerhouse site which includes land powerhouse, switchyard, Project colony and Project offices. Land at weir site is mostly riverine land and will be acquired from the government. Land required for the ALHPP is mentioned in the Table 16-8.



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**Table 16-8 Land Requirements for ALHPP**

| Sr. No. | Description | Town / Village | Land in Acres | Land in Kanals | Land Cost per Kanal (DC Rates) | Remarks |
|---|---|---|---|---|---|---|
| 1 | Powerhouse Side | Sarat | 4 | 32 | 750,000 | Community Land of Ganish Village |
| 2 | Weir and Associated Structures | Attabad | 15 | 120 | 500,000 | Mostly it is riverine land. Left Side of Hunza River is Community Land of Ganish Village and Right Side is Community Land of Attabad Village. |
| 3 | Access Roads to Sites | - | - | - | - | Old KKH will be repaired where available and new will be constructed where not available |
| 4 | Permanent Project Colony | Sarat | 2.5 | 20 | 1,500,000 | Community Land of Ganish Village |
| 5 | Transmission Line | Throughout the T.L route | As per site | As per site | Varies | Land for T.L will be acquired along the route |
| | **Total** | | **21.5** | **172** | | |



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# 17 ECONOMIC AND FINANCIAL ANALYSIS

## 17.1 INTRODUCTION

Electricity is imperative to social, agriculture, industrial development and growth of any Region. Electricity and energy consumption is an important indicator of economic growth. While 83% of the population of Pakistan presently has access to electricity, per capita energy consumption is about 516 KWh/year in the year 2020 (IGCEP-2021,2030)

Pakistan is endowed with a hydro potential of about 60,159 MW, most of which located in the provinces of Khyber Pakhtunkhwa (KPK), Northern Areas (NA) and Azad Jammu and Kashmir (AJK).

This section deals with quantitative analysis of the economic and financial aspects of ALHPP

## 17.2 ECONOMIC ANALYSIS

### 17.2.1 Introduction

Economic justification of investment in capital intensive project depends upon three factors, firstly the need of the project, secondly technological options available and the most economic choice (least cost option) for the project and thirdly the project will provide an acceptable return to the national economy and fulfills the debt obligation. The process involved the assessment of project benefits and identification of project cost over the economic life of the project. The basic technique for comparing costs and benefits occurring in different periods is discounted to express them in a common value in one point taking into account time value of money. Economic viability of the project has been checked under two approaches i.e. Equivalent Thermal Approach and Consumer Surplus to Pay (WTP).

## 17.3 CUSTOM DUTY

No import charges and sales tax has been added. However, custom duty @ 5% on import of plant and equipment not manufactured locally on foreign exchange component of E&M equipment are added to the project. (Refer Hydel policy for Power Generation Projects, 2015).

## 17.4 INTEREST DURING CONSTRUCTION (IDC)

The interest during construction has been calculated @12.20% per annum on both local and foreign cost components.

## 17.5 EXCHANGE RATE

Since 1982, the value of the Pakistani Rupee has been worked out with the help a "managed float" linking it to a basket of currencies. It is recognized that conversion factors are sometimes used even when a currency is floating especially if restrictions exist on currency exchange. Based on the facts it is concluded that conversion factor should not be applied to the exchange rate. Prevailing interbank exchange rate of US$= Rs 157 has therefore been applied.



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## 17.6 OPERATION AND MAINTENANCE COST

The operation and maintenance cost of the Project has been assessed @ 1% per annum of the base cost during its 30 years of useful life.

## 17.7 AUTHORITY OVERHEADS

The authority overhead has been fixed @ 1.5% on Civil, E&M and Preliminary Cost.

## 17.8 ANNUAL RECURRING COST

Recurring costs refer to expenses that reappear over a period. The annual O&M cost and annual amortization costs have been taken in the annual recurring cost.

## 17.9 LOCAL ESCALATION

There are three measures to compute escalation. These are GDP deflator, consumer price index (CPI) and wholesale price Index (WPI). The GDP deflator is the ratio of nominal gross domestic product (GDP) in a given year to real GDP of the year. Since the GDP deflator is based on all goods produced in the economy and is used to measure inflation and escalating project costs, hence the same is proposed for escalation purpose. The future projections of inflation rate are made on the basis of historical trends and government policies to curtail inflation.

The State Bank of Pakistan is taking hard decision to control the inflation by tightening the monetary policy. The government of Pakistan has also taken measures like reducing the budget deficit and effective management of domestic food supplies to curtail the inflation in Pakistan. During the last two years GDP rates were abnormal which cannot be applied for up-dating of costs. Taking a realistic value in a real term inflation rate of 6.5% has been used in this project.

## 17.10 FOREIGN ESCALATION

The major share of project cost shall be incurred on importing hydro-mechanical equipment's. The foreign cost shall also be required to be escalated during the construction. Two indices are available to escalate foreign cost components during construction. The manufacturing unit value index (MUV) represent the escalation rate of seven industrialized countries. For foreign cost updating escalation rate of 2% has been used (World Bank web site).

## 17.11 ERECTION & COMMISSIONING, LC, INSURANCE & SECURITY COST

These items have been charged @ 5% on Civil, E&M and Preliminary cost.

| **Base Cost (Million Rs.)** | |
|---|---|
| **Local** | 14350.480 |
| **Foreign** | 5678.440 |
| **Total Base Cost** | **20028.920** |
| Price Escalation of Local and Foreign | 1000.537 |
| Custom Duties | 216.706 |
| **Total Financial Cost** | **21246.163** |



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## 17.12 ANNUAL O&M COSTS

The annual operation and maintenance cost has been estimated keeping in view the recent years, expenditures and salaries of the staff. The O&M cost @1% of the base cost comes to Rs. 200.289 million with transmission line which will be met through selling of energy of power plant

## 17.13 PROJECT BENEFITS AND ANALYSIS

The economic and financial analyses have been carried on the following two scenarios:

1. Financial Internal Rate of Interest (FIRR) with transmission line without Capital Development mechanism (CDM)

2. FIRR with transmission line with CDM benefits

## 17.14 FINANCIAL BENEFITS

- The Hydro Power Project is highly beneficial due to less unit cost and providing inexpensive electricity. It will also help in saving foreign exchange on import of fuel.

- The financial benefits over the project life of 30 years calculated on certain assumptions depict an (FIRR) as 19.27%, and 19.17% with and without CDM benefits respectively which makes the Project significantly viable.

- The generation cost is worked out to be Rs 5.67/kWh (3.61 US Cents) over the useful life of the project and cost per MW of installed capacity being Rs 393.447 Mill (US $ 2.506 Million) with transmission line is also very attractive to reflect the financial benefits of the Project.

## 17.15 ECONOMIC BENEFITS

The economic analysis of the Project has been carried out on the basis of benefits to the overall economy as a consequence of least cost optimal development of the hydropower potential in the country. For this purpose, the benefits from the proposed steam unit/combustion turbine plant with (CDM) have been evaluated in term of costs foregone for providing an equivalent thermal generation.

The project will yield Internal Economic Rates of Return (IERR) of 22.54% & 22.36% with and without CDM benefits respectively. The benefit cost ratios come to 1.56:1, and 1.55:1, at 12% discount rate with and without CDM benefits respectively which also reflect the economic viability of the proposed Project.

## 17.16 SOCIAL BENEFITS

The Project with an installed capacity of 54 MW will generate 373.69 GWh of electricity annually which will assist in meeting power demand of the Hunza Region. The project will implement several programs that are designed to improve living standard of the area. These programs will provide improved health, education and infrastructure facilities while other programs will provide alternative source of income and create improved employment opportunities.



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Moreover, the Project will avoid annual releases of about 149,476 tons of $CO^2$ from an equivalent thermal plant which have a corresponding reduction in atmospheric pollution.

The revenues of would increase due to direct and indirect taxation, duties and levies on the production of goods and services that will arise from the power generation within the Project Area as well as from the electricity duty collected by the Federal Government, Government of Baluchistan or any other Government agency.

The hydel generation plays an important role in the country's economy due to utilization of indigenous energy resources, in reducing load shedding and saving of foreign exchange required to import furnace oil.

## 17.17 BENEFITS OF THE PROJECT

### 17.17.1 Quantifiable Benefits

ALHPP would be constructed at Attabad using existing infrastructure. It will provide inexpensive electricity of about 373.69 GWh annually to the National Grid. The total installed capacity of the Project is 54 MW. It has no adverse impacts on the local environment, on the other hand it will help to reduce emissions as compared to a thermal Project. There are many benefits associated with the construction of hydroelectric power generating facility. These benefits include:

- Power will be produced from a renewable resource instead of depleting reserves of the country.
- Harmful by-products such as $SO_2$, $NO_2$, and $CO_2$, etc. are not produced by hydropower as with other fossil fuel sources.
- It will increase the regional power grid stability, reliability and availability.
- Local socio- economic benefits as a result of the construction, operation and maintenance of the facility.
- Multi-use of the water resource thus maximizing the intrinsic value of the overall facility.

### 17.17.2 Non-Quantifiable Benefits

The hydel project needs extensive civil works and can create significant number of job opportunities for engineers, technicians, skilled and unskilled labour during execution and operation of the project. The project is envisaged to bring economic uplift activities of far-reaching effects in the project area particularly electrification. Construction of ALHPP will have direct and indirect benefits for the local area. It will create new employment and job opportunities during construction and operation stages.

The Project will provide incentive for the establishment of small and medium size industry based on local raw material, creating gainful employment opportunities to the increasing work force. This will further help in alleviating disguised unemployment in agriculture sector. Providing basic infrastructural facility of electricity in rural areas goes a long way in checking large scale migration of rural labour force to urban centers.



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Higher per capita disposable income would create more opportunities, improved health and education facilities. It would provide incentives to the work force to live near their homes and tendency to migrate to main urban centers would be reduced. In brief, it is envisaged that providing one of the basic infrastructure facilities of electricity at a suitable scale would usher in a continuous prosperity as well as economic emancipation by utilization of indigenous resources of land, labour and capital.

The revenues of the government would increase due to levies and taxes on the production of goods and services which would be a consequence of the electrification of the area as well as from electricity duty due to additional sale of power. Besides, the annual payment of interest charges to the federal government / loaning agency would be a substantial amount.

## 17.18 CLEAN DEVELOPMENT MECHANISM (CDM) BENEFITS

The CDM is an emission reduction (ER) trading agreement under the Kyoto Protocol between two countries, where greenhouse gas emission is reduced in a non-annex country and transferred to another country. Under the Kyoto Protocol

Pakistan deposited its intent of accession to the Kyoto Protocol in the UN Secretariat on 11 January 2005.To become eligible for CDM Projects, an operational strategy was developed to fulfill requirements of establishing a designated national authority (DNA) and ensuring transparent, participatory and effective management of CDM process in the country. Carbon Credits are applicable in certain cases of hydroelectric projects, where a demonstrable reduction in greenhouse gas emissions can be claimed as result of the project.

In order to qualify a project has to cross a number of barriers; in particular, by providing additionally measure of benefits that the project brings that would not have been available in its absence and quantifying the benefits in terms of a voided emissions. Once credits are confirmed, it is necessary to trade them through one of the carbon funds to convert into hard currency revenue from the start of the operation.

Recently a number of international organizations such as Asian Development Bank (ADB) have established a means of purchasing (CERs) units. The ADB also offer technical support to prospective developments for taking the necessary steps to be able to benefit from CDM. Unit can be traded in the open market on exchanging.

For the purposes of this analysis it is assumed that 373.69 GWh generated annually by this project will displace about 149,476 ton of $CO^2$ at 0.40 kg/kWh. One ton of CO2 corresponds to CER which is currently valued about 1.5 US$. Therefore, the CDM benefits worth will be 29.921 million Pak Rs per annum:



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**Table 17-1 Estimate of Annual CDM Benefits**

| Description | Unit | Value |
|---|---|---|
| Energy | GWh | 373.69 |
| $CO_2$ emission per kWh | Kg | 0.4 |
| $CO_2$ emission per GWh | Tons | 400 |
| Project $CO_2$ Emission | Million Tons | 0.149476 |
| $CO_2$ emission per Ton | US$ | 1.5 |
| Project CDM Benefits | US$ | 0.2242 |
| Project CDM Benefits | M.Rs | 35.20 |
| Benefits attributed to the Project | M.Rs | 29.921 |

## 17.19 FINANCIAL ANALYSIS

The Project with an installed capacity of 54 MW will generate 373.69 GWh of electricity annually which will assist in meeting power demand of the country and will help in reduction of load shedding though insignificant. The project will generate revenue of Rs 5037.462 million and Rs 5007.541 million with and without CDM benefits annually at full operation. The Internal Financial Rates of Return (IFRR) 19.27% and 19.17% with and without CDM benefits respectively are shown in Tables-17-2 to 17-3.



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## Table 17-2 Attabad Lake Hydropower Project
## Financial Analysis With CDM Benefits

| YEAR | PROJECT COST | O&M | TOTAL COST | ENERGY GWh | REVENUES | CDM BENEFITS | TOTAL BENEFITS | NET BENEFITS |
|---|---|---|---|---|---|---|---|---|
| 1 | 6317.890 | | 6317.890 | | | | | -6317.890 |
| 2 | 5521.856 | | 5521.856 | | | | | -5521.856 |
| 3 | 9406.417 | | 9406.417 | | | | | -9406.417 |
| 4 | | 200.289 | 200.289 | 373.69 | 5007.541 | 29.921 | 5037.462 | 4837.173 |
| 5 | | 200.289 | 200.289 | 373.69 | 5007.541 | 29.921 | 5037.462 | 4837.173 |
| 6 | | 200.289 | 200.289 | 373.69 | 5007.541 | 29.921 | 5037.462 | 4837.173 |
| 7 | | 200.289 | 200.289 | 373.69 | 5007.541 | 29.921 | 5037.462 | 4837.173 |
| 8 | | 200.289 | 200.289 | 373.69 | 5007.541 | 29.921 | 5037.462 | 4837.173 |
| 9 | | 200.289 | 200.289 | 373.69 | 5007.541 | 29.921 | 5037.462 | 4837.173 |
| 10 | | 200.289 | 200.289 | 373.69 | 5007.541 | 29.921 | 5037.462 | 4837.173 |
| 11 | | 200.289 | 200.289 | 373.69 | 5007.541 | 29.921 | 5037.462 | 4837.173 |
| 12 | | 200.289 | 200.289 | 373.69 | 5007.541 | 29.921 | 5037.462 | 4837.173 |
| 13 | | 200.289 | 200.289 | 373.69 | 5007.541 | 29.921 | 5037.462 | 4837.173 |
| 14 | | 200.289 | 200.289 | 373.69 | 5007.541 | 29.921 | 5037.462 | 4837.173 |
| 15 | | 200.289 | 200.289 | 373.69 | 5007.541 | 29.921 | 5037.462 | 4837.173 |
| 16 | | 200.289 | 200.289 | 373.69 | 5007.541 | 29.921 | 5037.462 | 4837.173 |
| 17 | | 200.289 | 200.289 | 373.69 | 5007.541 | 29.921 | 5037.462 | 4837.173 |
| 18 | | 200.289 | 200.289 | 373.69 | 5007.541 | 29.921 | 5037.462 | 4837.173 |
| 19 | | 200.289 | 200.289 | 373.69 | 5007.541 | 29.921 | 5037.462 | 4837.173 |
| 20 | | 200.289 | 200.289 | 373.69 | 5007.541 | 29.921 | 5037.462 | 4837.173 |
| 21 | | 200.289 | 200.289 | 373.69 | 5007.541 | 29.921 | 5037.462 | 4837.173 |
| 22 | | 200.289 | 200.289 | 373.69 | 5007.541 | 29.921 | 5037.462 | 4837.173 |
| 23 | | 200.289 | 200.289 | 373.69 | 5007.541 | 29.921 | 5037.462 | 4837.173 |
| 24 | | 200.289 | 200.289 | 373.69 | 5007.541 | 29.921 | 5037.462 | 4837.173 |
| 25 | | 200.289 | 200.289 | 373.69 | 5007.541 | 29.921 | 5037.462 | 4837.173 |
| 26 | | 200.289 | 200.289 | 373.69 | 5007.541 | 29.921 | 5037.462 | 4837.173 |
| 27 | | 200.289 | 200.289 | 373.69 | 5007.541 | 29.921 | 5037.462 | 4837.173 |
| 28 | | 200.289 | 200.289 | 373.69 | 5007.541 | 29.921 | 5037.462 | 4837.173 |
| 29 | | 200.289 | 200.289 | 373.69 | 5007.541 | 29.921 | 5037.462 | 4837.173 |
| 30 | | 200.289 | 200.289 | 373.69 | 5007.541 | 29.921 | 5037.462 | 4837.173 |
| 31 | | 200.289 | 200.289 | 373.69 | 5007.541 | 29.921 | 5037.462 | 4837.173 |
| 32 | | 200.289 | 200.289 | 373.69 | 5007.541 | 29.921 | 5037.462 | 4837.173 |
| 33 | - | 200.289 | - | 373.69 | 5007.541 | 29.921 | 5037.462 | 6593.657 |
| **TOTAL** | **21246.16** | **6008.67** | **25498.35** | **11210.70** | **150226.217** | **897.641** | **151123.857** | **125625.503** |

**INTERNAL RATE OF** **19.27%**



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## Table 17-3 Attabad Lake Hydropower Project
## Financial Analysis Without CDM Benefits

MILL.Rs

| YEAR | PROJECT COST | O&M | TOTAL COST | ENERGY GWH | TOTAL REVENUES | NET BENEFITS |
|---|---|---|---|---|---|---|
| 1 | 6317.890 | | 6317.890 | | | -6317.890 |
| 2 | 5521.856 | | 5521.856 | | | -5521.856 |
| 3 | 9406.417 | | 9406.417 | | | -9406.417 |
| 4 | | 200.289 | 200.289 | 373.69 | 5007.541 | 4807.251 |
| 5 | | 200.289 | 200.289 | 373.69 | 5007.541 | 4807.251 |
| 6 | | 200.289 | 200.289 | 373.69 | 5007.541 | 4807.251 |
| 7 | | 200.289 | 200.289 | 373.69 | 5007.541 | 4807.251 |
| 8 | | 200.289 | 200.289 | 373.69 | 5007.541 | 4807.251 |
| 9 | | 200.289 | 200.289 | 373.69 | 5007.541 | 4807.251 |
| 10 | | 200.289 | 200.289 | 373.69 | 5007.541 | 4807.251 |
| 11 | | 200.289 | 200.289 | 373.69 | 5007.541 | 4807.251 |
| 12 | | 200.289 | 200.289 | 373.69 | 5007.541 | 4807.251 |
| 13 | | 200.289 | 200.289 | 373.69 | 5007.541 | 4807.251 |
| 14 | | 200.289 | 200.289 | 373.69 | 5007.541 | 4807.251 |
| 15 | | 200.289 | 200.289 | 373.69 | 5007.541 | 4807.251 |
| 16 | | 200.289 | 200.289 | 373.69 | 5007.541 | 4807.251 |
| 17 | | 200.289 | 200.289 | 373.69 | 5007.541 | 4807.251 |
| 18 | | 200.289 | 200.289 | 373.69 | 5007.541 | 4807.251 |
| 19 | | 200.289 | 200.289 | 373.69 | 5007.541 | 4807.251 |
| 20 | | 200.289 | 200.289 | 373.69 | 5007.541 | 4807.251 |
| 21 | | 200.289 | 200.289 | 373.69 | 5007.541 | 4807.251 |
| 22 | | 200.289 | 200.289 | 373.69 | 5007.541 | 4807.251 |
| 23 | | 200.289 | 200.289 | 373.69 | 5007.541 | 4807.251 |
| 24 | | 200.289 | 200.289 | 373.69 | 5007.541 | 4807.251 |
| 25 | | 200.289 | 200.289 | 373.69 | 5007.541 | 4807.251 |
| 26 | | 200.289 | 200.289 | 373.69 | 5007.541 | 4807.251 |
| 27 | | 200.289 | 200.289 | 373.69 | 5007.541 | 4807.251 |
| 28 | | 200.289 | 200.289 | 373.69 | 5007.541 | 4807.251 |
| 29 | | 200.289 | 200.289 | 373.69 | 5007.541 | 4807.251 |
| 30 | | 200.289 | 200.289 | 373.69 | 5007.541 | 4807.251 |
| 31 | | 200.289 | 200.289 | 373.69 | 5007.541 | 4807.251 |
| 32 | | 200.289 | 200.289 | 373.69 | 5007.541 | 4807.251 |
| 33 | -1756.484 | 200.289 | -1556.195 | 373.69 | 5007.541 | 6563.735 |
| **TOTAL** | **21246.163** | **6008.676** | **25498.355** | **11210.70** | **150226.217** | **124727.862** |

**INTERNAL RATE OF RETURN = 19.17%**



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### 17.19.1 Unit Cost Analysis

The cost per kWh of energy generated has been estimated by dividing average annual recurring cost with annual generation of the Project. The average annual recurring cost is arrived at by amortizing the total financial cost of Rs 21246.163 Million (Local Rs 15360.187 million and foreign Rs. 5885.975 million) inclusive of escalation, custom duty and IDC at an interest rate of 12.20% for both local and foreign components for 20 years and levelized over 30 years. Annual O&M costs with transmission line of Rs 200.289 Million has also been included. The Project generation cost with transmission line per kWh and cost per MW of installed capacity are shown in Table-17-4.

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## Table 17-4 Cost Per KWh and MW

| Sr. No | Description | Million Rs. |
|---|---|---|
| 1 | BASE COST | 20028.920 |
| | a) Local | 14350.480 |
| | b) F.E.C | 5678.440 |
| 2 | ESCALATION | 1000.537 |
| | a) Local@ 6.5% | 793.002 |
| | b) Forgien @ 2% | 207.535 |
| 3 | Import Charges @ 5% | 216.706 |
| 4 | Interest During Construction | 0.000 |
| | a) Local | 0.000 |
| | b) F.E.C | 0.000 |
| 5 | **Financial Cost** | 21246.163 |
| | a) Local | 15360.187 |
| | b) F.E.C | 5885.975 |
| 6 | Amortization of Financial Cost @ 12.20% For 20 Year & Levelised 30 year of: | |
| | a) Local | 1388.162 |
| | b) F.E.C | 531.939 |
| 7 | Operation & Maintenance Cost @ 1% of Base Cost | 200.289 |
| 8 | Annual Recurring Cost | 2120.390 |
| 9 | Annual Energy (GWh) | 373.69 |
| 10 | Cost Per KWh - Rs | 5.67 |
| | US $ Cents | 3.61 |
| 11 | Installed Capacity (MW) | 54.00 |
| 12 | Installed Cost Per MW- MRs | 393.447 |
| | Mill US $ | 2.506 |
| | NOTE :- Exchange Rate: I US $ = Rs.157.00 . | |



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### 17.19.2 Breakeven Point (BEP)

BEP required to recover the recurring expenditure (Operating costs + Debt + Interest obligations). The breakeven production BEP is a production which determines the number of unit of energy volume of the project is 136.45 GWh of energy which is considerably less than the annual production of 373.69 GWh.

### 17.19.3 Payback Period

The payback period of the project are 5 years

### 17.19.4 Fuel Price

The scarcity of fossil, i.e. oil and gas for power generation demanded the development of renewable energy resources. Natural gas resources are depleting in Pakistan, which require from other countries, such as Dubai, Qatar, and Iran. The estimation of natural gas price to calculate the fuel cost per kWh of OCGT is cumbersome due to uncertainties in its availability. The price estimation further becomes complex with the depletion of indigenous natural gas reserves. Alternatively, re-gasification carryout from import of Liquefied Natural Gas (LNG) from Qatar is underway. Energy cost of thermal equivalent plants will be used.

The price of Qatar LNG has not yet been decided as such, LNG Price indicated in World Bank Commodities Data will be used to calculate the fuel price of the thermal plants. Average monthly price of LNG Japan is 5.98 $/mm Btu and after including shipping and re-gasification charges of 1.5 $/mm Btu, its comes to 7.48 $/mm Btu.AS per calculation depicted in Table 17-5

**Table 17-5 Fuel Price kWh**

| Sr. | Description | Unit | |
|---|---|---|---|
| 1 | LNG Cost | $ mm btu | 5.98 |
| 2 | Shipping and Regasification | $ mm btu | 1.50 |
| 3 | LNG Cost (Fob) | $ mm btu | 7.48 |
| 4 | Heat Rate | btu kWh | 6824 |
| 5 | Fuel Cost | Cent/kWh | 5.10 |
| 6 | Fuel Cost | Rs. | 8.42 |

## 17.20 ECONOMIC ANALYSIS

The economic analysis of the Project has been carried out on the basis of benefits to the overall economy as a consequence of least cost optimal development of the hydropower potential in the country. For this purpose, the benefits from the proposed steam unit/combustion turbine plant have been evaluated in terms of costs foregone for providing an equivalent generation.



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The economic analysis is based on the following assumptions and summarized below:

| DESCRIPTION | | UNIT | OIL-FIRED |
|---|---|---|---|
| 1. | Capital Cost/KW* | Rs | 157000 |
| 2. | Plant Factor | % | 80 |
| 3 | O&M Cost @operated) | % | 3.0 |
| 4. | Fuel Cost/KWh** Financial | Rs | 8.42 |
| 5 | Fuel cost / KWh: Economic | Rs | 7.58 |

Source: Commodity price data world bank.

Results of economic analysis i.e. IERR with and without CDM benefits are calculated as 22.54%, & 22.36%. Detailed economic analyses are given in Tables-17-8 to 17.-9.

## 17.21 SHADOW PRICING

The economic analysis of the project requires that all costs and benefits must be evaluated at prices within the economy which reflect their real worth. Major inputs into the scheme of economic analysis do not necessarily reflect their true opportunity cost to the economy because of distortions in market prices. Like many other developing countries, the prices of goods and services are distorted by subsidies and taxes in Pakistan too.

The rate of foreign exchange has differed from its true opportunity cost., the price of labour in most of sector has generally been higher than its true opportunity cost. Shadow pricing has, therefore, been used to find out true opportunity cost of capital as well as other inputs to determine the economic cost of this project to the national economy.

## 17.22 COST OF CAPITAL

Shadow price of capital is defined as the opportunity cost of funds withdrawn from other uses and is considered equal to marginal cost of capital in the economy of Pakistan. The World Bank has used 10% discount rate for rural electrification projects and 12% by Planning Commission of Pakistan for economic evaluation of public sector projects followed by a study of Harvard Advisory Group on opportunity cost of capital. Accordingly, costs and benefits have been discounted @ 12% for the assessment of economic feasibility of the project.

## 17.23 COST OF LABOUR

In cases where there is significant unemployment and under-employment in a local economy shadow wage rates for labour should be used which are considerably lower than actual wages paid. The objective in economic analysis is to use the opportunity cost as an alternative application. In Pakistan the situation is one of under-employment for unskilled labour rather than full employment since there is labour shortages in rural areas in sowing and harvesting seasons. There is no employment problem for skilled labour as there are sufficient opportunities locally and in nearby oil producing countries.

Therefore, shadow wage rates of 1.00 and 0.75 for skilled and unskilled labour respectively, have been used for deriving the economic cost The economic cost of labour has been determined by applying shadow wage factors to the total labour cost which is equivalent to 38%



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of the local cost of the project with 40% & 60% as skilled and unskilled labour components, respectively.

## 17.24 COST OF MATERIAL

Most of the material inputs for the project, i.e., steel, cement etc, are transported to the project site involving high freight expenditures. It is, therefore, assumed that shadow rate for material may be used as 0.91.

The results of shadow conversion factors have been applied to various components of project costs to derive adjusted economic costs

**Table 17-6 Derivation of Standard Conversion Factor**

**Rs.(Million)**

| No. | Description/Years | 2014-15 | 2015-16 | 2016-17 | 2017-18 | 2018-19 | Average |
|---|---|---|---|---|---|---|---|
| 1 | Total Imports* | 4644152 | 4658749 | 5540921 | 6694897 | 5,371,142 | 5381972 |
| 2 | Total Exports* | 2397513 | 2166846 | 2138186 | 2555043 | 2,263,648 | 2304247 |
| 3 | Import Duties** | 254360 | 255160 | 303476 | 366680 | 294177 | 294771 |
| 4 | Sales Tax on Imports** | 459492 | 460937 | 548219 | 662393 | 531421 | 532492 |
| 5 | Subsidies on Imports*** | 52525 | 52690 | 62668 | 75719 | 60748 | 60870 |
| 6 | Export Duties** | 5826 | 5265 | 5196 | 6209 | 5501 | 5599 |

$$\text{Standard Conversion Factor (SCF)} = M + X \quad \frac{(M+X)}{(M+Tm)+(X-Tx)} = \mathbf{0.91}$$

Source:-
* Economic Survey 2018-19

** FBR Year Book 2016-17 & 2018-19

*** Ministry of Finance, Islamabad

M = CIF Value of Imports

X = FOB value of Exports

TM= Net Value of Taxes on Imports

TX= Net Value of Taxes on Exports

## 17.25 ECONOMIC COST

The economic costs are derived by converting financial cost with adjustments for direct transfer payments like taxes, subsidies and interest (transfer payments) during construction, besides adjustments for distortions in the market prices of traded and untraded goods used in the project works. For this study also economic costs of the project have been derived by removing transfer payments in addition to adjustment of cost of labour and material with appropriate shadow conversion factors. The economic costs of the project thus derived have been used in economic evaluation and given in detailed calculations are as follows:



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**Table 17-7 Comparison of Economic Cost of the Project**

| Description | Million Rupees |
|---|---|
| Base Cost | **20028.920** |
| Local Cost | 14350.480 |
| Foreign Cost | 5678.440 |
| Labour Component | **5453.182** |
| - Skilled | 2181.273 |
| - Unskilled | 3271.909 |
| Material Component | **8897.298** |
| Labour Component | **4635.205** |
| - Skilled | 2181.273 |
| - Unskilled | 2453.932 |
| Material Component | 8096.541 |
| Local cost | 12731.746 |
| Foreign Cost | 5678.440 |
| **TOTAL** | **18410.186** |

## 17.26 DERIVATION OF THERMAL EQUIVALENCE

The Feasibility has been assessed on the assumption that in the absence of hydel generation, an equivalent thermal generation plant would be required to produce equivalent amount of energy per annum. A comparative study has, therefore, been made and costs calculated on the basis of providing an equivalent quantum of generation from the steam plant using furnace oil described as economic benefits



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## Table 17-8 Economic Analysis with CDM benefits

MILL.RS

| YEAR | COSTS | | | THERMAL EQUIVALENT | | | | CDM BENEFITS | TOTAL BENEFITS | NET BENEFITS |
|---|---|---|---|---|---|---|---|---|---|---|
| | CAPITAL | O & M | TOTAL | CAPITAL | O & M | FUEL | TOTAL | | | |
| 1 | 5806.57 | | 5806.57 | 0.00 | | | 0.00 | 0.00 | 0.00 | -5806.57 |
| 2 | 4771.92 | | 4771.92 | 4185.62 | | | 4185.62 | 0.00 | 4185.62 | -586.30 |
| 3 | 7831.69 | | 7831.69 | 4285.62 | | | 4285.62 | 0.00 | 4285.62 | -3546.07 |
| 4 | | 180.26 | 180.26 | | 251.14 | 2831.82 | 3082.96 | 29.92 | 3112.88 | 2932.62 |
| 5 | | 180.26 | 180.26 | | 251.14 | 2831.82 | 3082.96 | 29.92 | 3112.88 | 2932.62 |
| 6 | | 180.26 | 180.26 | | 251.14 | 2831.82 | 3082.96 | 29.92 | 3112.88 | 2932.62 |
| 7 | | 180.26 | 180.26 | | 251.14 | 2831.82 | 3082.96 | 29.92 | 3112.88 | 2932.62 |
| 8 | | 180.26 | 180.26 | | 251.14 | 2831.82 | 3082.96 | 29.92 | 3112.88 | 2932.62 |
| 9 | | 180.26 | 180.26 | | 251.14 | 2831.82 | 3082.96 | 29.92 | 3112.88 | 2932.62 |
| 10 | | 180.26 | 180.26 | | 251.14 | 2831.82 | 3082.96 | 29.92 | 3112.88 | 2932.62 |
| 11 | | 180.26 | 180.26 | | 251.14 | 2831.82 | 3082.96 | 29.92 | 3112.88 | 2932.62 |
| 12 | | 180.26 | 180.26 | | 251.14 | 2831.82 | 3082.96 | 29.92 | 3112.88 | 2932.62 |
| 13 | | 180.26 | 180.26 | | 251.14 | 2831.82 | 3082.96 | 29.92 | 3112.88 | 2932.62 |
| 14 | | 180.26 | 180.26 | | 251.14 | 2831.82 | 3082.96 | 29.92 | 3112.88 | 2932.62 |
| 15 | | 180.26 | 180.26 | | 251.14 | 2831.82 | 3082.96 | 29.92 | 3112.88 | 2932.62 |
| 16 | | 180.26 | 180.26 | | 251.14 | 2831.82 | 3082.96 | 29.92 | 3112.88 | 2932.62 |
| 17 | | 180.26 | 180.26 | | 251.14 | 2831.82 | 3082.96 | 29.92 | 3112.88 | 2932.62 |
| 18 | | 180.26 | 180.26 | | 251.14 | 2831.82 | 3082.96 | 29.92 | 3112.88 | 2932.62 |
| 19 | | 180.26 | 180.26 | | 251.14 | 2831.82 | 3082.96 | 29.92 | 3112.88 | 2932.62 |
| 20 | | 180.26 | 180.26 | | 251.14 | 2831.82 | 3082.96 | 29.92 | 3112.88 | 2932.62 |
| 21 | | 180.26 | 180.26 | | 251.14 | 2831.82 | 3082.96 | 29.92 | 3112.88 | 2932.62 |
| 22 | | 180.26 | 180.26 | | 251.14 | 2831.82 | 3082.96 | 29.92 | 3112.88 | 2932.62 |
| 23 | | 180.26 | 180.26 | | 251.14 | 2831.82 | 3082.96 | 29.92 | 3112.88 | 2932.62 |
| 24 | | 180.26 | 180.26 | | 251.14 | 2831.82 | 3082.96 | 29.92 | 3112.88 | 2932.62 |
| 25 | | 180.26 | 180.26 | | 251.14 | 2831.82 | 3082.96 | 29.92 | 3112.88 | 2932.62 |
| 26 | | 180.26 | 180.26 | | 251.14 | 2831.82 | 3082.96 | 29.92 | 3112.88 | 2932.62 |
| 27 | | 180.26 | 180.26 | | 251.14 | 2831.82 | 3082.96 | 29.92 | 3112.88 | 2932.62 |
| 28 | | 180.26 | 180.26 | | 251.14 | 2831.82 | 3082.96 | 29.92 | 3112.88 | 2932.62 |
| 29 | | 180.26 | 180.26 | | 251.14 | 2831.82 | 3082.96 | 29.92 | 3112.88 | 2932.62 |
| 30 | | 180.26 | 180.26 | | 251.14 | 2831.82 | 3082.96 | 29.92 | 3112.88 | 2932.62 |
| 31 | | 180.26 | 180.26 | | 251.14 | 2831.82 | 3082.96 | 29.92 | 3112.88 | 2932.62 |
| 32 | | 180.26 | 180.26 | | 251.14 | 2831.82 | 3082.96 | 29.92 | 3112.88 | 2932.62 |
| 33 | - | 180.26 | - | | 251.14 | 2831.82 | 3082.96 | 29.92 | 3112.88 | 4689.10 |
| **TOTAL** | **18410.19** | **5407.81** | **22061.51** | **8471.24** | **7534.11** | **84954.69** | **100960.04** | **897.64** | **101857.68** | **79796.17** |

| | | |
|---|---|---|
| **PW OF BENEFITS @ 12%; MILL.Rs** | **=** | **24234.94** |
| **PW OF COSTS @ 12%; MILL.Rs** | **=** | **15554.83** |
| **NET PRESENT WORTH; MILL.Rs** | **=** | **8680.11** |
| **BENEFIT COST RATIO** | **=** | **1.56** |
| **I.E.R.R** | **=** | **22.54%** |



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## Table 17-9 Economic Analysis Without CDM Benefits

MILL RS.

| YEAR | COSTS | | | THERMAL EQUIVALENT | | | | NET BENEFITS |
|---|---|---|---|---|---|---|---|---|
| | CAPITAL | O & M | TOTAL | CAPITAL | O & M | FUEL | TOTAL | |
| 1 | 5806.573 | | 5806.573 | 0.00 | | | 0.00 | -5806.573 |
| 2 | 4771.920 | | 4771.920 | 4185.62 | | | 4185.62 | -586.300 |
| 3 | 7831.693 | | 7831.693 | 4285.62 | | | 4285.62 | -3546.073 |
| 4 | | 180.260 | 180.260 | | 251.14 | 2831.82 | 3082.96 | 2902.700 |
| 5 | | 180.260 | 180.260 | | 251.14 | 2831.82 | 3082.96 | 2902.700 |
| 6 | | 180.260 | 180.260 | | 251.14 | 2831.82 | 3082.96 | 2902.700 |
| 7 | | 180.260 | 180.260 | | 251.14 | 2831.82 | 3082.96 | 2902.700 |
| 8 | | 180.260 | 180.260 | | 251.14 | 2831.82 | 3082.96 | 2902.700 |
| 9 | | 180.260 | 180.260 | | 251.14 | 2831.82 | 3082.96 | 2902.700 |
| 10 | | 180.260 | 180.260 | | 251.14 | 2831.82 | 3082.96 | 2902.700 |
| 11 | | 180.260 | 180.260 | | 251.14 | 2831.82 | 3082.96 | 2902.700 |
| 12 | | 180.260 | 180.260 | | 251.14 | 2831.82 | 3082.96 | 2902.700 |
| 13 | | 180.260 | 180.260 | | 251.14 | 2831.82 | 3082.96 | 2902.700 |
| 14 | | 180.260 | 180.260 | | 251.14 | 2831.82 | 3082.96 | 2902.700 |
| 15 | | 180.260 | 180.260 | | 251.14 | 2831.82 | 3082.96 | 2902.700 |
| 16 | | 180.260 | 180.260 | | 251.14 | 2831.82 | 3082.96 | 2902.700 |
| 17 | | 180.260 | 180.260 | | 251.14 | 2831.82 | 3082.96 | 2902.700 |
| 18 | | 180.260 | 180.260 | | 251.14 | 2831.82 | 3082.96 | 2902.700 |
| 19 | | 180.260 | 180.260 | | 251.14 | 2831.82 | 3082.96 | 2902.700 |
| 20 | | 180.260 | 180.260 | | 251.14 | 2831.82 | 3082.96 | 2902.700 |
| 21 | | 180.260 | 180.260 | | 251.14 | 2831.82 | 3082.96 | 2902.700 |
| 22 | | 180.260 | 180.260 | | 251.14 | 2831.82 | 3082.96 | 2902.700 |
| 23 | | 180.260 | 180.260 | | 251.14 | 2831.82 | 3082.96 | 2902.700 |
| 24 | | 180.260 | 180.260 | | 251.14 | 2831.82 | 3082.96 | 2902.700 |
| 25 | | 180.260 | 180.260 | | 251.14 | 2831.82 | 3082.96 | 2902.700 |
| 26 | | 180.260 | 180.260 | | 251.14 | 2831.82 | 3082.96 | 2902.700 |
| 27 | | 180.260 | 180.260 | | 251.14 | 2831.82 | 3082.96 | 2902.700 |
| 28 | | 180.260 | 180.260 | | 251.14 | 2831.82 | 3082.96 | 2902.700 |
| 29 | | 180.260 | 180.260 | | 251.14 | 2831.82 | 3082.96 | 2902.700 |
| 30 | | 180.260 | 180.260 | | 251.14 | 2831.82 | 3082.96 | 2902.700 |
| 31 | | 180.260 | 180.260 | | 251.14 | 2831.82 | 3082.96 | 2902.700 |
| 32 | | 180.260 | 180.260 | | 251.14 | 2831.82 | 3082.96 | 2902.700 |
| 33 | -1756.484 | 180.260 | -1576.224 | | 251.14 | 2831.82 | 3082.96 | 4659.184 |
| **TOTAL** | **18410.186** | **5407.808** | **22061.510** | **8471.24** | **7534.11** | **84954.69** | **100960.04** | **78898.530** |

| | | |
|---|---|---|
| **PW OF BENEFITS @ 12%; MILL.Rs** | **=** | **24063.39** |
| **PW OF COSTS @ 12%; MILL.Rs** | **=** | **15554.83** |
| **NET PRESENT WORTH; MILL.Rs** | **=** | **8508.56** |
| **BENEFIT COST RATIO** | **=** | **1.55** |
| **I.E.R.R** | **=** | **22.36%** |



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## 17.27 EMPLOYMENT ANALYSIS

The project will help in providing employment to the inhabitants of the local area and play an important role in the country's economy. The project will also help in improving/enhance the socio-economic settings of the area.

## 17.28 SENSITIVITY ANALYSIS

Although the project has shown financial viability with higher rates of return than the weighted cost of capital even then the project is susceptible to different kind of adverse circumstances like cost over-run, delay in construction and decrease in benefits. The financially viability of the project has, therefore, been assessed against 10% decrease in benefits, 20% cost overrun, as well as combined impact of both the variations to see if the project remains financially viable.

Tables-17-10 to 17-11 give risk/sensitivity analysis on the following assumptions:

I. 10% reduction in sale price.

II. 20% cost over-run.

III. Combined effect of above



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## Table 17-10 Risk / Sensitivity Analysis With CDM Benefits

MILL.Rs

| YEAR | TOTAL COST | BENEFITS | 10% LESS RED.IN S.P | NET BENEFITS | 20% COST OVER-RUN | NET BENEFITS | COMBINED IMPACT |
|---|---|---|---|---|---|---|---|
| 1 | 5806.573 | 0.000 | 0.000 | -5806.573 | 6967.887 | -6967.887 | -6967.887 |
| 2 | 4771.920 | 4185.620 | 3767.058 | -1004.862 | 5726.304 | -1540.684 | -1959.246 |
| 3 | 7831.693 | 4285.620 | 3857.058 | -3974.635 | 9398.032 | -5112.412 | -5540.974 |
| 4 | 180.260 | 3112.881 | 2801.593 | 2621.333 | 216.312 | 2896.569 | 2585.281 |
| 5 | 180.260 | 3112.881 | 2801.593 | 2621.333 | 216.312 | 2896.569 | 2585.281 |
| 6 | 180.260 | 3112.881 | 2801.593 | 2621.333 | 216.312 | 2896.569 | 2585.281 |
| 7 | 180.260 | 3112.881 | 2801.593 | 2621.333 | 216.312 | 2896.569 | 2585.281 |
| 8 | 180.260 | 3112.881 | 2801.593 | 2621.333 | 216.312 | 2896.569 | 2585.281 |
| 9 | 180.260 | 3112.881 | 2801.593 | 2621.333 | 216.312 | 2896.569 | 2585.281 |
| 10 | 180.260 | 3112.881 | 2801.593 | 2621.333 | 216.312 | 2896.569 | 2585.281 |
| 11 | 180.260 | 3112.881 | 2801.593 | 2621.333 | 216.312 | 2896.569 | 2585.281 |
| 12 | 180.260 | 3112.881 | 2801.593 | 2621.333 | 216.312 | 2896.569 | 2585.281 |
| 13 | 180.260 | 3112.881 | 2801.593 | 2621.333 | 216.312 | 2896.569 | 2585.281 |
| 14 | 180.260 | 3112.881 | 2801.593 | 2621.333 | 216.312 | 2896.569 | 2585.281 |
| 15 | 180.260 | 3112.881 | 2801.593 | 2621.333 | 216.312 | 2896.569 | 2585.281 |
| 16 | 180.260 | 3112.881 | 2801.593 | 2621.333 | 216.312 | 2896.569 | 2585.281 |
| 17 | 180.260 | 3112.881 | 2801.593 | 2621.333 | 216.312 | 2896.569 | 2585.281 |
| 18 | 180.260 | 3112.881 | 2801.593 | 2621.333 | 216.312 | 2896.569 | 2585.281 |
| 19 | 180.260 | 3112.881 | 2801.593 | 2621.333 | 216.312 | 2896.569 | 2585.281 |
| 20 | 180.260 | 3112.881 | 2801.593 | 2621.333 | 216.312 | 2896.569 | 2585.281 |
| 21 | 180.260 | 3112.881 | 2801.593 | 2621.333 | 216.312 | 2896.569 | 2585.281 |
| 22 | 180.260 | 3112.881 | 2801.593 | 2621.333 | 216.312 | 2896.569 | 2585.281 |
| 23 | 180.260 | 3112.881 | 2801.593 | 2621.333 | 216.312 | 2896.569 | 2585.281 |
| 24 | 180.260 | 3112.881 | 2801.593 | 2621.333 | 216.312 | 2896.569 | 2585.281 |
| 25 | 180.260 | 3112.881 | 2801.593 | 2621.333 | 216.312 | 2896.569 | 2585.281 |
| 26 | 180.260 | 3112.881 | 2801.593 | 2621.333 | 216.312 | 2896.569 | 2585.281 |
| 27 | 180.260 | 3112.881 | 2801.593 | 2621.333 | 216.312 | 2896.569 | 2585.281 |
| 28 | 180.260 | 3112.881 | 2801.593 | 2621.333 | 216.312 | 2896.569 | 2585.281 |
| 29 | 180.260 | 3112.881 | 2801.593 | 2621.333 | 216.312 | 2896.569 | 2585.281 |
| 30 | 180.260 | 3112.881 | 2801.593 | 2621.333 | 216.312 | 2896.569 | 2585.281 |
| 31 | 180.260 | 3112.881 | 2801.593 | 2621.333 | 216.312 | 2896.569 | 2585.281 |
| 32 | 180.260 | 3112.881 | 2801.593 | 2621.333 | 216.312 | 2896.569 | 2585.281 |
| 33 | -1576.224 | 3112.881 | 2801.593 | 4377.817 | -1891.468 | 5004.350 | 4693.062 |
| **TOTAL** | **22061.510** | **101857.681** | **91671.913** | **69610.402** | **26473.812** | **75383.868** | **65198.100** |



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| | | | | |
|---|---|---|---|---|
| **INTERNAL RATE OF RETURN =** | **22.54%** | **19.40%** | **17.40%** | **15.00%** |

## Table 17-11 Risk / Sensitivity Analysis With CDM Benefits

**MILL.Rs**

| YEAR | TOTAL COST | BENEFITS | 10% LESS RED.IN S.P | NET BENEFITS | 20% COST OVER-RUN | NET BENEFITS | COMBINED IMPACT |
|---|---|---|---|---|---|---|---|
| 1 | 5806.573 | 0.000 | 0.000 | -5806.573 | 6967.887 | -6967.887 | -6967.887 |
| 2 | 4771.920 | 4185.620 | 3767.058 | -1004.862 | 5726.304 | -1540.684 | -1959.246 |
| 3 | 7831.693 | 4285.620 | 3857.058 | -3974.635 | 9398.032 | -5112.412 | -5540.974 |
| 4 | 180.260 | 3082.960 | 2774.664 | 2594.404 | 216.312 | 2866.648 | 2558.352 |
| 5 | 180.260 | 3082.960 | 2774.664 | 2594.404 | 216.312 | 2866.648 | 2558.352 |
| 6 | 180.260 | 3082.960 | 2774.664 | 2594.404 | 216.312 | 2866.648 | 2558.352 |
| 7 | 180.260 | 3082.960 | 2774.664 | 2594.404 | 216.312 | 2866.648 | 2558.352 |
| 8 | 180.260 | 3082.960 | 2774.664 | 2594.404 | 216.312 | 2866.648 | 2558.352 |
| 9 | 180.260 | 3082.960 | 2774.664 | 2594.404 | 216.312 | 2866.648 | 2558.352 |
| 10 | 180.260 | 3082.960 | 2774.664 | 2594.404 | 216.312 | 2866.648 | 2558.352 |
| 11 | 180.260 | 3082.960 | 2774.664 | 2594.404 | 216.312 | 2866.648 | 2558.352 |
| 12 | 180.260 | 3082.960 | 2774.664 | 2594.404 | 216.312 | 2866.648 | 2558.352 |
| 13 | 180.260 | 3082.960 | 2774.664 | 2594.404 | 216.312 | 2866.648 | 2558.352 |
| 14 | 180.260 | 3082.960 | 2774.664 | 2594.404 | 216.312 | 2866.648 | 2558.352 |
| 15 | 180.260 | 3082.960 | 2774.664 | 2594.404 | 216.312 | 2866.648 | 2558.352 |
| 16 | 180.260 | 3082.960 | 2774.664 | 2594.404 | 216.312 | 2866.648 | 2558.352 |
| 17 | 180.260 | 3082.960 | 2774.664 | 2594.404 | 216.312 | 2866.648 | 2558.352 |
| 18 | 180.260 | 3082.960 | 2774.664 | 2594.404 | 216.312 | 2866.648 | 2558.352 |
| 19 | 180.260 | 3082.960 | 2774.664 | 2594.404 | 216.312 | 2866.648 | 2558.352 |
| 20 | 180.260 | 3082.960 | 2774.664 | 2594.404 | 216.312 | 2866.648 | 2558.352 |
| 21 | 180.260 | 3082.960 | 2774.664 | 2594.404 | 216.312 | 2866.648 | 2558.352 |
| 22 | 180.260 | 3082.960 | 2774.664 | 2594.404 | 216.312 | 2866.648 | 2558.352 |
| 23 | 180.260 | 3082.960 | 2774.664 | 2594.404 | 216.312 | 2866.648 | 2558.352 |
| 24 | 180.260 | 3082.960 | 2774.664 | 2594.404 | 216.312 | 2866.648 | 2558.352 |
| 25 | 180.260 | 3082.960 | 2774.664 | 2594.404 | 216.312 | 2866.648 | 2558.352 |
| 26 | 180.260 | 3082.960 | 2774.664 | 2594.404 | 216.312 | 2866.648 | 2558.352 |
| 27 | 180.260 | 3082.960 | 2774.664 | 2594.404 | 216.312 | 2866.648 | 2558.352 |
| 28 | 180.260 | 3082.960 | 2774.664 | 2594.404 | 216.312 | 2866.648 | 2558.352 |
| 29 | 180.260 | 3082.960 | 2774.664 | 2594.404 | 216.312 | 2866.648 | 2558.352 |
| 30 | 180.260 | 3082.960 | 2774.664 | 2594.404 | 216.312 | 2866.648 | 2558.352 |
| 31 | 180.260 | 3082.960 | 2774.664 | 2594.404 | 216.312 | 2866.648 | 2558.352 |
| 32 | 180.260 | 3082.960 | 2774.664 | 2594.404 | 216.312 | 2866.648 | 2558.352 |
| 33 | -1576.224 | 3082.960 | 2774.664 | 4350.888 | -1891.468 | 4974.428 | 4666.132 |
| **TOTAL** | **22061.510** | **100960.040** | **90864.036** | **68802.526** | **26473.812** | **74486.228** | **64390.224** |
| **INTERNAL RATE OF RETURN =** | | | **22.36%** | **19.24%** | **17.25%** | | **14.86%** |



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## 17.29 CONCLUSION

The Project is economically, financially and socially viable in addition to its technology viability hence recommended for implementation.

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# 18 CONCLUSIONS AND RECOMMENDATION

Attabad Lake Hydropower Project (ALHPP) is a Run off River peaking scheme on Hunza River in Hunza Region at Attabad Lake. Attabad Lake is located about 120 km from Gilgit on the Hunza River along Karakorum Highway and 735 km from Federal Capital Islamabad. The Project is planned to develop the reach of river 2.5 km downstream of Attabad Lake with an installed capacity of 54 MW to generate mean annual electricity of 374 GWh.

The Feasibility Study of ALHPP has been carried out with due consideration of intensive field investigations (topographic and hydrographic survey, subsoil investigations and geological mapping), Socio-Economic and Environmental Survey.

With landslide on Hunza River on January 4, 2010, Attabad Lake was created. The natural head available from Lake to 2.5 km downstream and perennial flows of Hunza River attract to develop the indigenous hydroelectric resource. The slided mass have been investigated to propose the overflow weir/sediment flushing channel for flood evacuation, sediment flushing and desing discharge through headrace tunnel.

Detailed topographic survey and geological mapping have been carried for all major structures like overflow weir/ungated spillway, sediment flushing channel, intake, low pressure tunnel, and power house area. For reservoir area, hydrographic survey have been carried out six (6) borehole have been drilled at important sturctures location with total drilling depth of 400m.

For social and environmental aspects, detail survey has been conducted in the field and maps with DEM have been prepared to cover the Project Area details.

Power and energy potential at the site have been estimated on average 10-daily basis using time series data from 1966 to 2015. Keeping in view historic data, optimized design discharge of 60 $m^3/s$ has been selected that could be made available during peak hours throughout the year . The available head across the hydropower facility has been estimated as 106 m with the consideration of upstream and downstream water level variation. The estimated mean annual energy is 374 Gwh and plant factor is 79.0%.

Overflow weir/ ungated spillway, sediment flushing channel/under sluices, intake, low pressure tunnel, surge tank and powerhouse, main dam and dykes / embankments have been designed based on field investigations to accommodate the flood and reservoir variation from 2014 m a.s.l to 2021 m a.s.l.

The cost estimate for the Project has been prepared using bill of quantities (BOQ) and costs for Infrastructure development, Preliminaries and Environmental Mitigation, Civil, Hydro-mechanical, Electrical, etc. Major Civil Works items such as rock excavation quantities, slope stability by benching concrete and grouting works, etc. have been estimated as Rs.21.246 million (US$ 135.32 million).

The Project is found economically and financially feasible. The calculated economic internal rate of return (EIRR) is above 22.36% (the assumed opportunity cost of capital in Pakistan) and the financial internal rate of return (FIRR) comes out to be 19.17%.



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ALHPP is found to be technically feasible, economically viable and environmentally acceptable and will fulfill electricity needs particularly for Hunza City and in general for Hunza, Gilgit and Ghizar Regions. Therefore recommended for implementation at earliest.

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# ATTABAD LAKE HYDROPOWER PROJECT

## LIST OF DRAWINGS

| CATEGORY | SERIAL No. | DRAWING TITLE | DRAWING No. |
|---|---|---|---|
| **GENERAL** | **1.** | Project Location Map | AFS-GN-101 |
| | **2.** | Project Area Accessibility Map from Islamabad | AFS-GN-102 |
| | **3.** | Regional Map of Northern Area | AFS-GN-103 |
| | **4.** | Catchment Area Map | AFS-GN-104 |
| **TOPOGRAPHIC SURVEY** | **5.** | Project Area Topographic Survey Maps | AFS-TS-201 |
| | **6.** | Project Area Topographic Survey Maps (Sheet 01 of 20) | AFS-TS-202 |
| | **7.** | Project Area Topographic Survey Maps (Sheet 02 of 20) | AFS-TS-203 |
| | **8.** | Project Area Topographic Survey Maps (Sheet 03 of 20) | AFS-TS-204 |
| | **9.** | Project Area Topographic Survey Maps (Sheet 04 of 20) | AFS-TS-205 |
| | **10.** | Project Area Topographic Survey Maps (Sheet 05 of 20) | AFS-TS-206 |
| | **11.** | Project Area Topographic Survey Maps (Sheet 06 of 20) | AFS-TS-207 |
| | **12.** | Project Area Topographic Survey Maps (Sheet 07 of 20) | AFS-TS-208 |
| | **13.** | Project Area Topographic Survey Maps (Sheet 08 of 20) | AFS-TS-209 |
| | **14.** | Project Area Topographic Survey Maps (Sheet 09 of 20) | AFS-TS-210 |
| | **15.** | Project Area Topographic Survey Maps (Sheet 10 of 20) | AFS-TS-211 |
| | **16.** | Project Area Topographic Survey Maps (Sheet 11 of 20) | AFS-TS-212 |
| | **17.** | Project Area Topographic Survey Maps (Sheet 12 of 20) | AFS-TS-213 |
| | **18.** | Project Area Topographic Survey Maps (Sheet 13 of 20) | AFS-TS-214 |
| | **19.** | Project Area Topographic Survey Maps (Sheet 14 of 20) | AFS-TS-215 |
| | **20.** | Project Area Topographic Survey Maps (Sheet 15 of 20) | AFS-TS-216 |
| | **21.** | Project Area Topographic Survey Maps (Sheet 16 of 20) | AFS-TS-217 |
| | **22.** | Project Area Topographic Survey Maps (Sheet 17 of 20) | AFS-TS-218 |
| | **23.** | Project Area Topographic Survey Maps (Sheet 18 of 20) | AFS-TS-219 |
| | **24.** | Project Area Topographic Survey Maps (Sheet 19 of 20) | AFS-TS-220 |
| | **25.** | Project Area Topographic Survey Maps (Sheet 20 of 20) | AFS-TS-221 |
| **CROSS SECTIONS** | **26.** | Project Area Cross Section Plan | AFS-CS-231 |
| | **27.** | Project Area Cross Section at RD=000 & 0+200 (Sheet 1 of 10) | AFS-CS-232 |
| | **28.** | Project Area Cross Section at RD=0+400 & 0+600 (Sheet 2 of 10) | AFS-CS-233 |
| | **29.** | Project Area Cross Section at RD=0+800 & 1+000 (Sheet 3 of 10) | AFS-CS-234 |
| | **30.** | Project Area Cross Section at RD=1+200 & 1+400 (Sheet 4 of 10) | AFS-CS-235 |
| | **31.** | Project Area Cross Section at RD=1+600 & 1+800 (Sheet 5 of 10) | AFS-CS-236 |
| | **32.** | Project Area Cross Section at RD=2+000, 2+200 & 2+400 (Sheet 6 of 10) | AFS-CS-237 |

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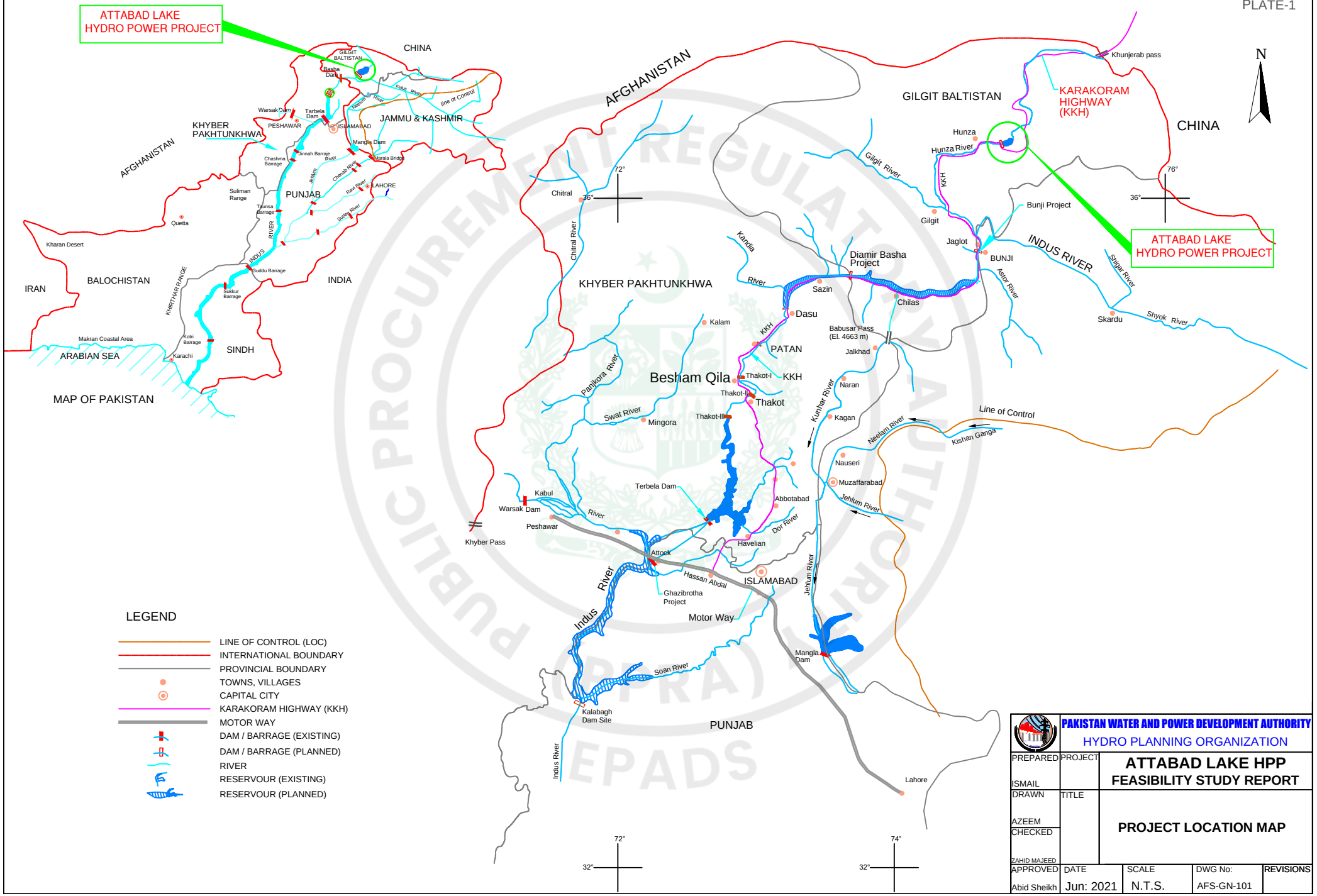
| CATEGORY | SERIAL No. | DRAWING TITLE | DRAWING No. |
|---|---|---|---|
| | **33.** | Project Area Cross Section at RD=2+600 & 2+800 (Sheet 7 of 10) | AFS-CS-238 |
| | **34.** | Project Area Cross Section at RD=3+000 & 3+200 (Sheet 8 of 10) | AFS-CS-239 |
| | **35.** | Project Area Cross Section at RD=3+400 & 3+600 (Sheet 9 of 10) | AFS-CS-240 |
| | **36.** | Project Area Cross Section at RD=3+800 & 4+000 (Sheet 10 of 10) | AFS-CS-241 |
| **PLAN AND PROFILE** | **37.** | Water Surface - Plan And Profile (Sheet 01 of 11) | AFS-SP-251 |
| | **38.** | Water Surface - Plan And Profile (Sheet 02 of 11) | AFS-SP-252 |
| | **39.** | Water Surface - Plan And Profile (Sheet 03 of 11) | AFS-SP-253 |
| | **40.** | Water Surface - Plan And Profile (Sheet 04 of 11) | AFS-SP-254 |
| | **41.** | Water Surface - Plan And Profile (Sheet 05 of 11) | AFS-SP-255 |
| | **42.** | Water Surface - Plan And Profile (Sheet 06 of 11) | AFS-SP-256 |
| | **43.** | Water Surface - Plan And Profile (Sheet 07 of 11) | AFS-SP-257 |
| | **44.** | Water Surface - Plan And Profile (Sheet 08 of 11) | AFS-SP-258 |
| | **45.** | Water Surface - Plan And Profile (Sheet 09 of 11) | AFS-SP-259 |
| | **46.** | Water Surface - Plan And Profile (Sheet 10 of 11) | AFS-SP-260 |
| | **47.** | Water Surface - Plan And Profile (Sheet 11 of 11) | AFS-SP-261 |
| **HYDROGRAPHIC SURVEY** | **48.** | Hydrographic Survey of Attabad Lake X- Section No(1 to 4) | AFS-HS-271 |
| | **49.** | Hydrographic Survey of Attabad Lake X- Section No(5 to 8) | AFS-HS-272 |
| | **50.** | Hydrographic Survey of Attabad Lake X- Section No(9 to 12) | AFS-HS-273 |
| | **51.** | Hydrographic Survey of Attabad Lake X- Section No(13 to 16) | AFS-HS-274 |
| | **52.** | Hydrographic Survey of Attabad Lake X- Section No(17 to 20) | AFS-HS-275 |
| | **53.** | Hydrographic Survey of Attabad Lake X- Section No(21 to 24) | AFS-HS-276 |
| | **54.** | Hydrographic Survey of Attabad Lake X- Section No(25 to 27) | AFS-HS-277 |
| | **55.** | Hydrographic Survey of Attabad Lake X- Section No(28 to 30) | AFS-HS-278 |
| | **56.** | Hydrographic Survey of Attabad Lake X- Section No(31 to 34) | AFS-HS-279 |
| | **57.** | Hydrographic Survey of Attabad Lake X- Section No(35 to 38) | AFS-HS-280 |
| | **58.** | Hydrographic Survey of Attabad Lake X- Section No(39 to 40) | AFS-HS-281 |
| **GEOLOGY** | **59.** | Regional Geological Map | AFS-GE-291 |
| | **60.** | Regional Tectonics Map | AFS-GE-292 |
| | **61.** | Surface Geological Map ( Sheet 01 of 20) | AFS-GE-293 |
| | **62.** | Surface Geological Map ( Sheet 02 of 20) | AFS-GE-294 |
| | **63.** | Surface Geological Map ( Sheet 03 of 20) | AFS-GE-295 |
| | **64.** | Surface Geological Map ( Sheet 04 of 20) | AFS-GE-296 |
| | **65.** | Surface Geological Map ( Sheet 05 of 20) | AFS-GE-297 |
| | **66.** | Surface Geological Map ( Sheet 06 of 20) | AFS-GE-298 |
| | **67.** | Surface Geological Map ( Sheet 07 of 20) | AFS-GE-299 |
| | **68.** | Surface Geological Map ( Sheet 08 of 20) | AFS-GE-300 |
| | **69.** | Surface Geological Map ( Sheet 09 of 20) | AFS-GE-301 |

| CATEGORY | SERIAL No. | DRAWING TITLE | DRAWING No. |
|---|---|---|---|
| | **70.** | Surface Geological Map ( Sheet 10 of 20) | AFS-GE-302 |
| | **71.** | Surface Geological Map ( Sheet 11 of 20) | AFS-GE-303 |
| | **72.** | Surface Geological Map ( Sheet 12 of 20) | AFS-GE-304 |
| | **73.** | Surface Geological Map ( Sheet 13 of 20) | AFS-GE-305 |
| | **74.** | Surface Geological Map ( Sheet 14 of 20) | AFS-GE-306 |
| | **75.** | Surface Geological Map ( Sheet 15 of 20) | AFS-GE-307 |
| | **76.** | Surface Geological Map ( Sheet 16 of 20) | AFS-GE-308 |
| | **77.** | Surface Geological Map ( Sheet 17 of 20) | AFS-GE-309 |
| | **78.** | Surface Geological Map ( Sheet 18 of 20) | AFS-GE-310 |
| | **79.** | Surface Geological Map ( Sheet 19 of 20) | AFS-GE-311 |
| | **80.** | Surface Geological Map ( Sheet 20 of 20) | AFS-GE-312 |
| | **81.** | Geological X Section AA', Weir Site | AFS-GE-313 |
| | **82.** | Geological X Section BB', Intake Area | AFS-GE-314 |
| | **83.** | Geological X Section DD', Penstock & P/H Area | AFS-GE-315 |
| | **84.** | Borehole Location Map | AFS-GE-316 |
| | **85.** | Location of Test Pits | AFS-GE-317 |
| | **86.** | Neotectonic Study Area | AFS-GE-318 |
| | **87.** | Neotectonic Study Area | AFS-GE-319 |
| | **88.** | Neotectonic Study Area | AFS-GE-320 |
| | **89.** | Project Location Area | AFS-GN-401 |
| | **90.** | Project Vicinity Map | AFS-GN-402 |
| | **91.** | Project Layout on G.T Sheet | AFS-LAY-403 |
| **PROJECT LAYOUT** | **92.** | Project Layout | AFS-LAY-404 |
| **WEIR** | **93.** | Weir and Power Intake Arrangements | AFS-LAY-405 |
| | **94.** | Surge To Powerhouse Arrangements | AFS-LAY-406 |
| | **95.** | Project Longitudinal Section | AFS-LAY-407 |
| | **96.** | Weir Arrangement | AFS-WR-408 |
| | **97.** | Plan For Weir | AFS-WR-409 |
| | **98.** | Weir Longitudinal Sections | AFS-WR-410 |
| | **99.** | Weir Cross sections | AFS-WR-411 |
| | **100.** | Weir Diversion Scheme (Stage I) | AFS-WR-412 |
| | **101.** | Weir Diversion Scheme (Stage II) | AFS- WR-413 |
| | **102.** | Cross Section At RD 0+0 From Downstream of Weir Site | AFS-WR-414 |
| | **103.** | Cross Section At RD 0+50 From Downstream of Weir Site | AFS-WR-415 |
| | **104.** | Cross Section At RD 0+100 From Downstream of Weir Site | AFS-WR-416 |
| | **105.** | Cross Section At RD 0+150 From Downstream of Weir Site | AFS-WR-417 |
| | **106.** | Cross Section At RD 0+200 From Downstream of Weir Site | AFS-WR-418 |
| | **107.** | Cross Section At RD 0+250 From Downstream of Weir Site | AFS-WR-419 |
| | **108.** | Cross Section At RD 0+300 From Downstream of Weir Site | AFS-WR-420 |
| | **109.** | Cross Section At RD 0+350 From Downstream of Weir Site | AFS-WR-421 |
| | **110.** | Cross Section At RD 0+400 From Downstream of Weir Site | AFS-WR-422 |

| CATEGORY | SERIAL No. | DRAWING TITLE | DRAWING No. |
|---|---|---|---|
| | **111.** | Cross Section At RD 0+450 From Downstream of Weir Site | AFS-WR-423 |
| **POWER INTAKE** | **112.** | Plan For Power Intake | AFS-PI-424 |
| | **113.** | Longitudinal Section For Power Intake | AFS-PI-425 |
| | **114.** | Power Intake Sections | AFS-PI-426 |
| **SURGE TANK** | **115.** | Surge Tank Layout | AFS-ST-427 |
| | **116.** | Surge Tank Plan And Sections | AFS-ST-428 |
| | **117.** | Surge Tank Sections | AFS-ST-429 |
| | **118.** | Penstock Plan And Longitudinal Profile | AFS-ST-430 |
| **POWER HOUSE** | **119.** | Power House Layout | AFS-PH-431 |
| | **120.** | Plan For Power House | AFS-PH-432 |
| | **121.** | Generator Floor Plan | AFS-PH-433 |
| | **122.** | Machine Hall Plan | AFS-PH-434 |
| | **123.** | Cross Section for Power House | AFS-PH-435 |
| | **124.** | Longitudinal Section for Power House | AFS-PH-436 |
| **REINFORCEMENT DETAILS** | **125.** | Typical Detail for Concrete Joints | AFS-MIS-437 |
| | **126.** | Miscellaneous Reinforcement Details (Sheet 01 of 2) | AFS-MIS-438 |
| | **127.** | Miscellaneous Reinforcement Details (Sheet 02 of 2) | AFS-MIS-439 |
| **PENSTOCK** | **128.** | Penstock Details of Horizontal Anchor Blocks | AFS-MIS-440 |
| | **129.** | Penstock Details of Vertical Anchor Blocks | AFS-MIS-441 |
| **ELECTRO-MECHANICAL** | **130.** | Main Single Line Diagram | AFS-EM-451 |
| | **131.** | AC Supply System | AFS-EM-452 |
| | **132.** | AC LV Supply System | AFS-EM-453 |
| | **133.** | DC Supply System | AFS-EM-454 |
| | **134.** | Plant Control System | AFS-EM-455 |
| | **135.** | Protection Schemes | AFS-EM-456 |
| | **136.** | 132KV- Transmission Line Type-ZM1 | AFS-EM-457 |
| | **137.** | 132KV- Transmission Line Type-ZM30 | AFS-EM-458 |
| | **138.** | 132KV- Transmission Line Type-ZM60 | AFS-EM-459 |
| | **139.** | Typical Tower Foundation | AFS-EM-460 |
| **OFFICES AND RESIDENTIAL COMPLEX** | **140.** | Offices and Residential Complex Master Plan | AFS-ORC-471 |
| | **141.** | Office Building Plan | AFS-ORC-472 |
| | **142.** | Officers Hostel Ground Floor Plan | AFS-ORC-473 |
| | **143.** | Officers Hostel First Floor Plan | AFS-ORC-474 |
| | **144.** | Rest House Plan | AFS-ORC-475 |
| | **145.** | Mosque Plan | AFS-ORC-476 |
| **ENVIRONMENTAL** | **146.** | Project Land Requirement | AFS-EN-477 |
| **CONSTRUCTION PLANNING** | **147.** | Project Implementation Plan | AFS-CP-478 |

PLATE-1




LEGEND

- LINE OF CONTROL (LOC)
- INTERNATIONAL BOUNDARY
- PROVINCIAL BOUNDARY
- TOWNS, VILLAGES
- CAPITAL CITY
- KARAKORAM HIGHWAY (KKH)
- MOTOR WAY
- DAM / BARRAGE (EXISTING)
- DAM / BARRAGE (PLANNED)
- RIVER
- RESERVOUR (EXISTING)
- RESERVOUR (PLANNED)

**PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY**
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: ISMAIL | PROJECT | **ATTABAD LAKE HPP FEASIBILITY STUDY REPORT** |
| DRAWN: AZEEM | TITLE | **PROJECT LOCATION MAP** |
| CHECKED: ZAHID MAJEED | | |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: N.T.S. / DWG No: AFS-GN-101 / REVISIONS |

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

DISTANCES FROM ISLAMABAD

| Destination | Kilometers |
|---|---|
| Abbottabad | 116 |
| Balakot | 188 |
| Bahrain | 319 |
| Bhurban | 75 |
| Besham | 272 |
| Barseen | 390 |
| Chilas | 482 |
| Chitral | 365 |
| Dir | 265 |
| Gilgit | 628 |
| Gulmit | 766 |
| Haripur | 80 |
| Hasssanabadal | 58 |
| Hunza (Karimabad) | 730 |
| Kohat | 185 |
| Kaghan | 275 |
| Khunjerab Pass | 906 |
| Kalam | 384 |
| Muzaffarabad | 152 |
| Mardan | 154 |
| Malakand Pass | 211 |
| Madyan | 308 |
| Mansehra | 140 |
| Murree | 62 |
| Mingora | 264 |
| Naran | 278 |
| Nathiagali | 100 |
| Nowshera | 136 |
| Pattan | 312 |
| Passu | 780 |
| Peshawar | 176 |
| Sost | 806 |
| Skardu | 793 |
| Saidu Sharif | 266 |
| Taxila (Museum) | 40 |
| Tarbela Dam | 110 |
| Thandiani | 162 |

ATTABAD LAKE HPP

LEGEND

- Motorway
- Provincial / Regional Boundary
- International Boundary
- Main Roads / Highways
- Karakoram Highway
- Country Capital
- Jeep Roads
- Rivers
- Lakes
- Peaks
- Air Routes
- Archaeological Sites
- Mountain Passes
- PTDC Hotel / Motels
- PTDC Tourist information Centres

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | | | | |
|---|---|---|---|---|---|
| PREPARED Ismaeel | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT | | | |
| DRAWN Arshad | TITLE | PROJECT AREA ACCESSIBILITY MAP | | | |
| CHECKED Ismaeel | | | | | |
| APPROVED Abid Sheikh | DATE Aug:2021 | SCALE N .T . S | DWG No: AFS-GN-102 | REVISIONS | |

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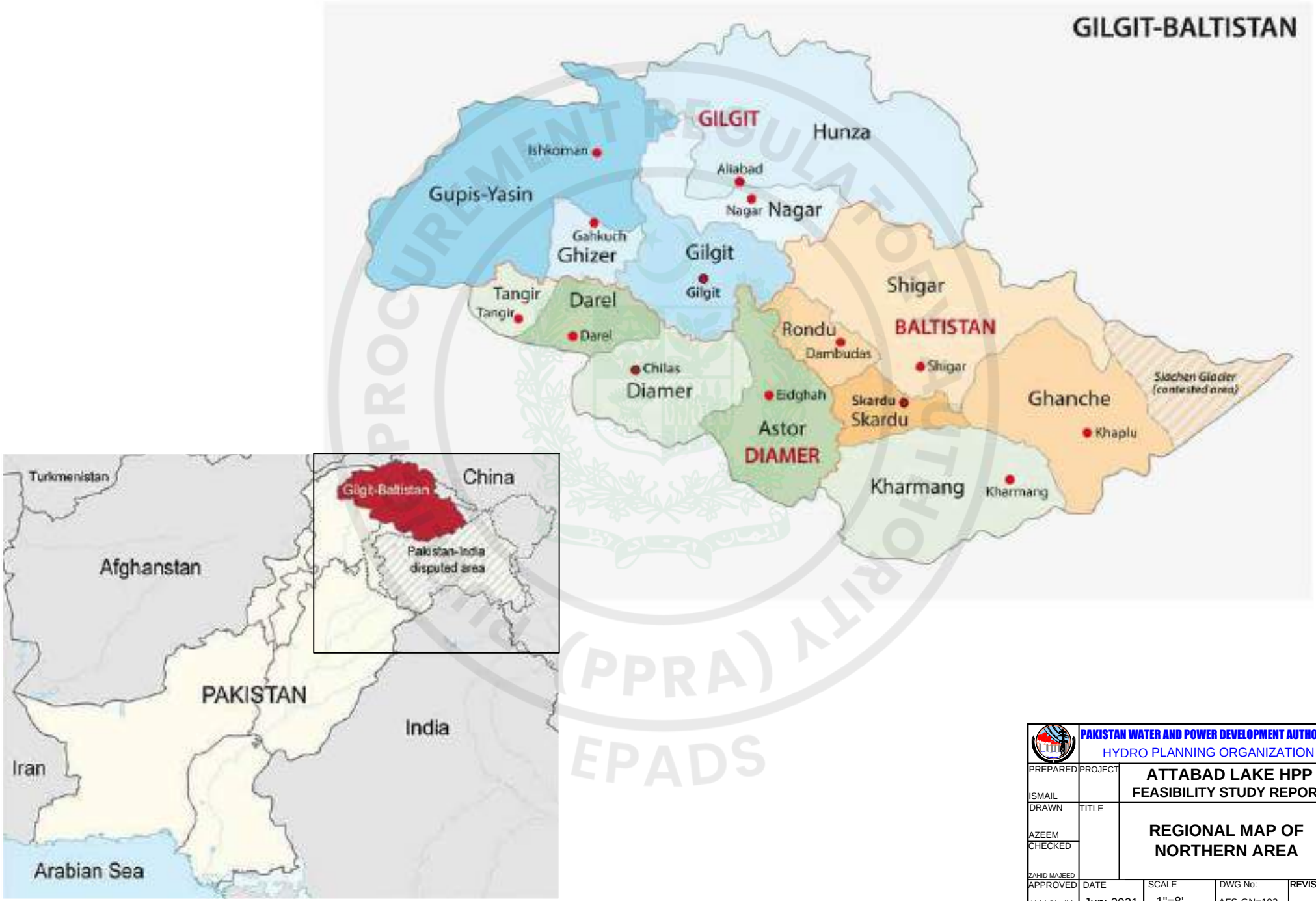


| | | | | | |
|---|---|---|---|---|---|
| | PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | | | | |
| PREPARED<br>ISMAIL | PROJECT | ATTABAD LAKE HPP<br>FEASIBILITY STUDY REPORT | | | |
| DRAWN<br>AZEEM | TITLE | REGIONAL MAP OF NORTHERN AREA | | | |
| CHECKED<br>ZAHID MAJEED | | | | | |
| APPROVED<br>Abid Sheikh | DATE<br>Jun: 2021 | SCALE<br>1"=8' | DWG No:<br>AFS-GN=103 | REVISIONS | |

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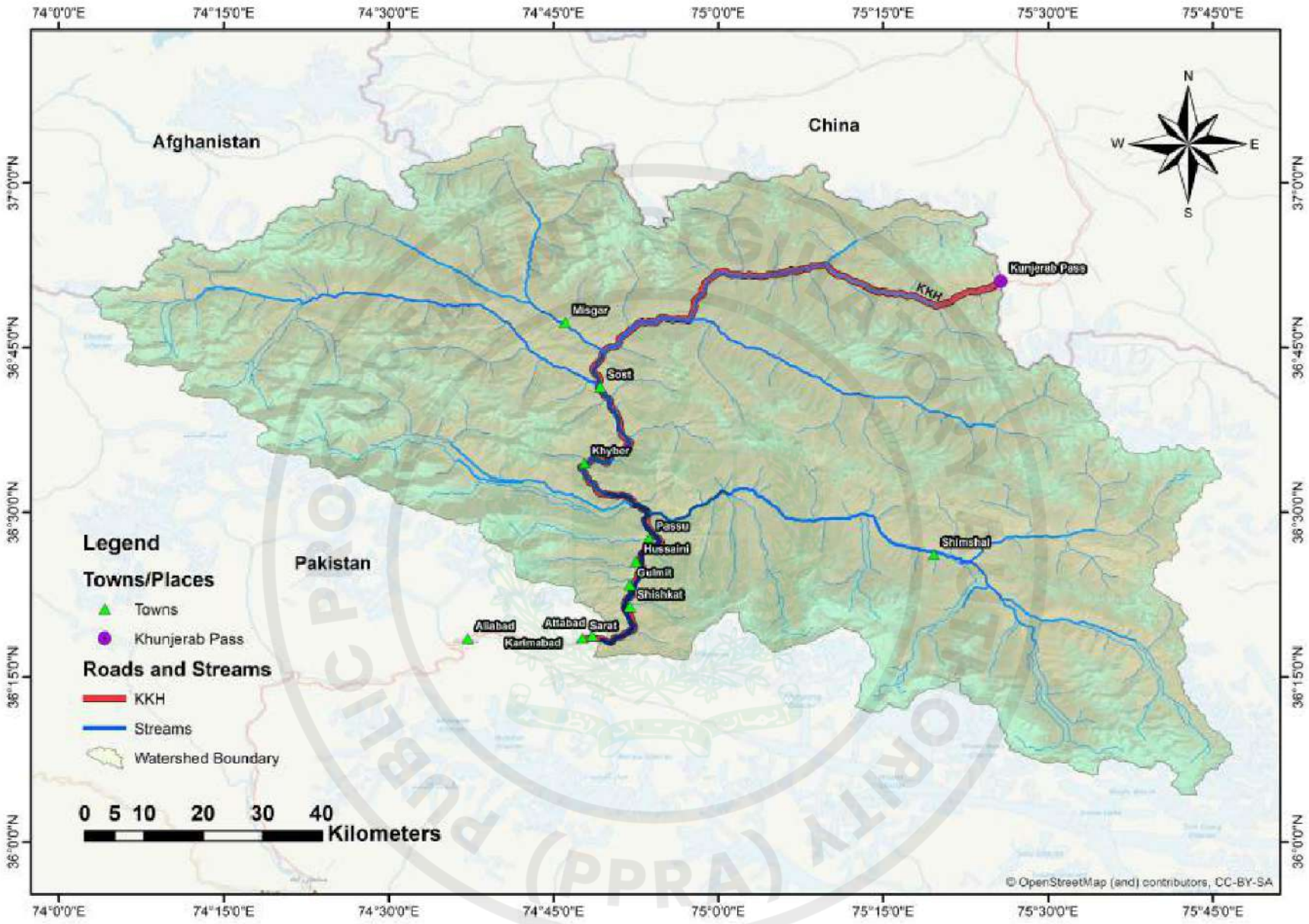


| | | | |
|---|---|---|---|
| PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | | | |
| PREPARED<br>ISMAIL | PROJECT | ATTABAD LAKE HPP<br>FEASIBILITY STUDY REPORT | |
| DRAWN<br>AZEEM | TITLE | CATCHMENT AREA MAP | |
| CHECKED<br>ZAHID MAJEED | | | |
| APPROVED<br>Abid Sheikh | DATE<br>Jun: 2021 | SCALE<br>1"=8' | DWG No.<br>AFS-CA-104 |

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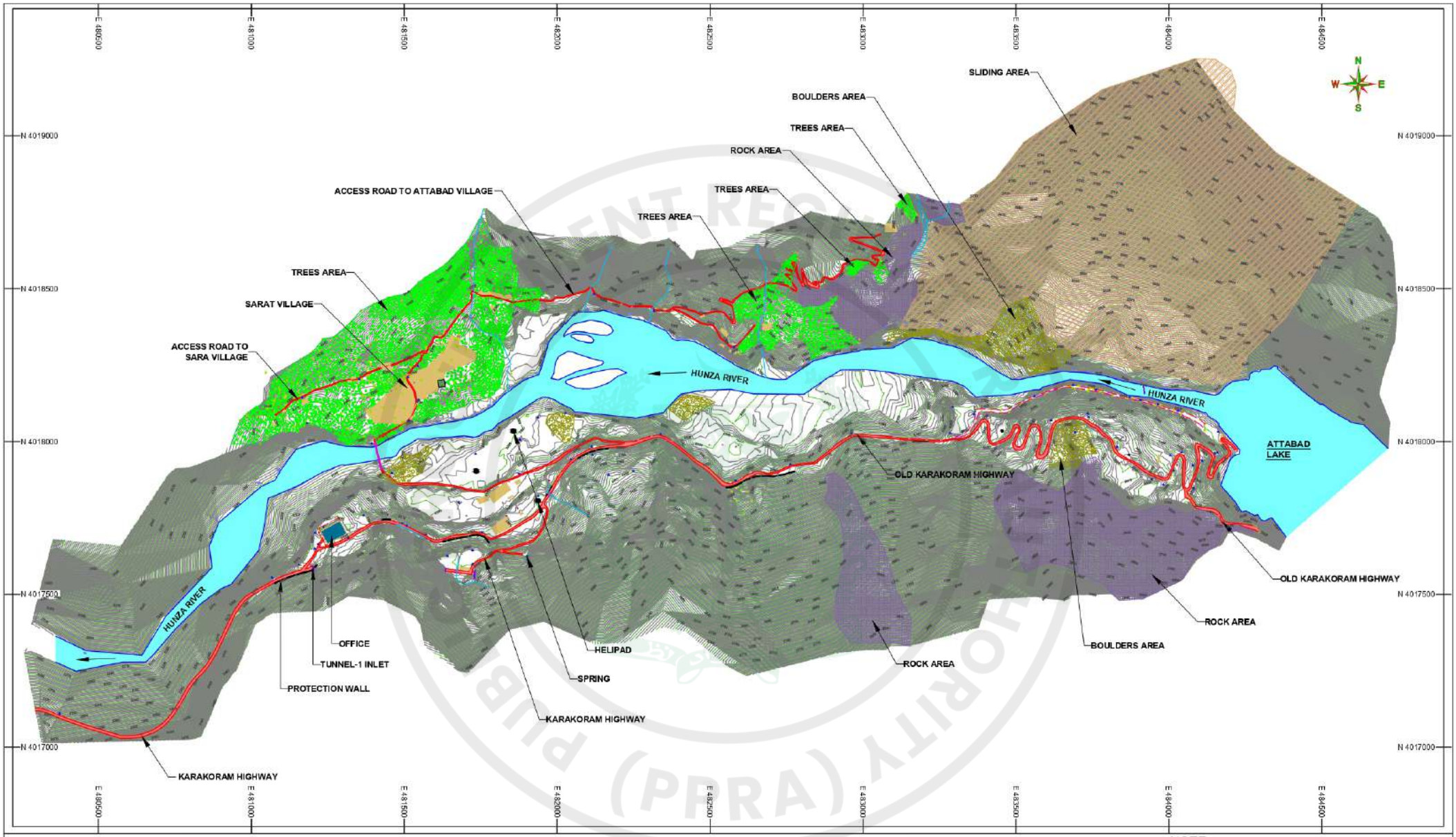


## LEGENDS:

- RIVER/NALLA
- HOUSES/SHOPS
- ROAD
- KATCHA ROAD/TRACK
- CONTROL POINTS
- CONTOURS
- ELECTRIC POLE/T.POLE
- RETAINING WALL
- TREES AREA
- DRAIN AND NULLAH
- BRIDGE AND CULVERT
- BOULDERS
- WATER TANK
- SPRING
- JAMAT KHANA
- HFL
- HELLIPAD
- SLIDING
- ROCK

100 0 100 200 300 400 500m

SCALE

NOTE.

1. ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED
2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FILED OBSERVATIONS.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Ehsan | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE | PROJECT AREA TOPOGRAPHIC SURVEY MAP |
| CHECKED: Ehsan | | |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 12,000 |
| | DWG No: ASP-TS-201 | REVISIONS |

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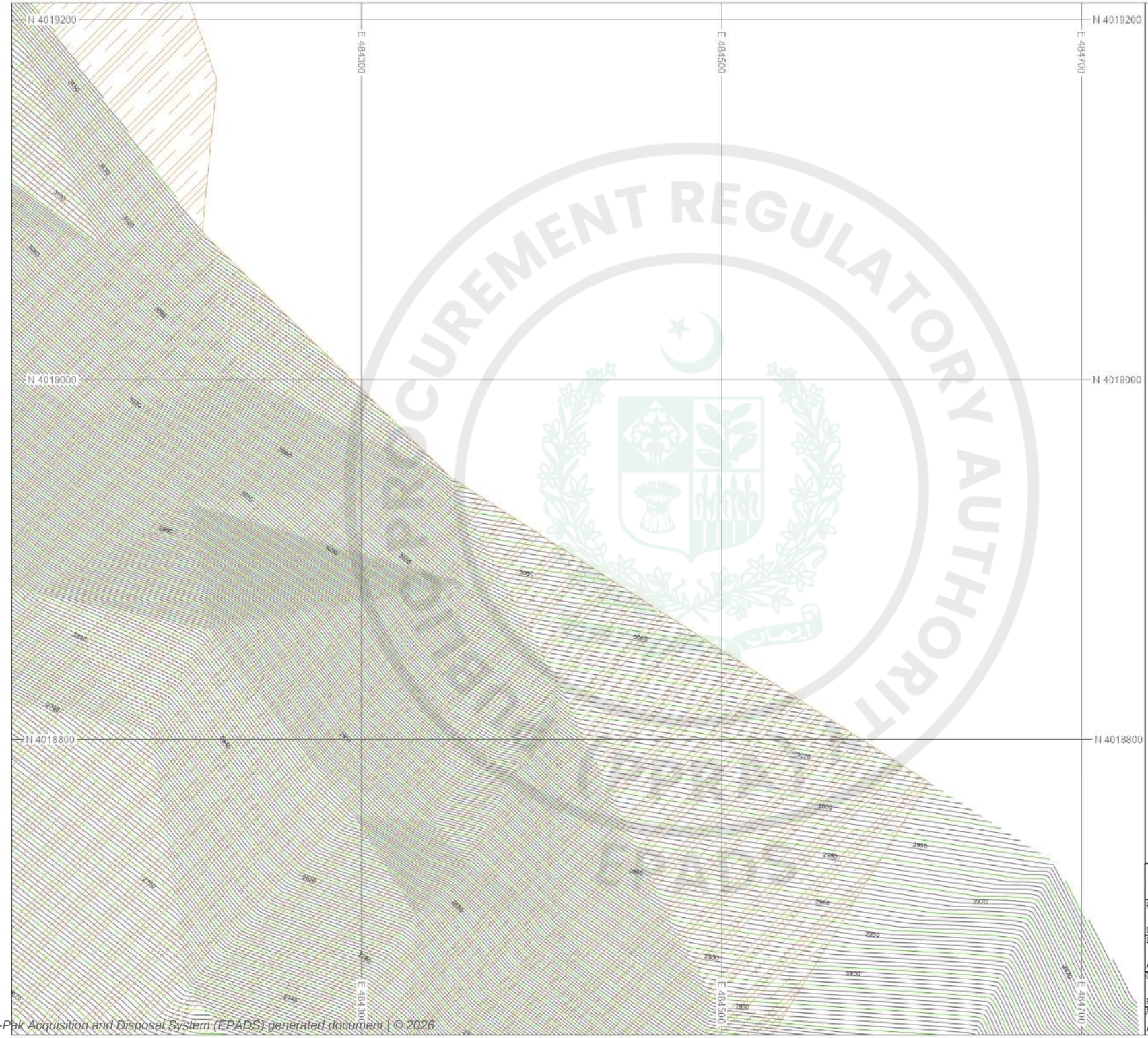
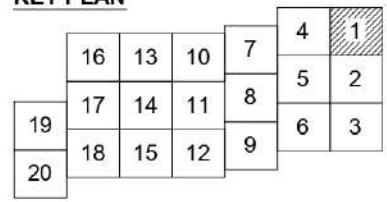



## KEY PLAN




## LEGENDS:

- RIVER/NALLA
- HOUSES/SHOPS
- ROADS
- KATCHA ROAD/TRACK
- CONTROL POINTS
- CONTOURS
- ELECTRIC POLE/T.POLE
- RETAINING WALL
- TREES AREA
- DRAIN AND NULLAH
- BRIDGE AND CULVERT
- BOULDERS
- WATER TANK
- SPRING
- JAMAT KHANA
- HFL
- HELIPAD
- SLIDING
- ROCK

0 25 50 75 100 125m

SCALE

NOTE.

1. ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED
2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FILED OBSERVATIONS.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Ehsan | PROJECT | ATTABAD LAKE HPP<br>FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE | PROJECT AREA<br>TOPOGRAPHIC SURVEY<br>(Sheet 1 of 20) |
| CHECKED: Ehsan | | |
| APPROVED: Abid Sheikh | DATE: Jun. 2021 | SCALE: 1 : 2,000 |
| | | DWG No. APS-TS-202 |
| | | REVISIONS |

PROCUREMENT REGULATORY AUTHORITY PAKISTAN

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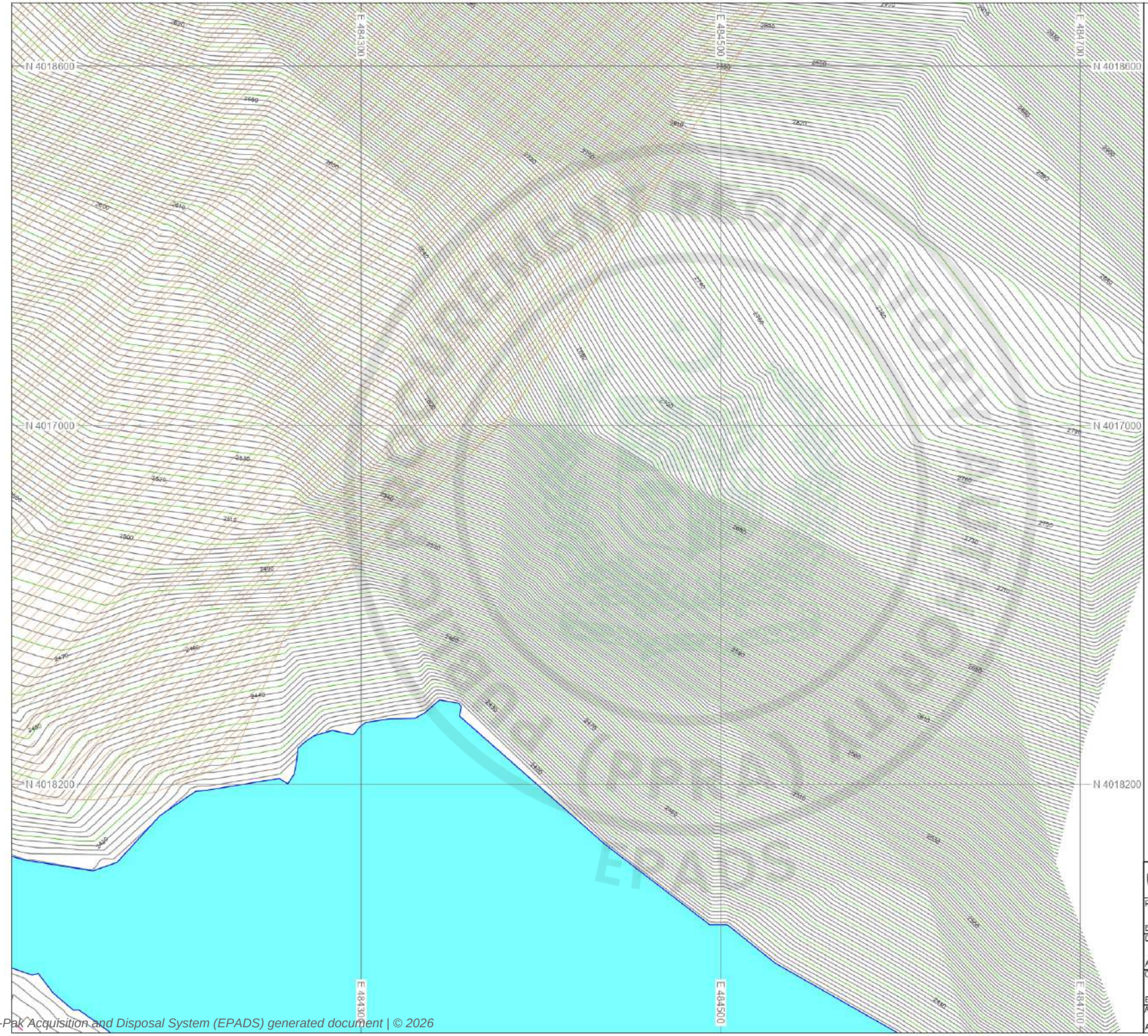
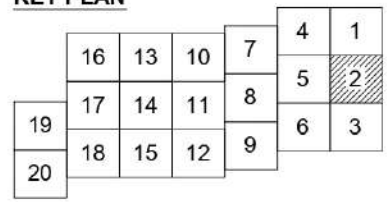



## KEY PLAN




## LEGENDS:

- RIVER/NALLA
- HOUSES/SHOPS
- ROADS
- KATCHA ROAD/TRACK
- CONTROL POINTS
- CONTOURS
- ELECTRIC POLE/T.POLE
- RETAINING WALL
- TREES AREA
- DRAIN AND NULLAH
- BRIDGE AND CULVERT
- BOULDERS
- WATER TANK
- SPRING
- JAMAT KHANA
- HFL
- HELIPAD
- SLIDING
- ROCK

0 25 50 75 100 125m

SCALE

NOTE.

1. ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED
2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FILED OBSERVATIONS.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Ehsan | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE | PROJECT AREA TOPOGRAPHIC SURVEY (Sheet 2 of 20) |
| CHECKED: Ehsan | | |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 2,000 |
| | | DWG No.: APS-TS-203 |
| | | REVISIONS |

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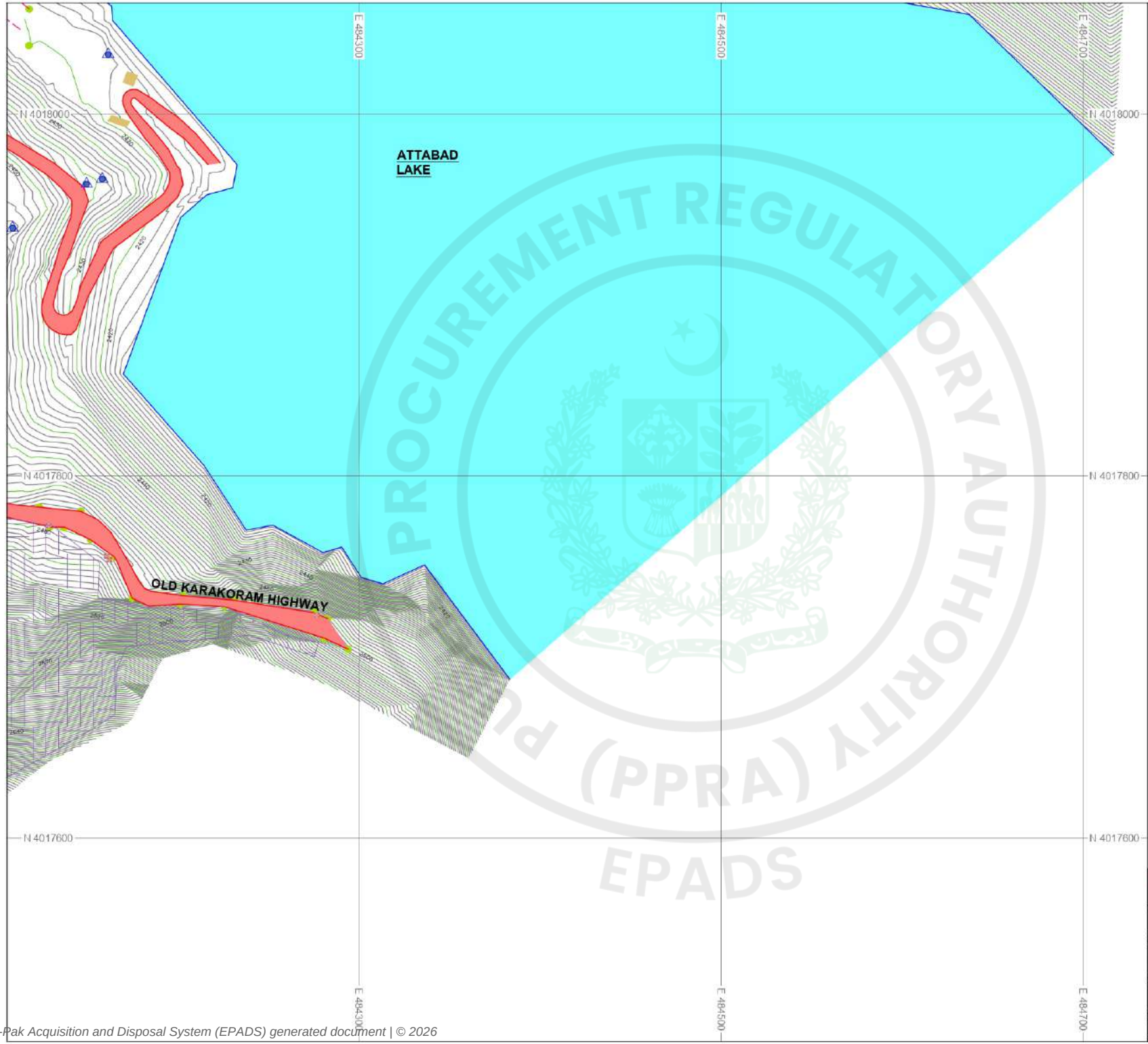


PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

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## KEY PLAN

| | | | | | | |
|---|---|---|---|---|---|---|
| | 16 | 13 | 10 | 7 | 4 | 1 |
| | 17 | 14 | 11 | 8 | 5 | 2 |
| 19 | 18 | 15 | 12 | 9 | 6 | 3 |
| 20 | | | | | | |

## LEGENDS:

- RIVER/NALLA
- HOUSES/SHOPS
- ROADS
- KATCHA ROAD/TRACK
- CONTROL POINTS
- CONTOURS
- ELECTRIC POLE/T.POLE
- RETAINING WALL
- TREES AREA
- DRAIN AND NULLAH
- BRIDGE AND CULVERT
- BOULDERS
- WATER TANK
- SPRING
- JAMAT KHANA
- HFL
- HELIPAD
- SLIDING
- ROCK

0 25 50 75 100 125m

SCALE

NOTE.

1. ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED
2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FILED OBSERVATIONS.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Ehsan | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE | PROJECT AREA TOPOGRAPHIC SURVEY (Sheet 3 of 20) |
| CHECKED: Ehsan | | |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 2,000 |
| | | DWG No: APS-TS-204 |
| | | REVISIONS |

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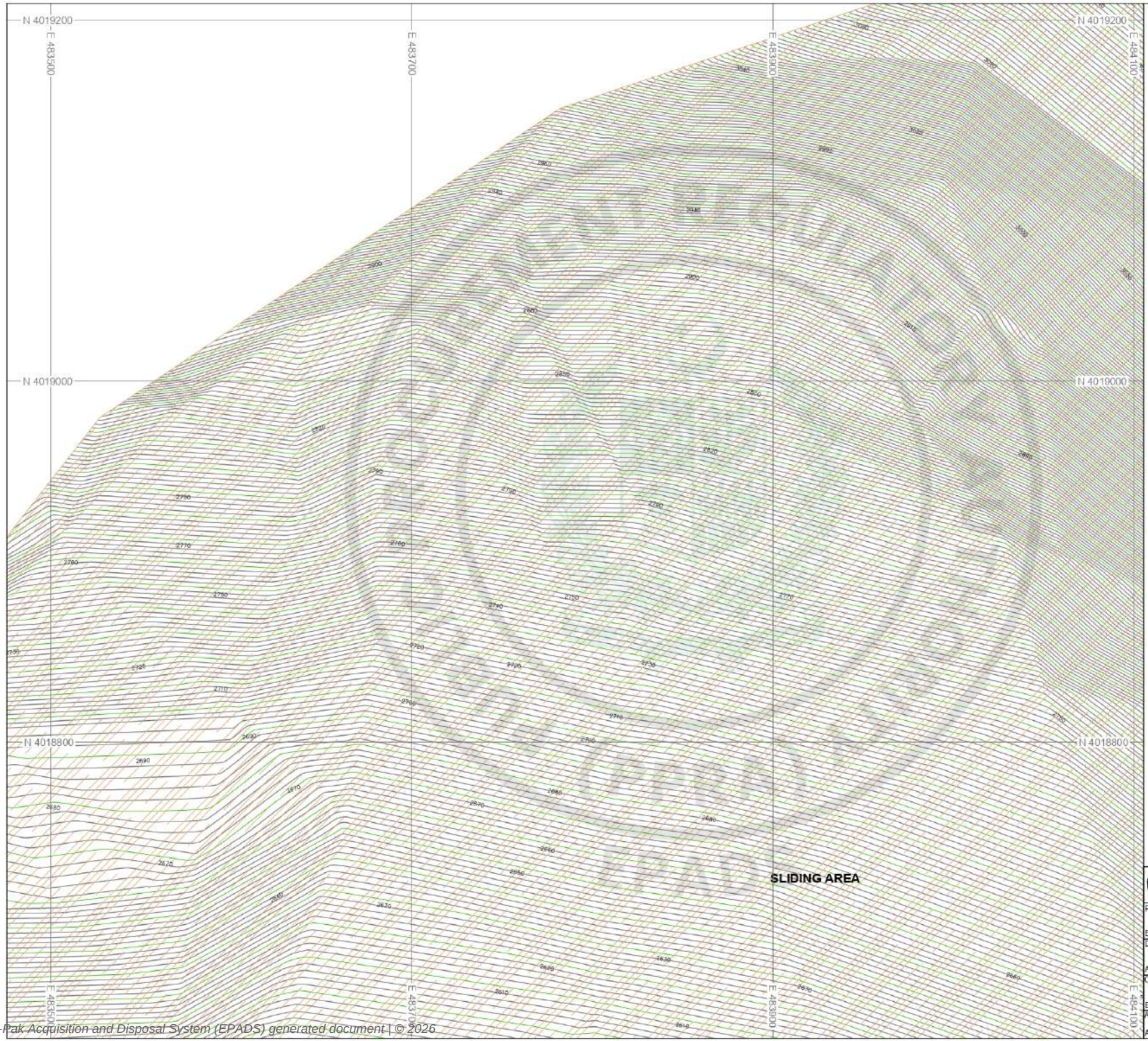
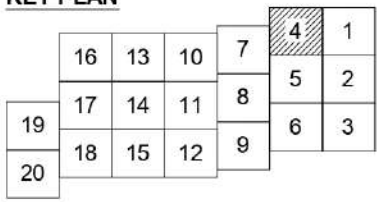



## KEY PLAN




## LEGENDS:

- RIVER/NALLA
- HOUSES/SHOPS
- ROADS
- KATCHA ROAD/TRACK
- CONTROL POINTS
- CONTOURS
- ELECTRIC POLE/T.POLE
- RETAINING WALL
- TREES AREA
- DRAIN AND NULLAH
- BRIDGE AND CULVERT
- BOULDERS
- WATER TANK
- SPRING
- JAMAT KHANA
- HFL
- HELIPAD
- SLIDING
- ROCK

0 25 50 75 100 125m

SCALE

NOTE.

1. ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED
2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FILED OBSERVATIONS.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Ehsan | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE | PROJECT AREA TOPOGRAPHIC SURVEY (Sheet 4 of 20) |
| CHECKED: Ehsan | | |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 2,000 |
| | DWG No: APS-TS-206 | REVISIONS |

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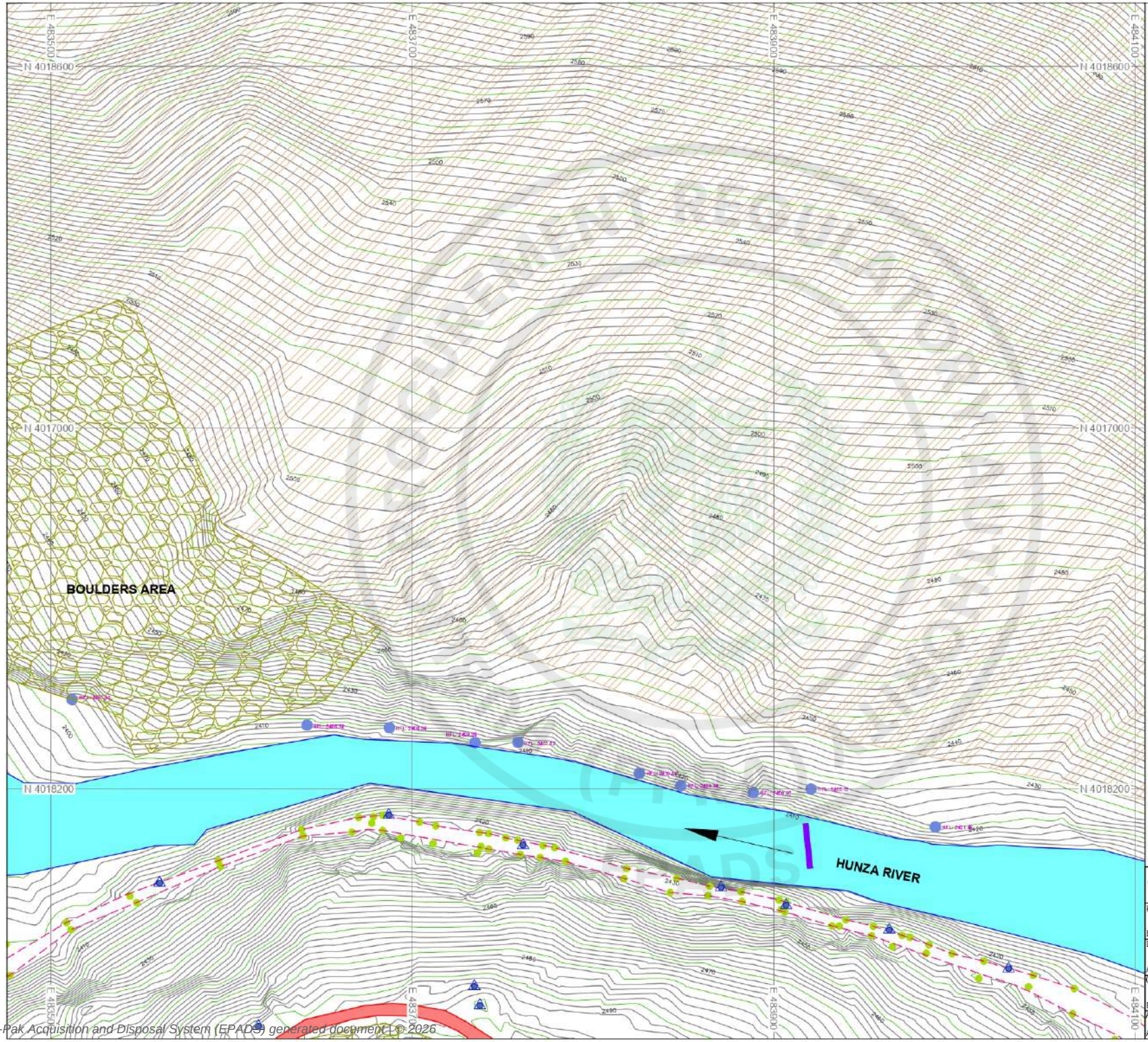
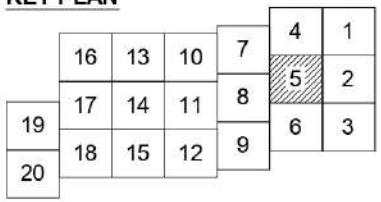



## KEY PLAN




## LEGENDS:

- RIVER/NALLA
- HOUSES/SHOPS
- ROADS
- KATCHA ROAD/TRACK
- CONTROL POINTS
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- ELECTRIC POLE/T.POLE
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- WATER TANK
- SPRING
- JAMAT KHANA
- HFL
- HELIPAD
- SLIDING
- ROCK

0 25 50 75 100 125m

SCALE

NOTE.

1. ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED
2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FILED OBSERVATIONS.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Ehsan | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE | PROJECT AREA TOPOGRAPHIC SURVEY (Sheet 5 of 20) |
| CHECKED: Ehsan | | |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 2,000 |
| | DWG No: APS-TS-206 | REVISIONS |

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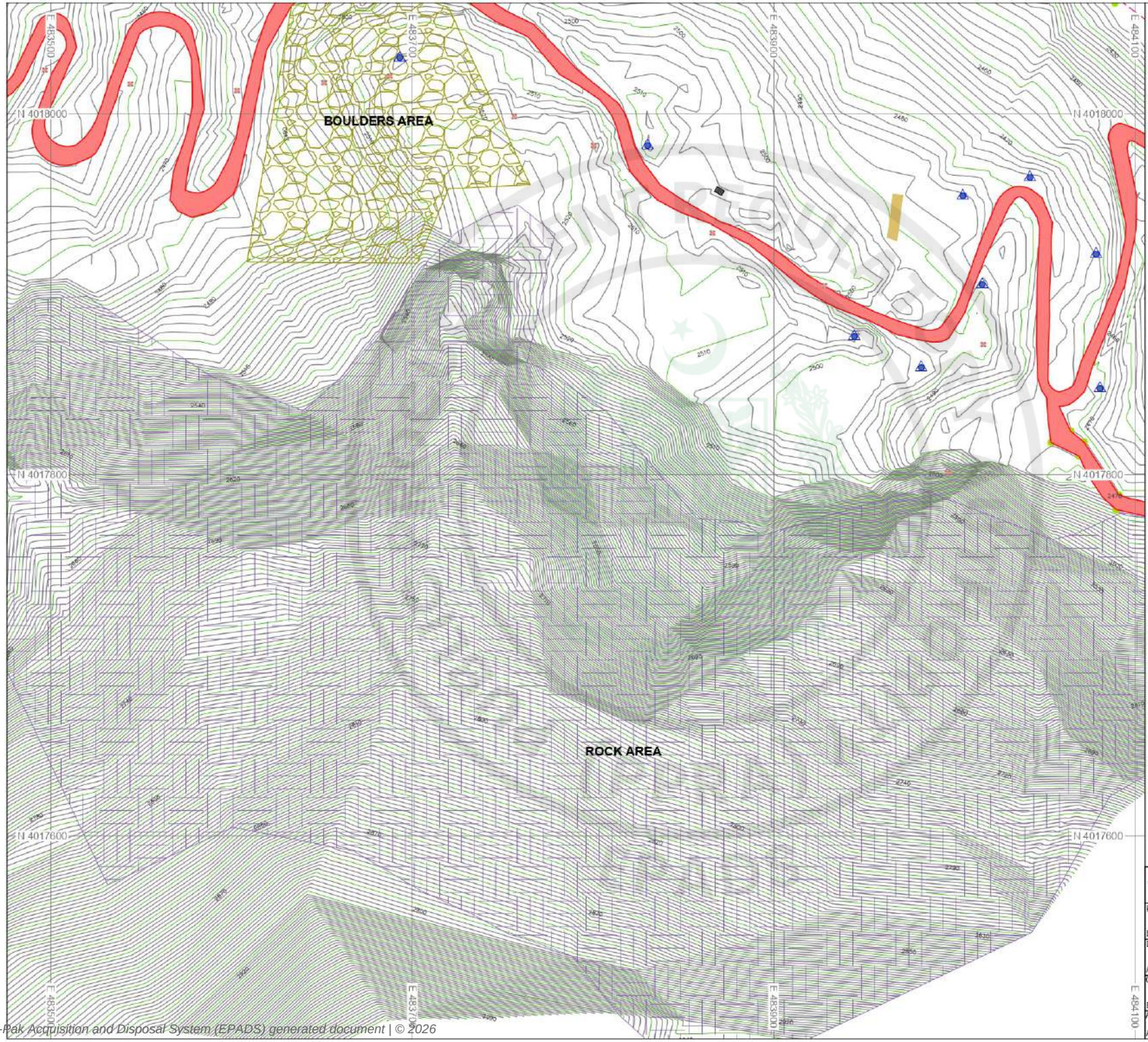


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## KEY PLAN

| | | | | | | |
|---|---|---|---|---|---|---|
| | 16 | 13 | 10 | 7 | 4 | 1 |
| | 17 | 14 | 11 | 8 | 5 | 2 |
| 19 | 18 | 15 | 12 | 9 | 6 | 3 |
| 20 | | | | | | |

## LEGENDS:

- RIVER/NALLA
- HOUSES/SHOPS
- ROADS
- KATCHA ROAD/TRACK
- CONTROL POINTS
- CONTOURS
- ELECTRIC POLE/T.POLE
- RETAINING WALL
- TREES AREA
- DRAIN AND NULLAH
- BRIDGE AND CULVERT
- BOULDERS
- WATER TANK
- SPRING
- JAMAT KHANA
- HFL
- HELIPAD
- SLIDING
- ROCK

0 25 50 75 100 125m

SCALE

NOTE.

1. ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED
2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FILED OBSERVATIONS.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| PREPARED | PROJECT | |
|---|---|---|
| Ehsan | | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN | TITLE | |
| Arshad | | PROJECT AREA TOPOGRAPHIC SURVEY (Sheet 6 of 20) |
| CHECKED | | |
| Ehsan | | |

| APPROVED | DATE | SCALE | DWG No. | REVISIONS |
|---|---|---|---|---|
| Abid Sheikh | Jun: 2021 | 1 : 2,000 | APS-TS-207 | |

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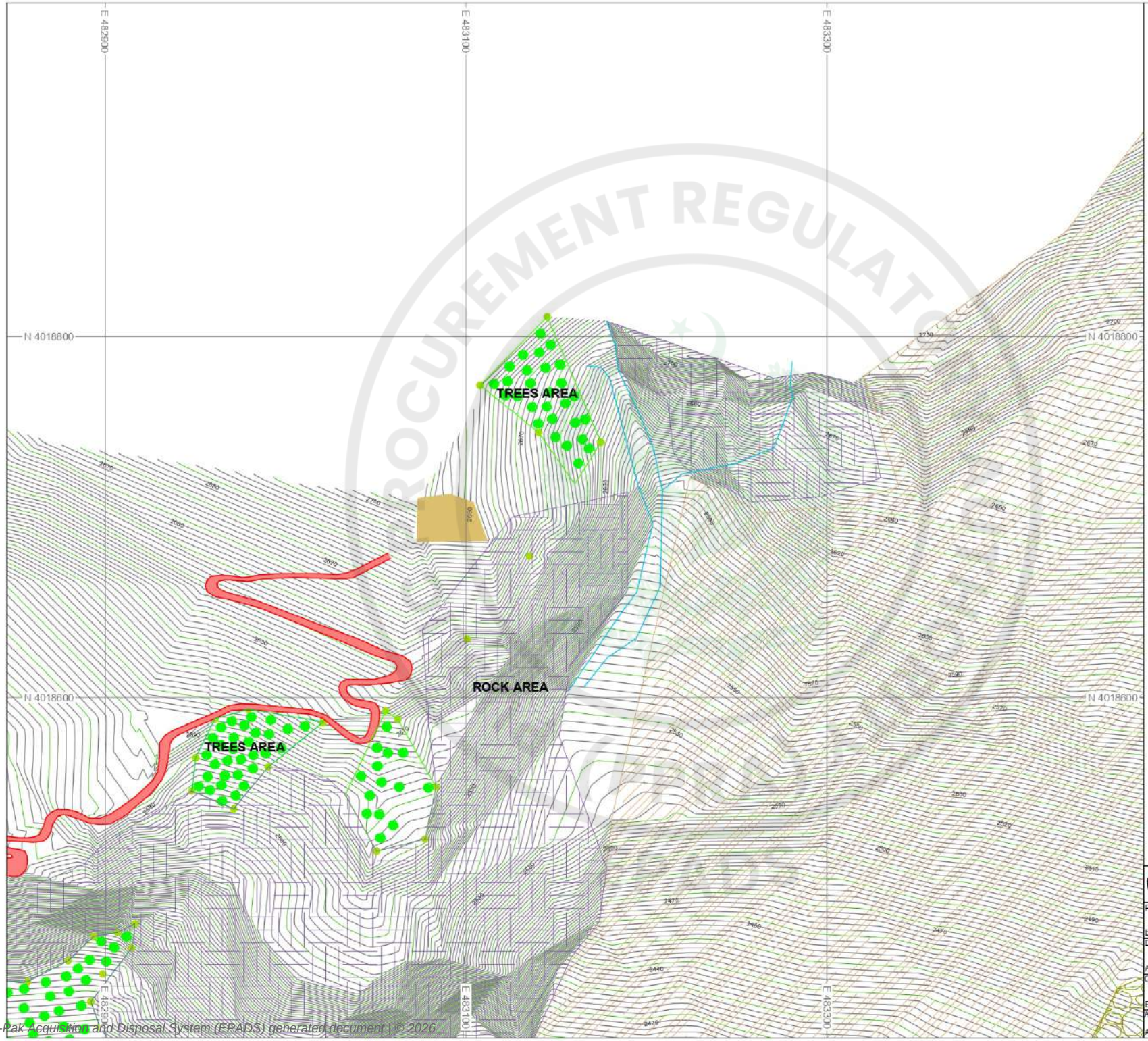


## KEY PLAN

| | | | | | | |
|---|---|---|---|---|---|---|
| | 16 | 13 | 10 | 7 | 4 | 1 |
| | 17 | 14 | 11 | 8 | 5 | 2 |
| 19 | 18 | 15 | 12 | 9 | 6 | 3 |
| 20 | | | | | | |

## LEGENDS:

- RIVER/NALLA
- HOUSES/SHOPS
- ROADS
- KATCHA ROAD/TRACK
- CONTROL POINTS
- CONTOURS
- ELECTRIC POLE/T.POLE
- RETAINING WALL
- TREES AREA
- DRAIN AND NULLAH
- BRIDGE AND CULVERT
- BOULDERS
- WATER TANK
- SPRING
- JAMAT KHANA
- HFL
- HELIPAD
- SLIDING
- ROCK

0 25 50 75 100 125m

SCALE

NOTE.

1. ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED
2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FILED OBSERVATIONS.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Ehsan | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE | PROJECT AREA TOPOGRAPHIC SURVEY (Sheet 7 of 20) |
| CHECKED: Ehsan | | |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 2,000 |
| | DWG No: APS-TS-208 | REVISIONS |

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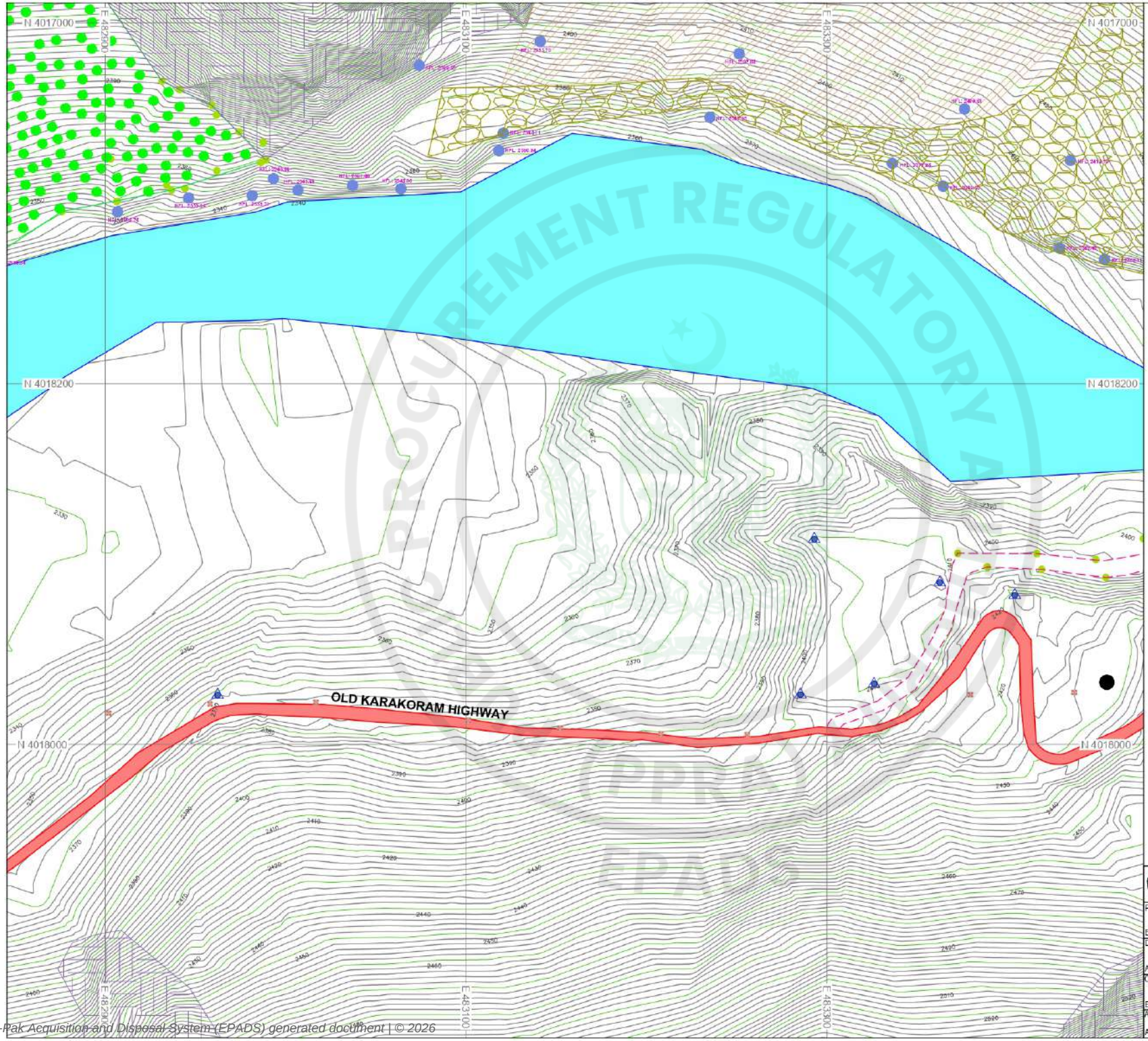
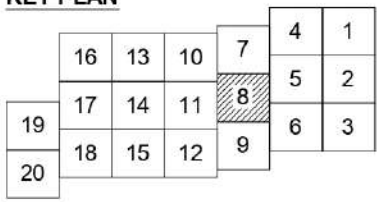



## KEY PLAN




## LEGENDS:

- RIVER/NALLA
- HOUSES/SHOPS
- ROADS
- KATCHA ROAD/TRACK
- CONTROL POINTS
- CONTOURS
- ELECTRIC POLE/T.POLE
- RETAINING WALL
- TREES AREA
- DRAIN AND NULLAH
- BRIDGE AND CULVERT
- BOULDERS
- WATER TANK
- SPRING
- JAMAT KHANA
- HFL
- HELIPAD
- SLIDING
- ROCK

0 25 50 75 100 125m

SCALE

NOTE.

1. ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED
2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FILED OBSERVATIONS.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Ehsan | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE | PROJECT AREA TOPOGRAPHIC SURVEY (Sheet 8 of 20) |
| CHECKED: Ehsan | | |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 2,000 |
| | DWG No: APS-TS-208 | REVISIONS |

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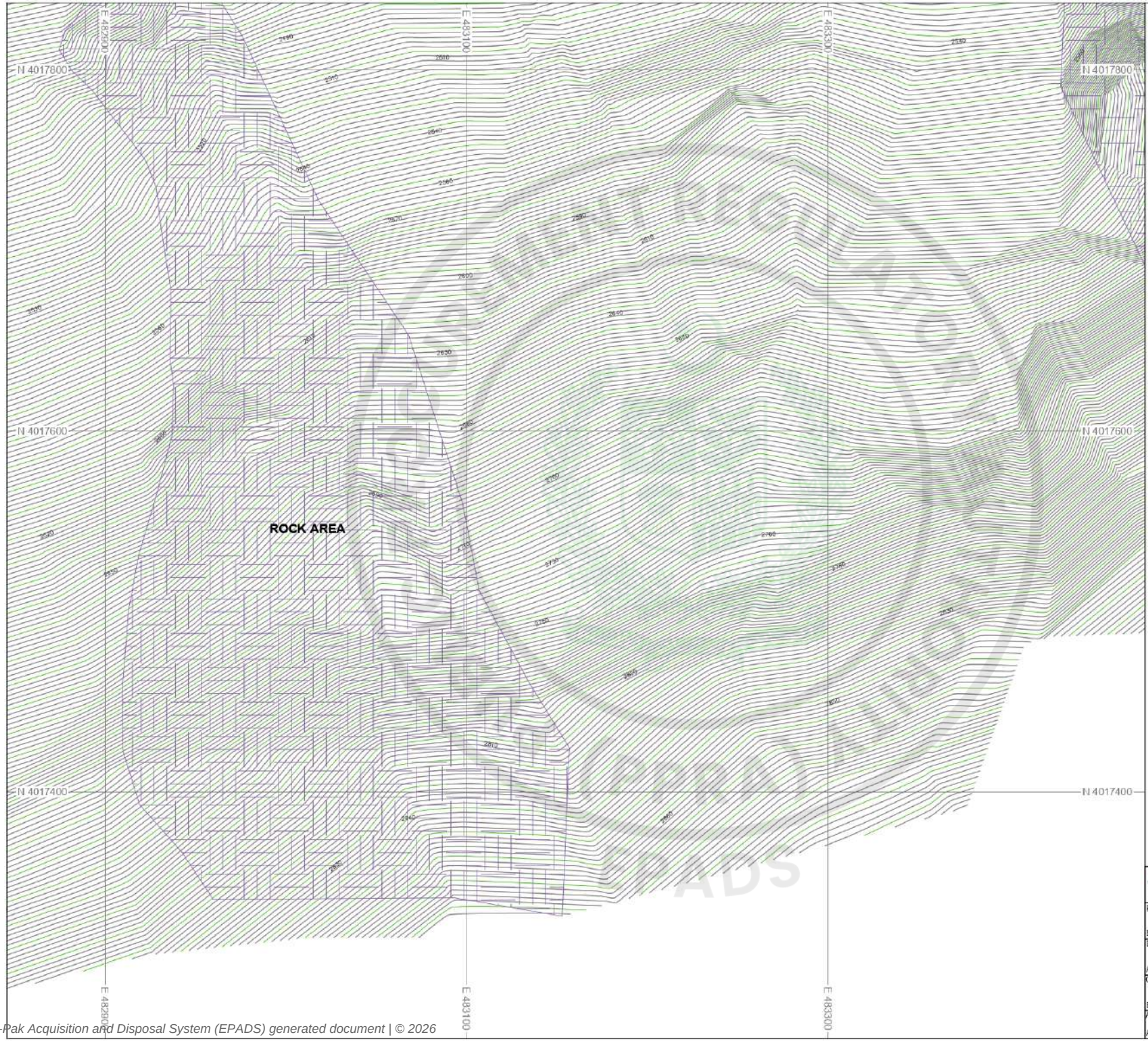
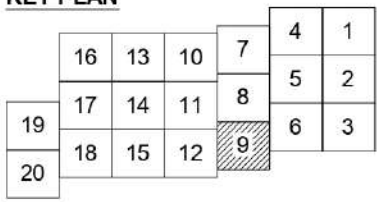



## KEY PLAN




## LEGENDS:

- RIVER/NALLA
- HOUSES/SHOPS
- ROADS
- KATCHA ROAD/TRACK
- CONTROL POINTS
- CONTOURS
- ELECTRIC POLE/T.POLE
- RETAINING WALL
- TREES AREA
- DRAIN AND NULLAH
- BRIDGE AND CULVERT
- BOULDERS
- WATER TANK
- SPRING
- JAMAT KHANA
- HFL
- HELIPAD
- SLIDING
- ROCK

0 25 50 75 100 125m

SCALE

NOTE.

1. ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED
2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FILED OBSERVATIONS.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Ehsan | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE | PROJECT AREA TOPOGRAPHIC SURVEY (Sheet 9 of 20) |
| CHECKED: Ehsan | | |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 2,000 |
| | DWG No: APS-TS-210 | REVISIONS |

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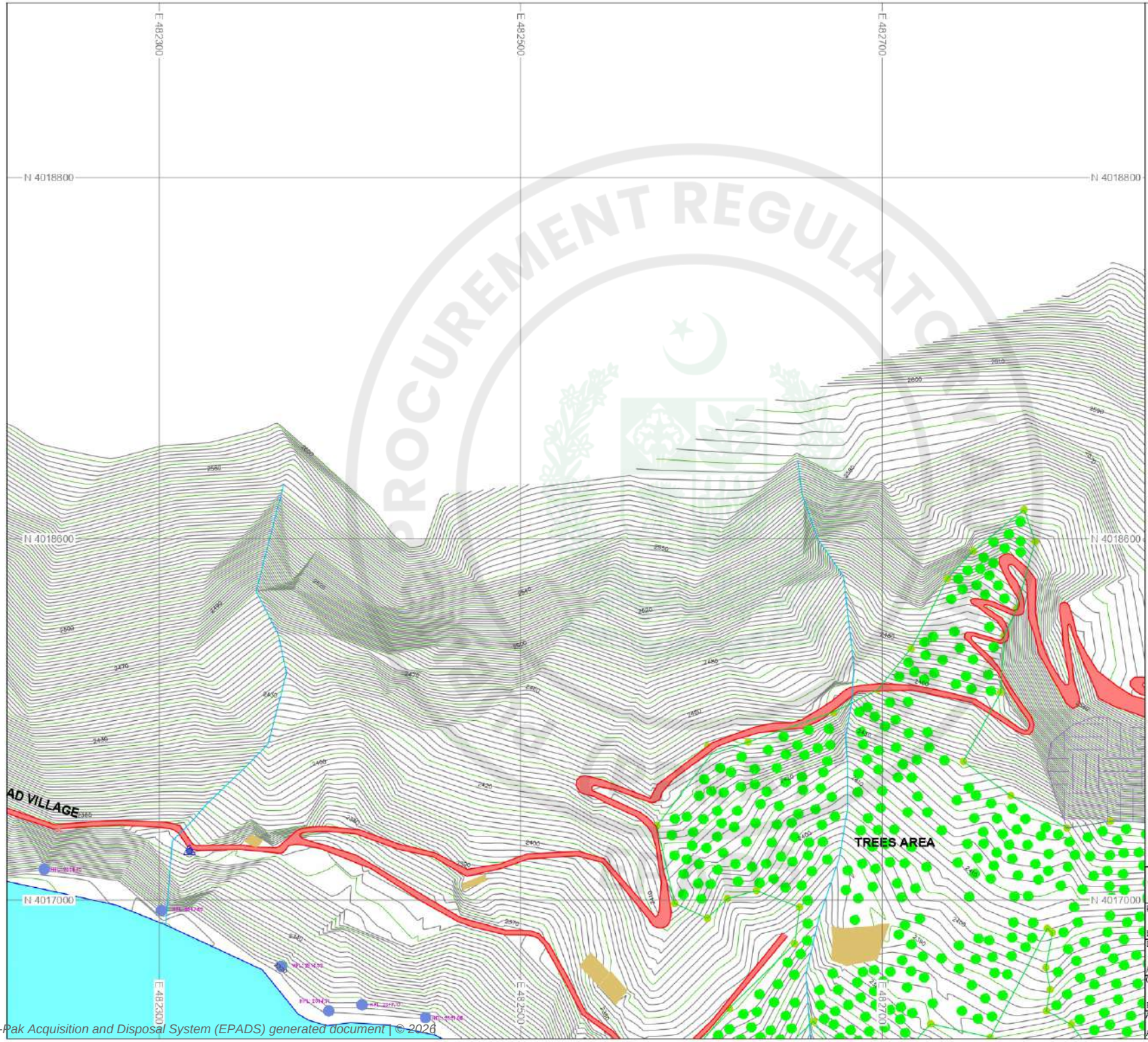


## KEY PLAN

| | | | | | | |
|---|---|---|---|---|---|---|
| | 16 | 13 | 10 | 7 | 4 | 1 |
| | 17 | 14 | 11 | 8 | 5 | 2 |
| 19 | 18 | 15 | 12 | 9 | 6 | 3 |
| 20 | | | | | | |

## LEGENDS:

- RIVER/NALLA
- HOUSES/SHOPS
- ROADS
- KATCHA ROAD/TRACK
- CONTROL POINTS
- CONTOURS
- ELECTRIC POLE/T.POLE
- RETAINING WALL
- TREES AREA
- DRAIN AND NULLAH
- BRIDGE AND CULVERT
- BOULDERS
- WATER TANK
- SPRING
- JAMAT KHANA
- HFL
- HELIPAD
- SLIDING
- ROCK

0 25 50 75 100 125m

SCALE

NOTE.

1. ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED
2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FILED OBSERVATIONS.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Ehsan | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE | PROJECT AREA TOPOGRAPHIC SURVEY (Sheet 10 of 20) |
| CHECKED: Ehsan | | |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 2,000 |
| | DWG No: APS-TS-211 | REVISIONS |

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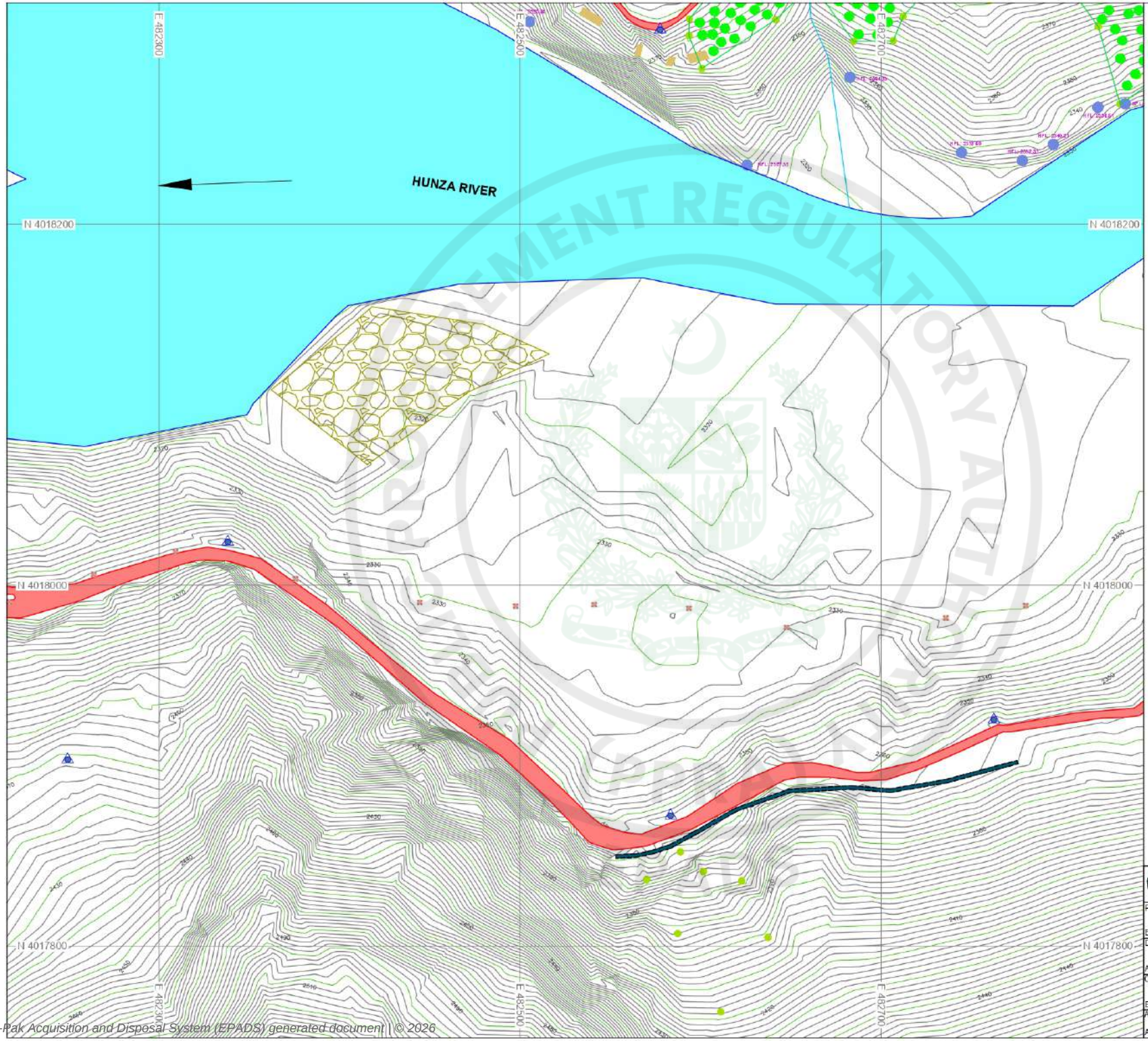


## KEY PLAN

| | | | | | | |
|---|---|---|---|---|---|---|
| | 16 | 13 | 10 | 7 | 4 | 1 |
| | 17 | 14 | 11 | 8 | 5 | 2 |
| 19 | 18 | 15 | 12 | 9 | 6 | 3 |
| 20 | | | | | | |

## LEGENDS:

- RIVER/NALLA
- HOUSES/SHOPS
- ROADS
- KATCHA ROAD/TRACK
- CONTROL POINTS
- CONTOURS
- ELECTRIC POLE/T.POLE
- RETAINING WALL
- TREES AREA
- DRAIN AND NULLAH
- BRIDGE AND CULVERT
- BOULDERS
- WATER TANK
- SPRING
- JAMAT KHANA
- HFL
- HELIPAD
- SLIDING
- ROCK

0 25 50 75 100 125m

SCALE

NOTE.

1. ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED
2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FILED OBSERVATIONS.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Ehsan | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE | PROJECT AREA TOPOGRAPHIC SURVEY (Sheet 11 of 20) |
| CHECKED: Ehsan | | |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 2,000 |
| | DWG No: APS-TS-212 | REVISIONS |

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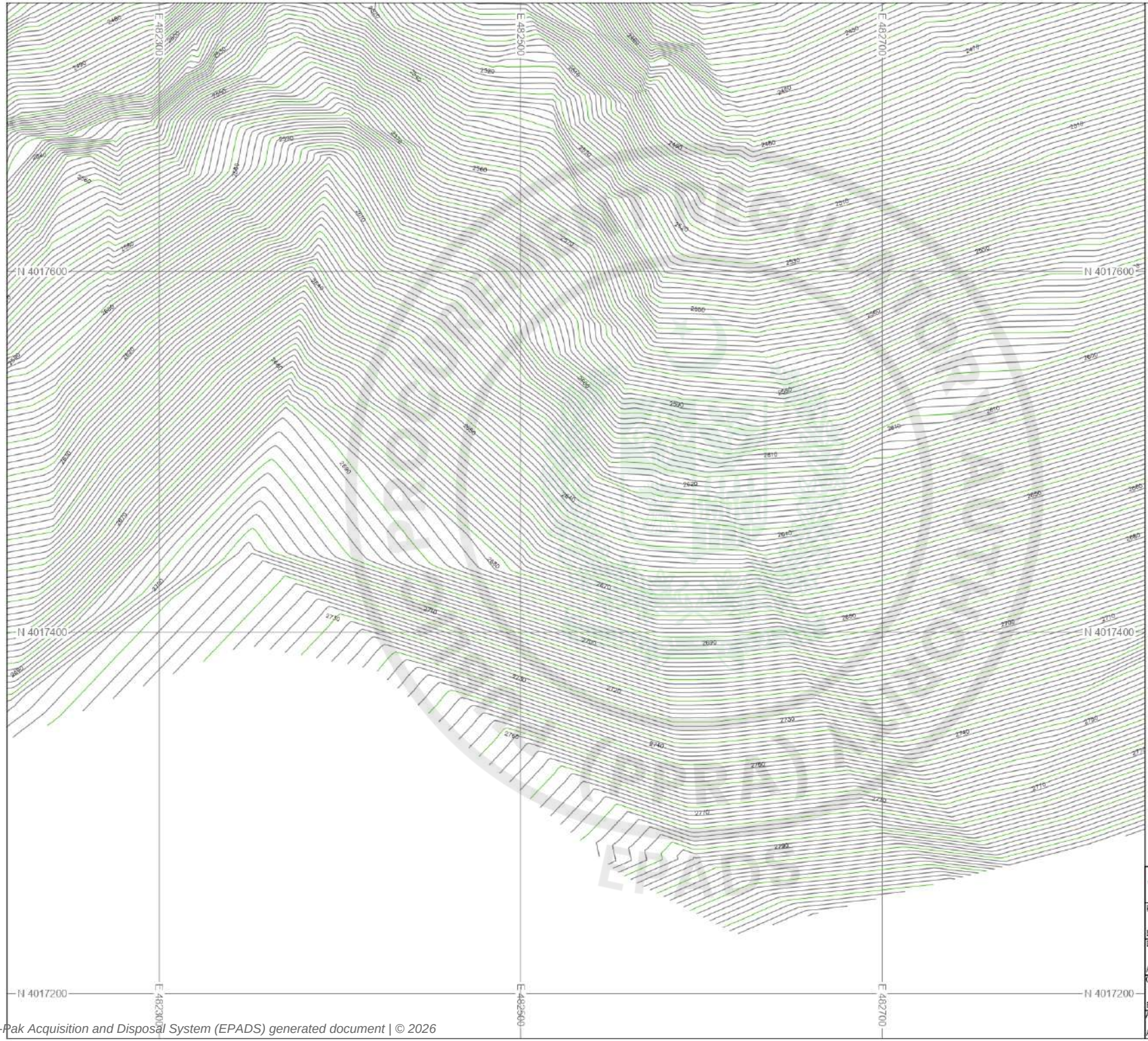
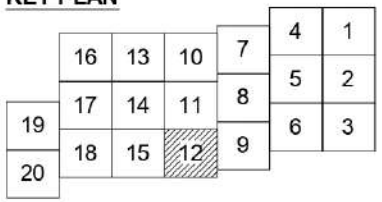



## KEY PLAN




## LEGENDS:

- RIVER/NALLA
- HOUSES/SHOPS
- ROADS
- KATCHA ROAD/TRACK
- CONTROL POINTS
- CONTOURS
- ELECTRIC POLE/T.POLE
- RETAINING WALL
- TREES AREA
- DRAIN AND NULLAH
- BRIDGE AND CULVERT
- BOULDERS
- WATER TANK
- SPRING
- JAMAT KHANA
- HFL
- HELIPAD
- SLIDING
- ROCK

0 25 50 75 100 125m

SCALE

NOTE.

1. ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED
2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FILED OBSERVATIONS.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Ehsan | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE | PROJECT AREA TOPOGRAPHIC SURVEY (Sheet 12 of 20) |
| CHECKED: Ehsan | | |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 2,000 |
| | DWG No: APS-TS-213 | REVISIONS |

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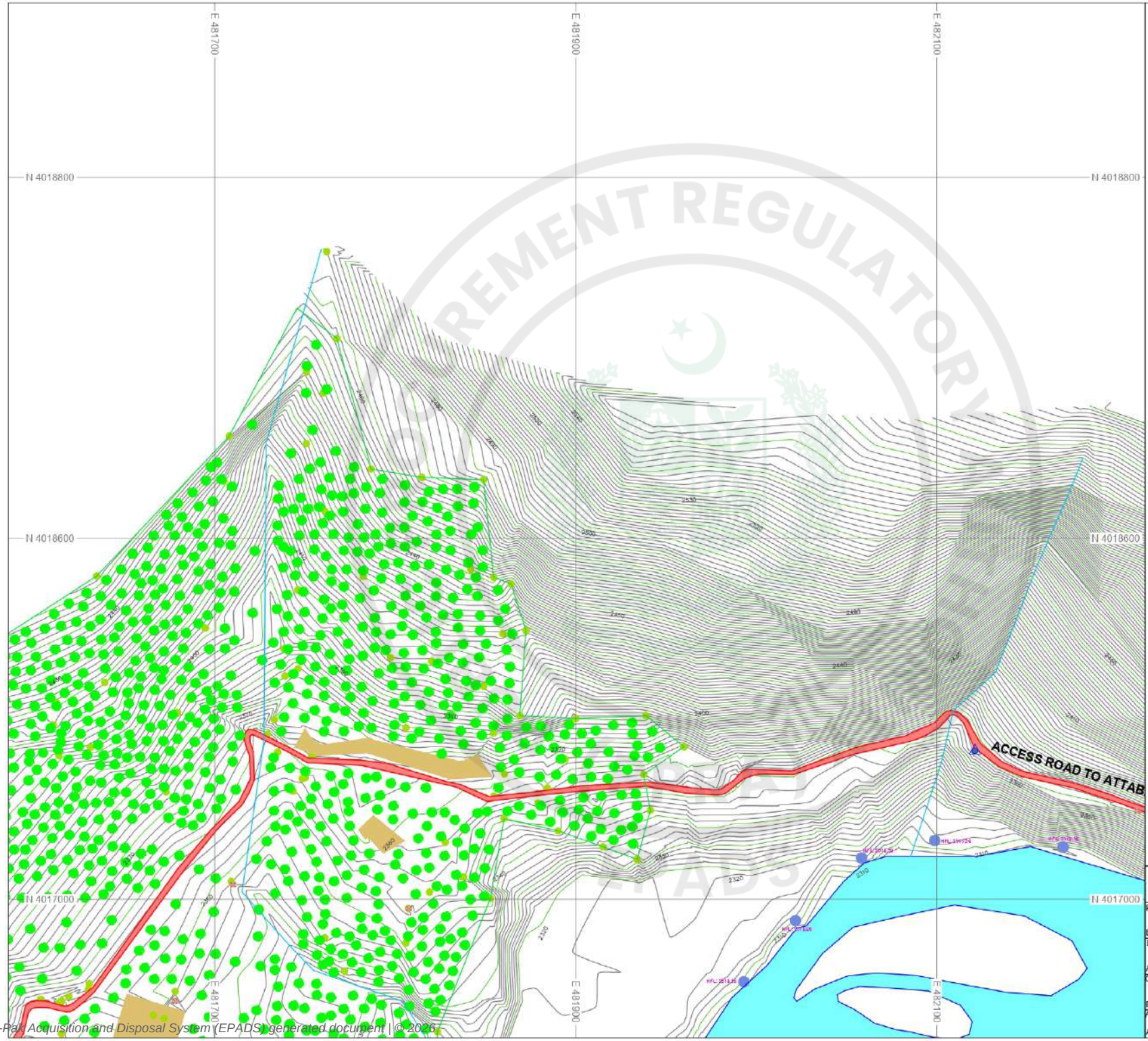
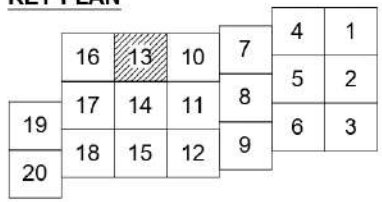



## KEY PLAN




## LEGENDS:

- RIVER/NALLA
- HOUSES/SHOPS
- ROADS
- KATCHA ROAD/TRACK
- CONTROL POINTS
- CONTOURS
- ELECTRIC POLE/T.POLE
- RETAINING WALL
- TREES AREA
- DRAIN AND NULLAH
- BRIDGE AND CULVERT
- BOULDERS
- WATER TANK
- SPRING
- JAMAT KHANA
- HFL
- HELIPAD
- SLIDING
- ROCK

0 25 50 75 100 125m

SCALE

NOTE.

1. ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED
2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FILED OBSERVATIONS.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Ehsan | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE | PROJECT AREA TOPOGRAPHIC SURVEY (Sheet 13 of 20) |
| CHECKED: Ehsan | | |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 2,000 |
| | | DWG No.: APS-TS-214 |
| | | REVISIONS |

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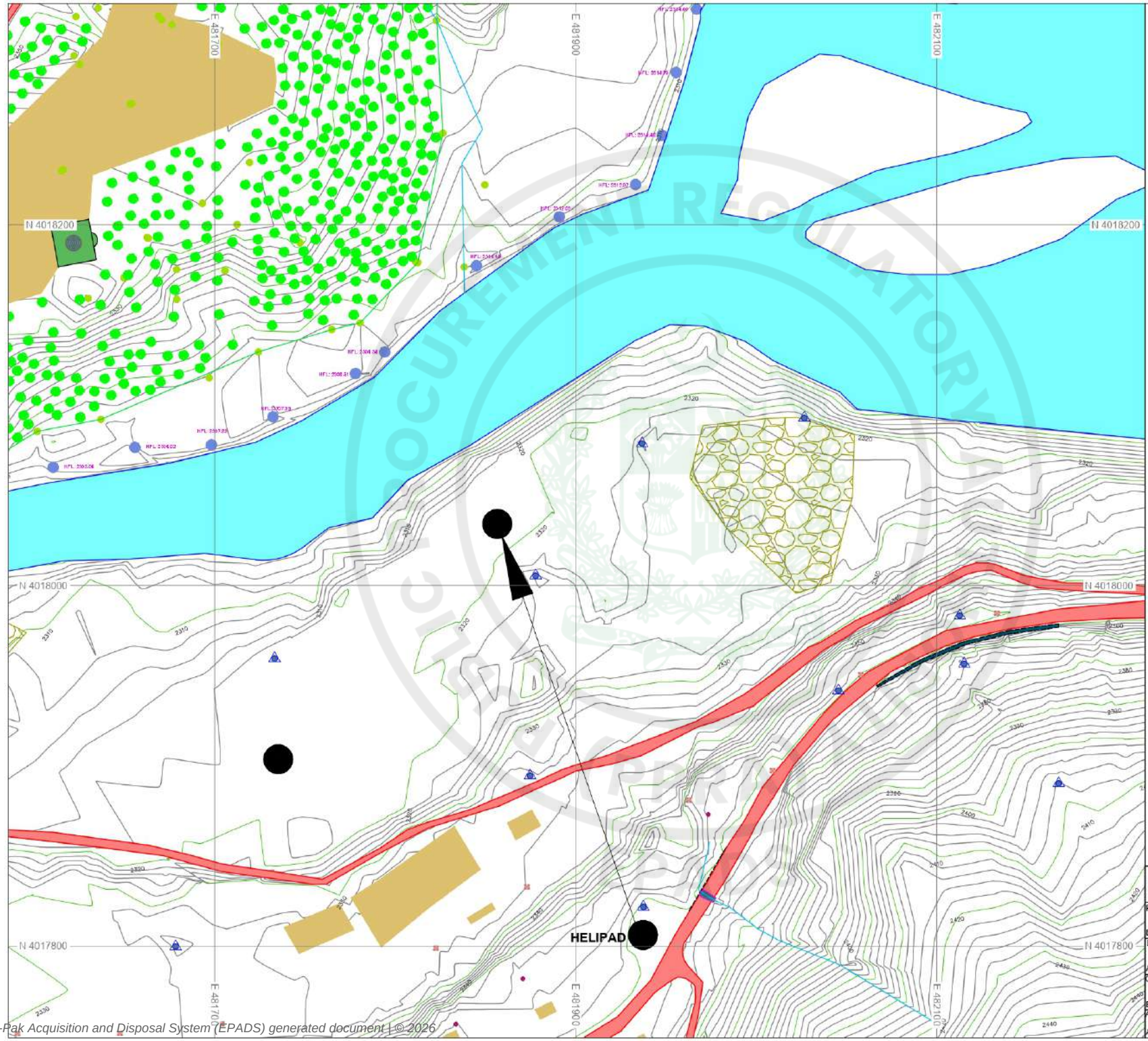


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## KEY PLAN

| | | | | | | |
|---|---|---|---|---|---|---|
| | 16 | 13 | 10 | 7 | 4 | 1 |
| | 17 | 14 | 11 | 8 | 5 | 2 |
| 19 | 18 | 15 | 12 | 9 | 6 | 3 |
| 20 | | | | | | |

## LEGENDS:

- RIVER/NALLA
- HOUSES/SHOPS
- ROADS
- KATCHA ROAD/TRACK
- CONTROL POINTS
- CONTOURS
- ELECTRIC POLE/T.POLE
- RETAINING WALL
- TREES AREA
- DRAIN AND NULLAH
- BRIDGE AND CULVERT
- BOULDERS
- WATER TANK
- SPRING
- JAMAT KHANA
- HFL
- HELIPAD
- SLIDING
- ROCK

0 25 50 75 100 125m

SCALE

NOTE.

1. ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED
2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FILED OBSERVATIONS.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Ehsan | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE | PROJECT AREA TOPOGRAPHIC SURVEY (Sheet 14 of 20) |
| CHECKED: Ehsan | | |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 2,000 |
| | | DWG No.: APS-TS-2147 |
| | | REVISIONS |

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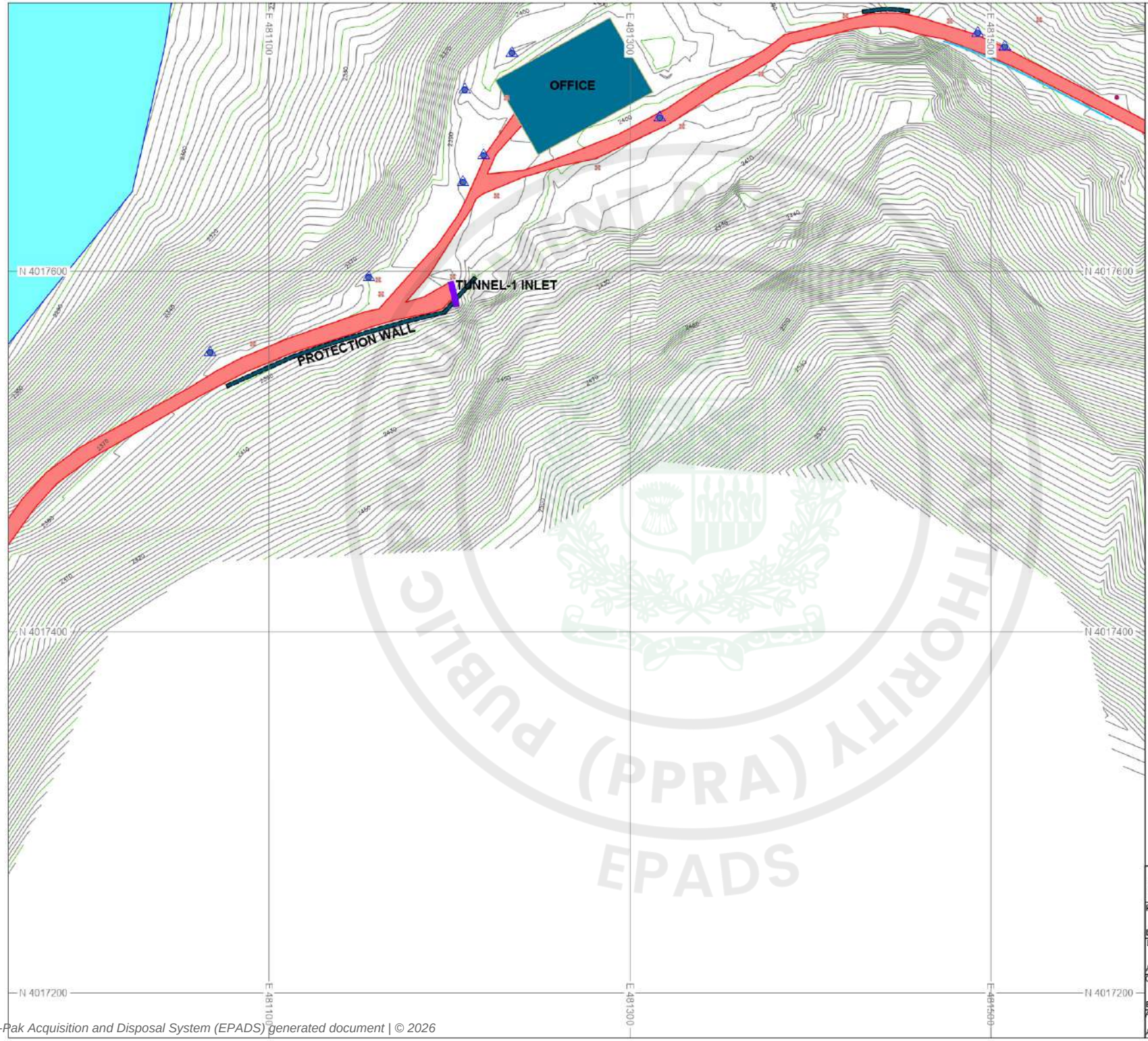
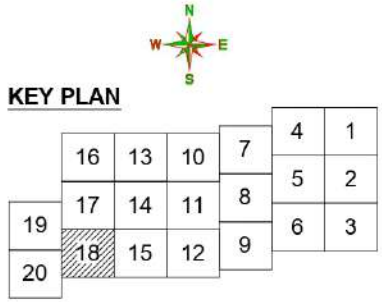



## KEY PLAN




## LEGENDS:

- RIVER/NALLA
- HOUSES/SHOPS
- ROADS
- KATCHA ROAD/TRACK
- CONTROL POINTS
- CONTOURS
- ELECTRIC POLE/T.POLE
- RETAINING WALL
- TREES AREA
- DRAIN AND NULLAH
- BRIDGE AND CULVERT
- BOULDERS
- WATER TANK
- SPRING
- JAMAT KHANA
- HFL
- HELIPAD
- SLIDING
- ROCK

0 25 50 75 100 125m

SCALE

NOTE.

1. ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED
2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FILED OBSERVATIONS.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Ehsan | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE | PROJECT AREA TOPOGRAPHIC SURVEY (Sheet 18 of 20) |
| CHECKED: Ehsan | | |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 2,000 |
| | | DWG No.: APS-TS-218 |
| | | REVISIONS |

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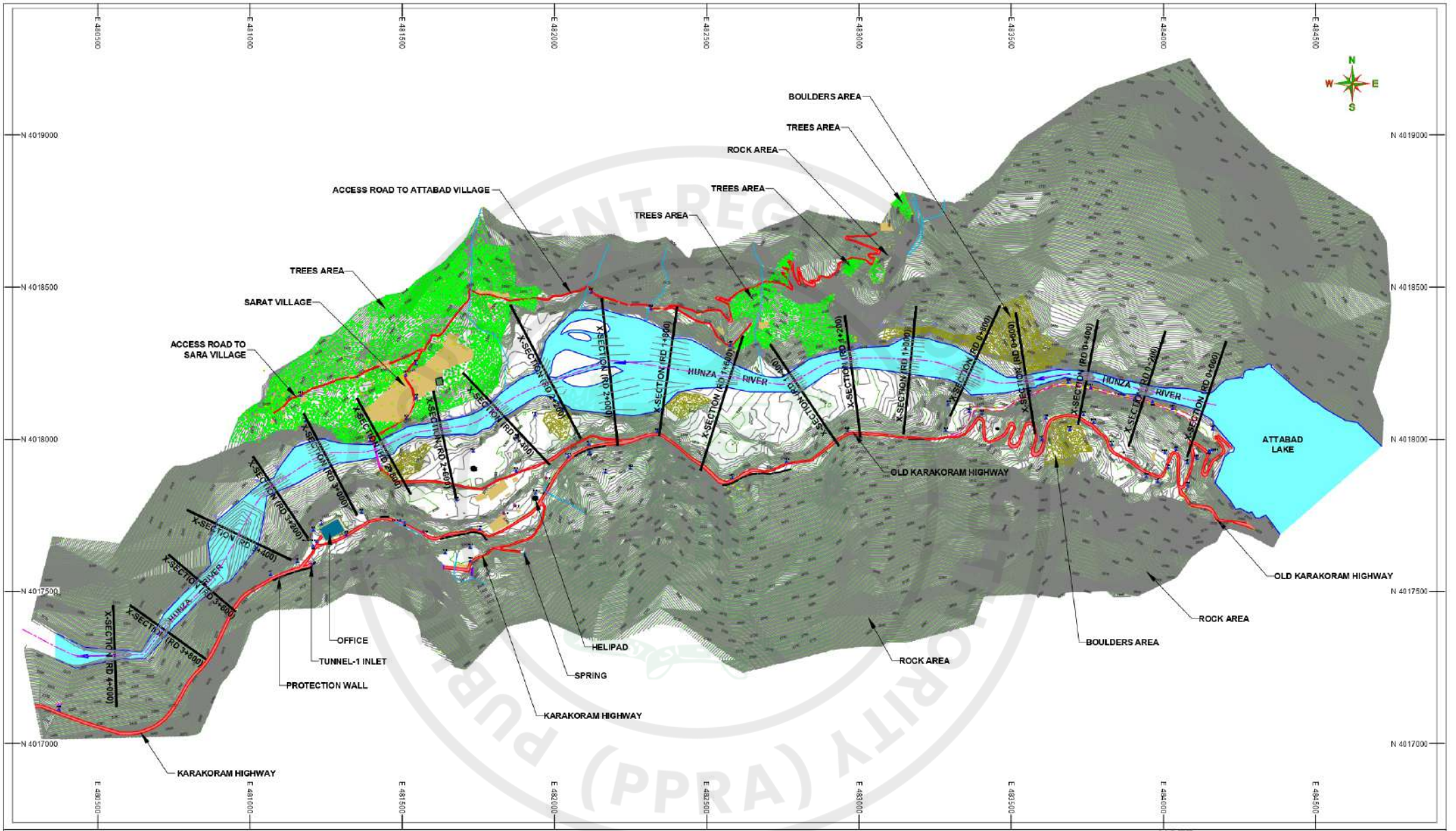


**LEGENDS:**

- RIVER/NALLA
- HOUSES/SHOPS
- ROAD
- KATCHA ROAD/TRACK
- CONTROL POINTS
- CONTOURS
- ELECTRIC POLE/T.POLE
- RETAINING WALL
- TREES AREA
- DRAIN AND NULLAH
- BRIDGE AND CULVERT
- BOULDERS
- X-SECTION (RD 1+200)
- WATER TANK
- SPRING
- JAMAT KHANA
- HFL
- HELLIPAD
- SLIDING
- ROCK

100 0 100 200 300 400 500m
SCALE

NOTE.
1. ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED
2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FILED OBSERVATIONS.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| PREPARED | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
|---|---|---|
| Ehsan | | |
| DRAWN | TITLE | PROJECT AREA CROSS SECTION PLAN |
| Arshad | | |
| CHECKED | | |
| Ehsan | | |
| APPROVED | DATE | SCALE | DWG No. | REVISIONS |
| Abid Sheikh | Jun: 2021 | 1 : 12,000 | APS-CS-231 | |

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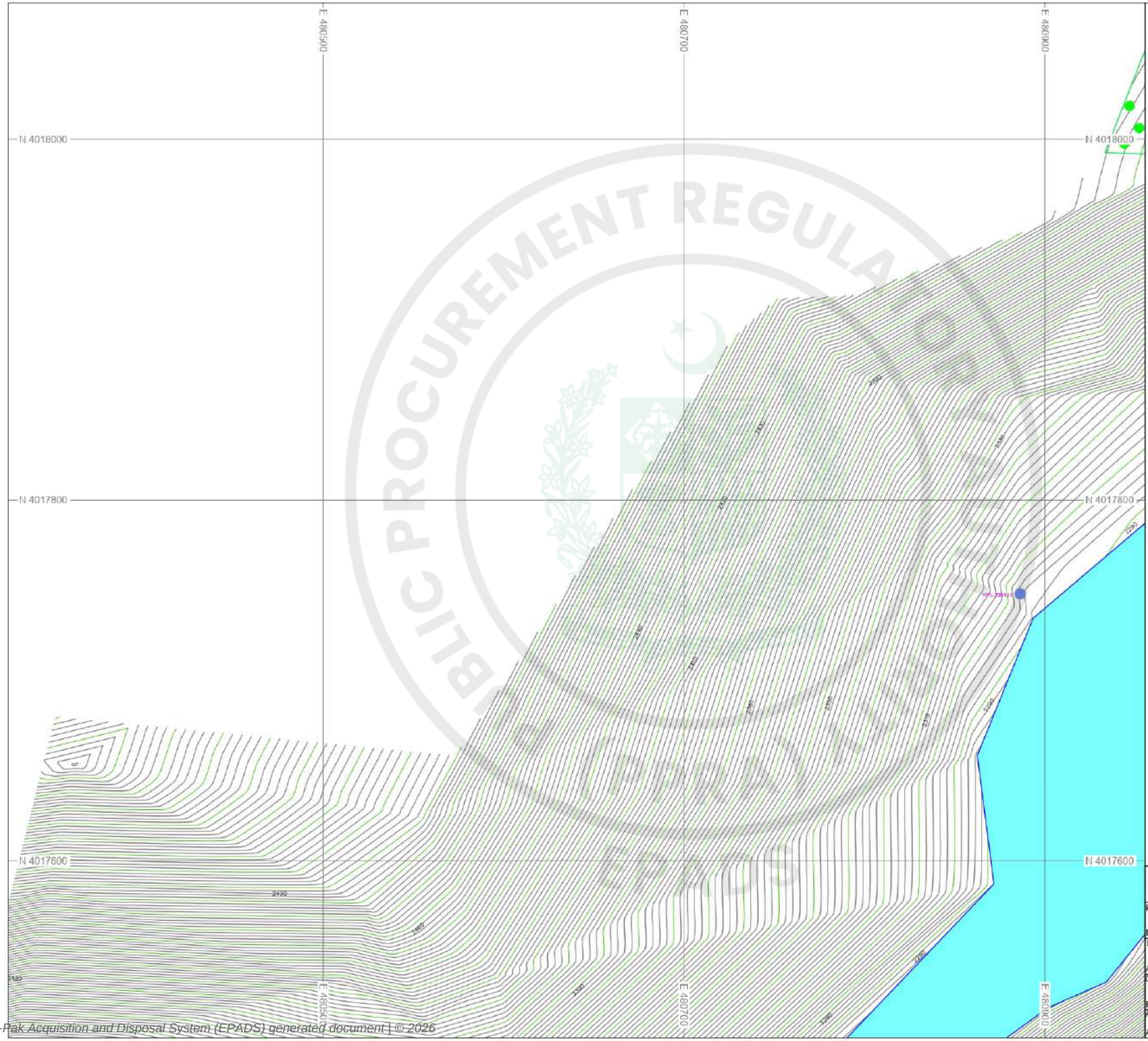
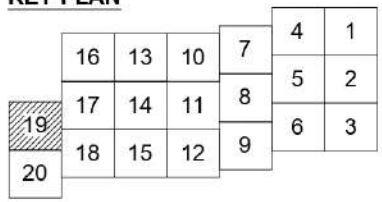



## KEY PLAN




## LEGENDS:

- RIVER/NALLA
- HOUSES/SHOPS
- ROADS
- KATCHA ROAD/TRACK
- CONTROL POINTS
- CONTOURS
- ELECTRIC POLE/T.POLE
- RETAINING WALL
- TREES AREA
- DRAIN AND NULLAH
- BRIDGE AND CULVERT
- BOULDERS
- WATER TANK
- SPRING
- JAMAT KHANA
- HFL
- HELIPAD
- SLIDING
- ROCK

0 25 50 75 100 125m

SCALE

NOTE.

1. ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED
2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FILED OBSERVATIONS.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Ehsan | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE | PROJECT AREA TOPOGRAPHIC SURVEY (Sheet 19 of 20) |
| CHECKED: Ehsan | | |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 2,000 |
| | | DWG No.: APS-TS-220 |
| | | REVISIONS |

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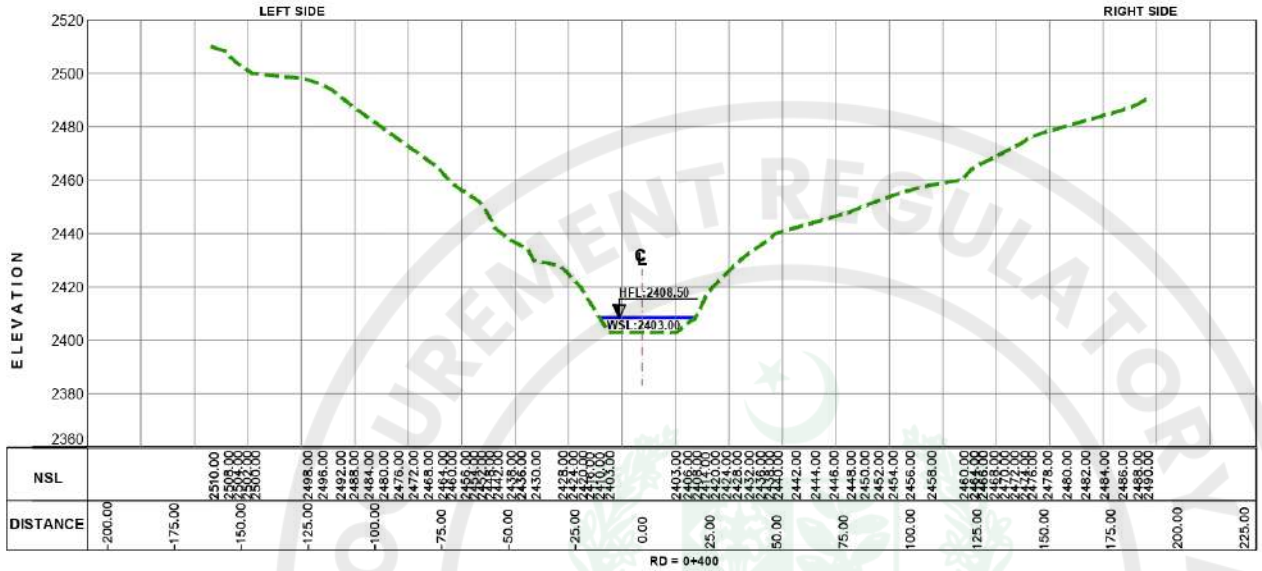


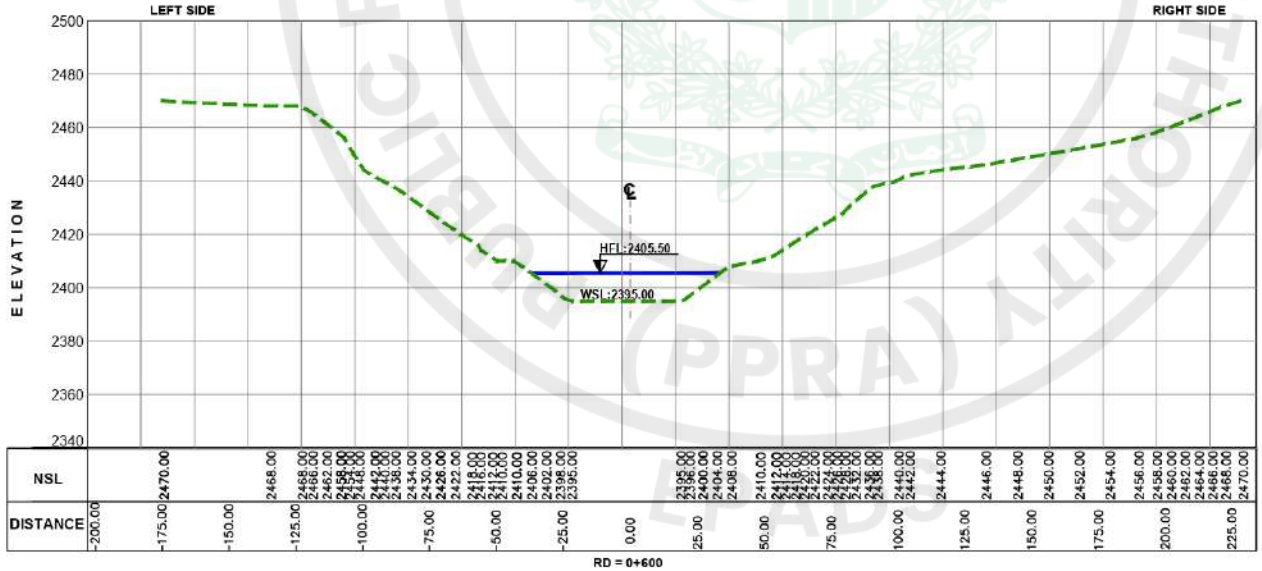


20 0 20 40 60 80 100 m

SCALE

**NOTE:**

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS UNLESS OTHERWISE SPECIFIED.

| | | |
|---|---|---|
| PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | | |
| PREPARED<br>Ehsan | PROJECT | **ATTABAD LAKE HPP**<br>**FEASIBILITY STUDY REPORT** |
| DRAWN<br>Arshad | TITLE | **HUNZA RIVER**<br>**X - SECTION AT RD. 0+400 & 0+600**<br>(Sheet 2 of 10) |
| CHECKED<br>Ehsan | | |
| APPROVED<br>Abid Sheikh | DATE<br>Jun: 2021 | SCALE<br>1 : 2,000 |
| | DWG No.<br>APS-CS-233 | REVISIONS |

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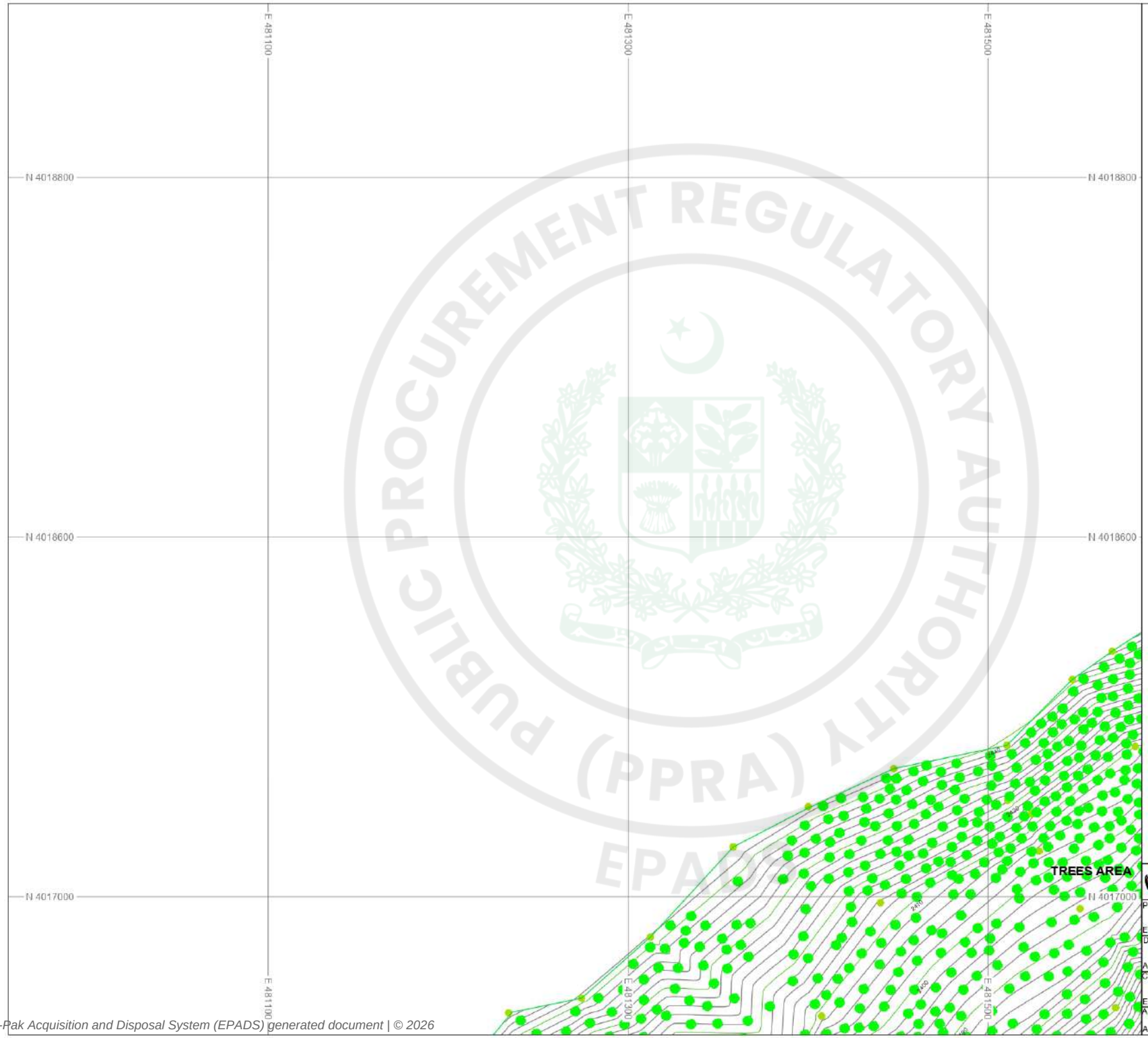
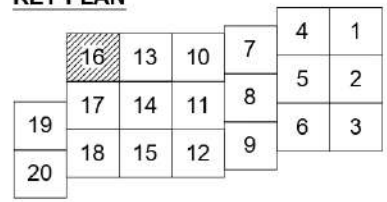



## KEY PLAN




## LEGENDS:

- RIVER/NALLA
- HOUSES/SHOPS
- ROADS
- KATCHA ROAD/TRACK
- CONTROL POINTS
- CONTOURS
- ELECTRIC POLE/T.POLE
- RETAINING WALL
- TREES AREA
- DRAIN AND NULLAH
- BRIDGE AND CULVERT
- BOULDERS
- WATER TANK
- SPRING
- JAMAT KHANA
- HFL
- HELIPAD
- SLIDING
- ROCK

0 25 50 75 100 125m

SCALE

NOTE.

1. ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED
2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FILED OBSERVATIONS.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| PREPARED | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
|---|---|---|
| Ehsan | | |
| DRAWN | TITLE | PROJECT AREA TOPOGRAPHIC SURVEY (Sheet 16 of 20) |
| Arshad | | |
| CHECKED | | |
| Ehsan | | |
| APPROVED | DATE | SCALE / DWG No. / REVISIONS |
| Abid Sheikh | Jun: 2021 | 1 : 2,000 / APS-TS-2417 |

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

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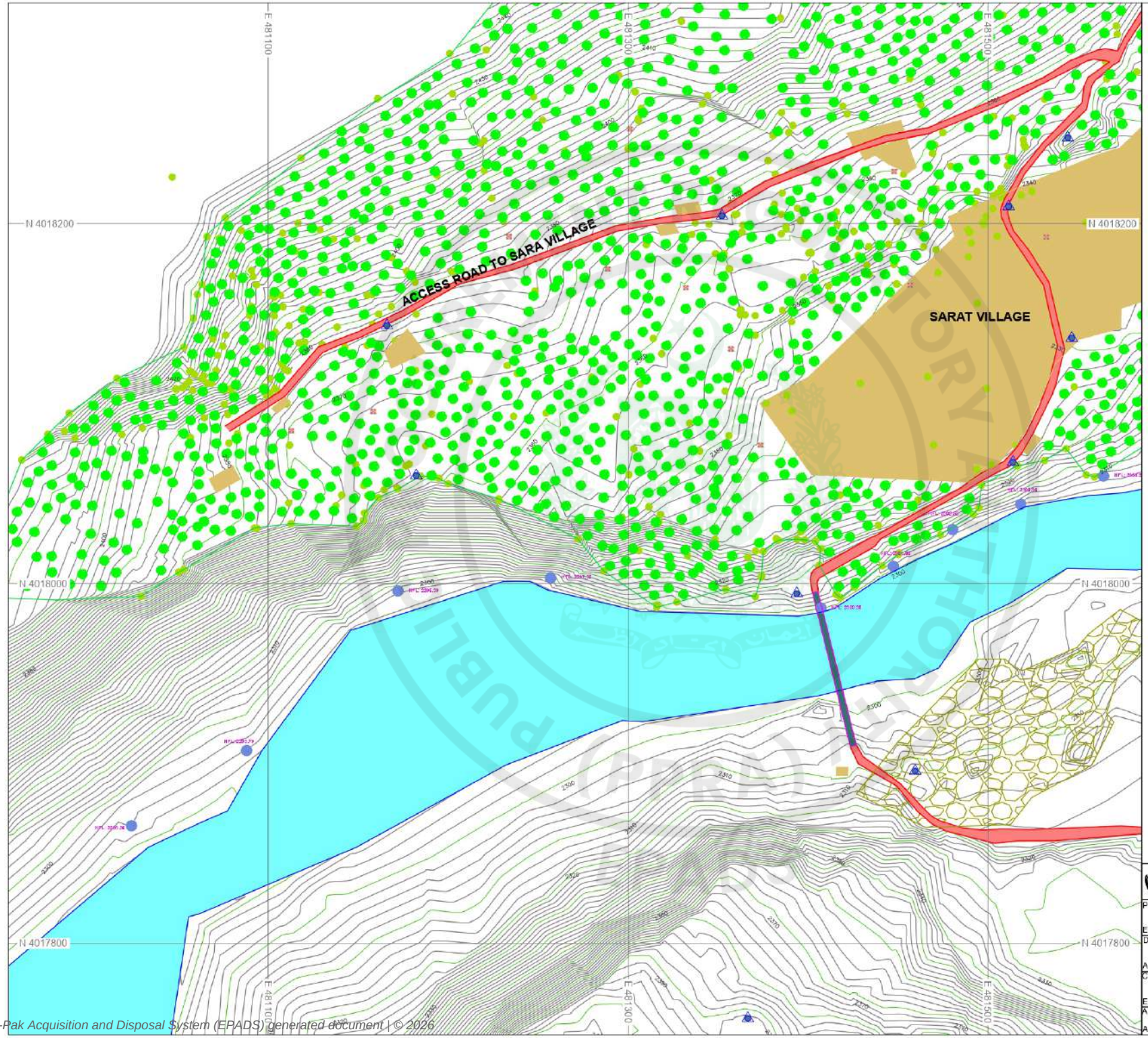


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## KEY PLAN

| | | | | | | |
|---|---|---|---|---|---|---|
| | 16 | 13 | 10 | 7 | 4 | 1 |
| | 17 | 14 | 11 | 8 | 5 | 2 |
| 19 | 18 | 15 | 12 | 9 | 6 | 3 |
| 20 | | | | | | |

## LEGENDS:

- RIVER/NALLA
- HOUSES/SHOPS
- ROADS
- KATCHA ROAD/TRACK
- CONTROL POINTS
- CONTOURS
- ELECTRIC POLE/T.POLE
- RETAINING WALL
- TREES AREA
- DRAIN AND NULLAH
- BRIDGE AND CULVERT
- BOULDERS
- WATER TANK
- SPRING
- JAMAT KHANA
- HFL
- HELIPAD
- SLIDING
- ROCK

0 25 50 75 100 125m

SCALE

NOTE.

1. ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED
2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FILED OBSERVATIONS.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Ehsan | PROJECT | ATTABAD LAKE HPP<br>FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE | PROJECT AREA<br>TOPOGRAPHIC SURVEY<br>(Sheet 17 of 20) |
| CHECKED: Ehsan | | |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 2,000 |
| | | DWG No.: APS-TS-218 |
| | | REVISIONS |

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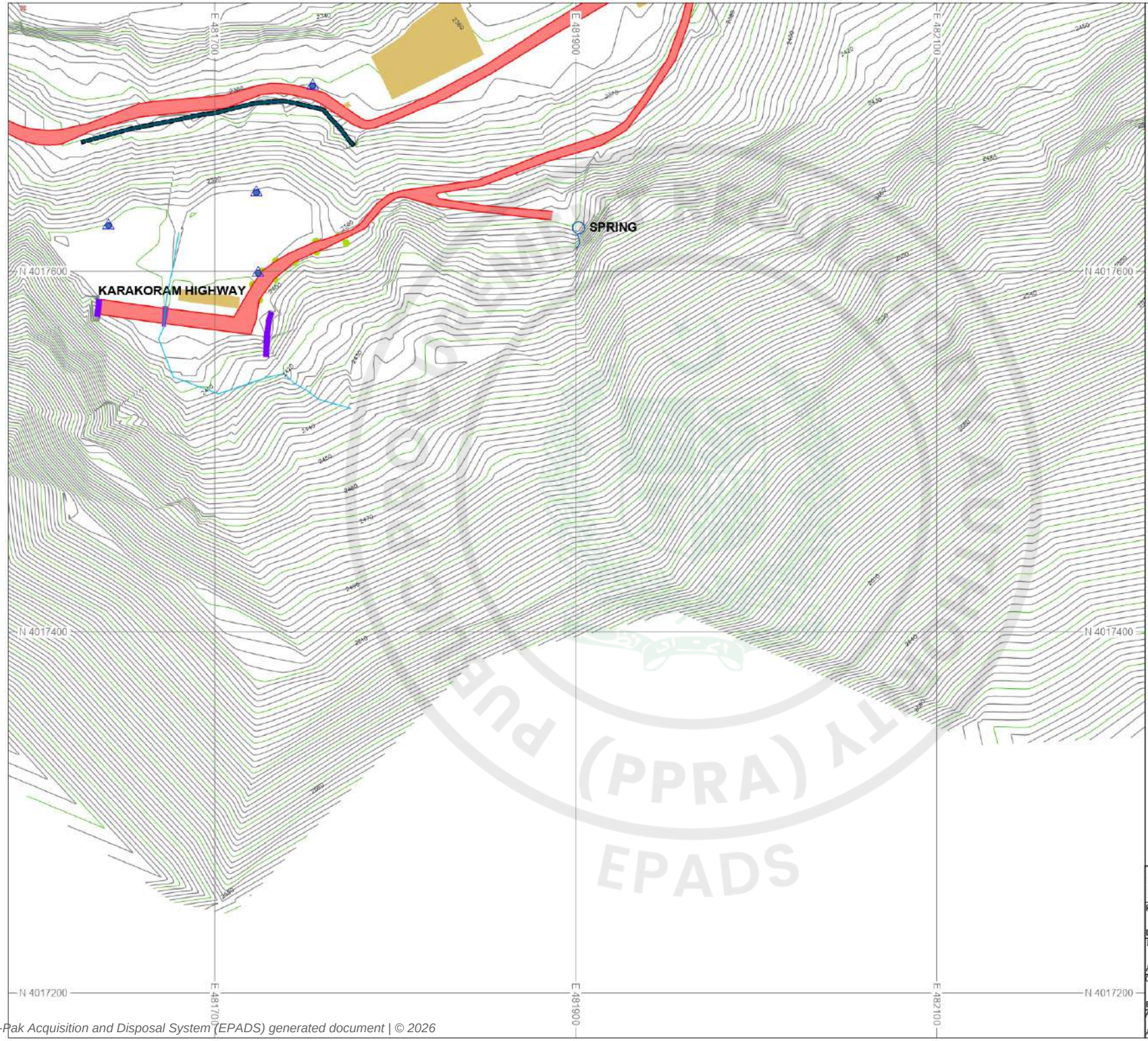
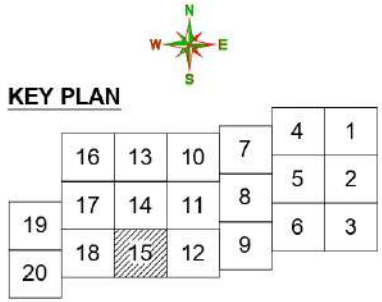



## KEY PLAN




## LEGENDS:

- RIVER/NALLA
- HOUSES/SHOPS
- ROADS
- KATCHA ROAD/TRACK
- CONTROL POINTS
- CONTOURS
- ELECTRIC POLE/T.POLE
- RETAINING WALL
- TREES AREA
- DRAIN AND NULLAH
- BRIDGE AND CULVERT
- BOULDERS
- WATER TANK
- SPRING
- JAMAT KHANA
- HFL
- HELIPAD
- SLIDING
- ROCK

0 25 50 75 100 125m

SCALE

NOTE.

1. ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED
2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FILED OBSERVATIONS.

**PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY**
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Ehsan | PROJECT | **ATTABAD LAKE HPP FEASIBILITY STUDY REPORT** |
| DRAWN: Arshad | TITLE | **PROJECT AREA TOPOGRAPHIC SURVEY** (Sheet 15 of 20) |
| CHECKED: Ehsan | | |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 2,000 |
| | | DWG No.: APS-TS-216 |
| | | REVISIONS |

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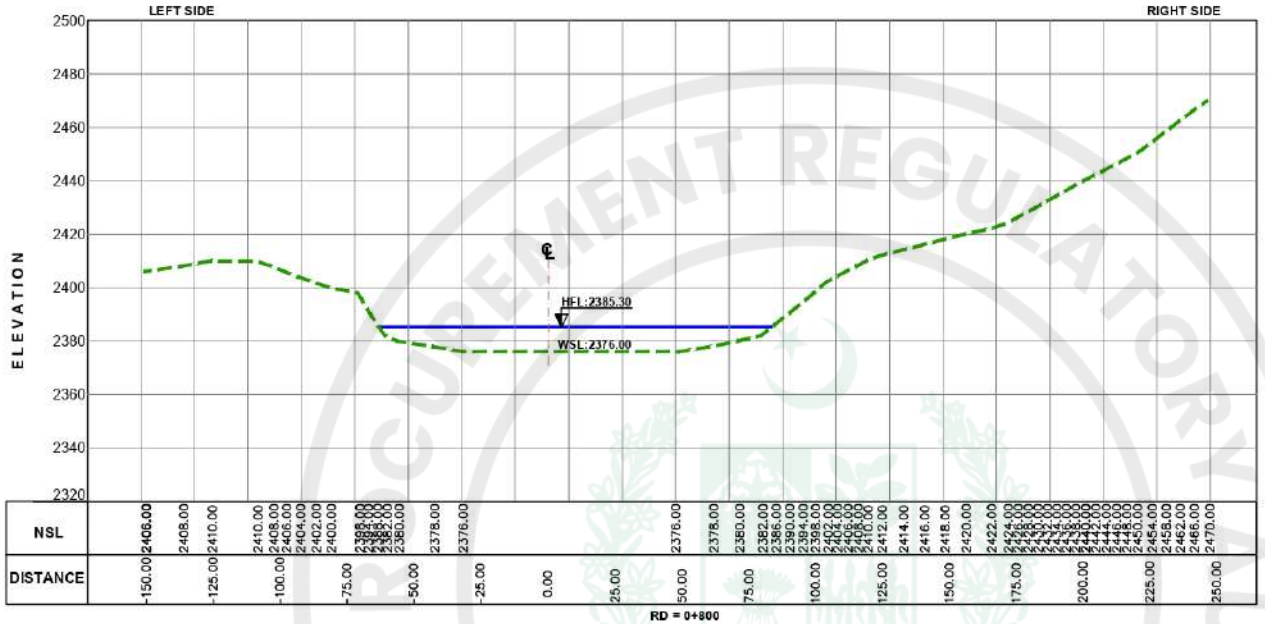


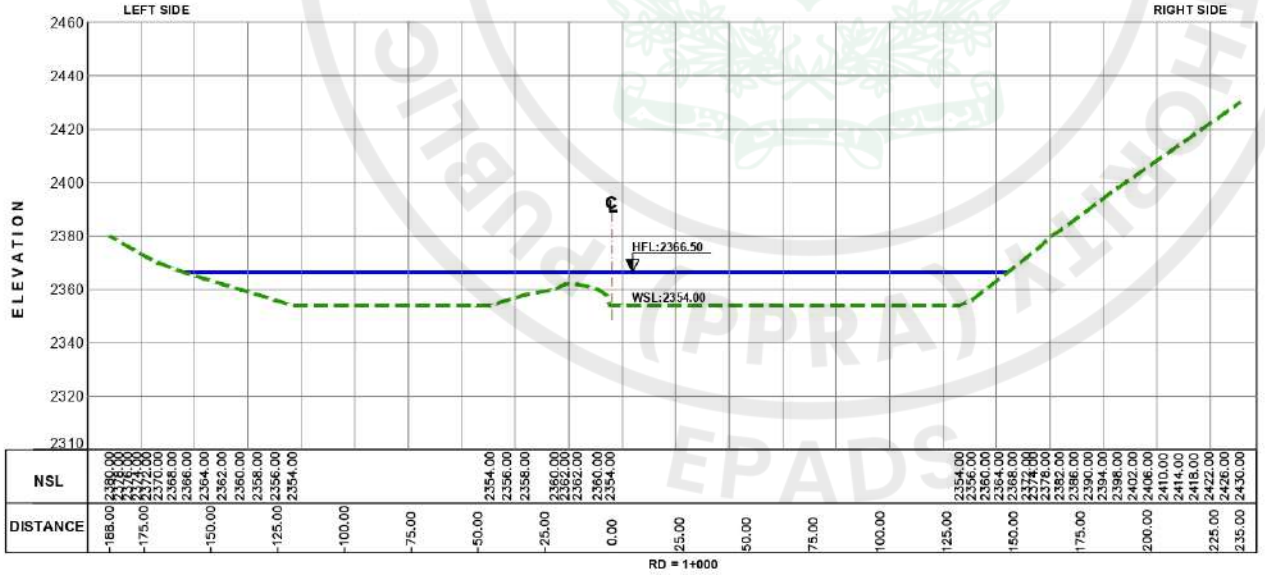


20 0 20 40 60 80 100 m

SCALE

**NOTE:**

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS UNLESS OTHERWISE SPECIFIED.

| | | |
|---|---|---|
| PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | | |
| PREPARED<br>Ehsan | PROJECT | **ATTABAD LAKE HPP**<br>**FEASIBILITY STUDY REPORT** |
| DRAWN<br>Arshad | TITLE | **HUNZA RIVER**<br>**X - SECTION AT RD. 0+800 & 1+000**<br>(Sheet 3 of 10) |
| CHECKED<br>Ehsan | | |
| APPROVED<br>Abid Sheikh | DATE<br>Jun: 2021 | SCALE<br>1 : 2,000 |
| | DWG No.<br>APS-CS-234 | REVISIONS |

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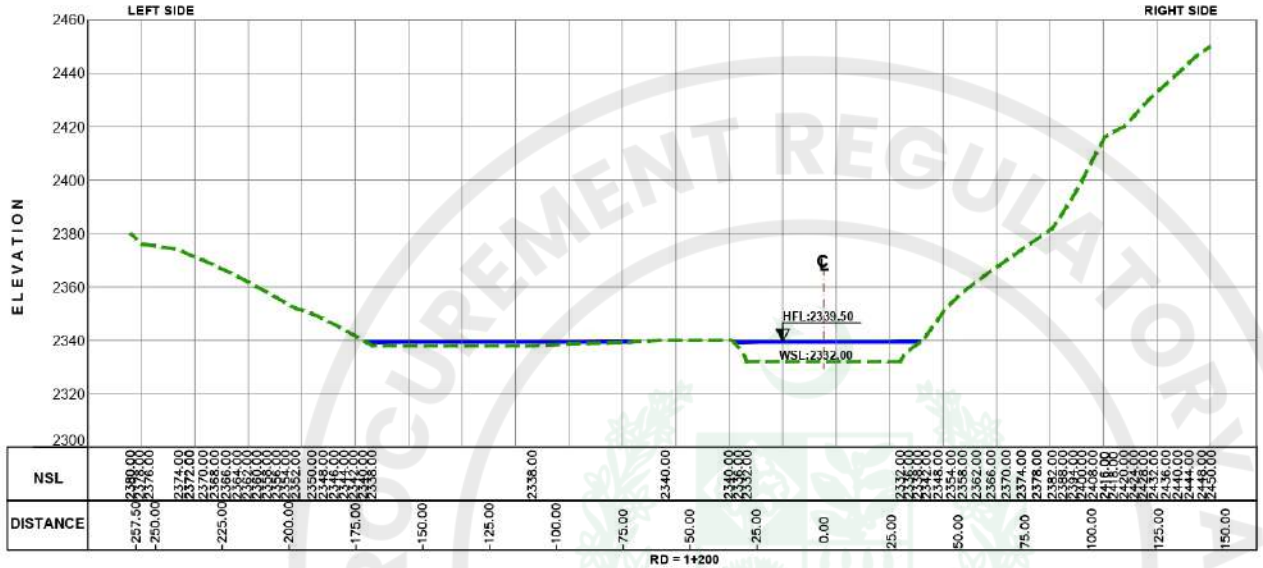


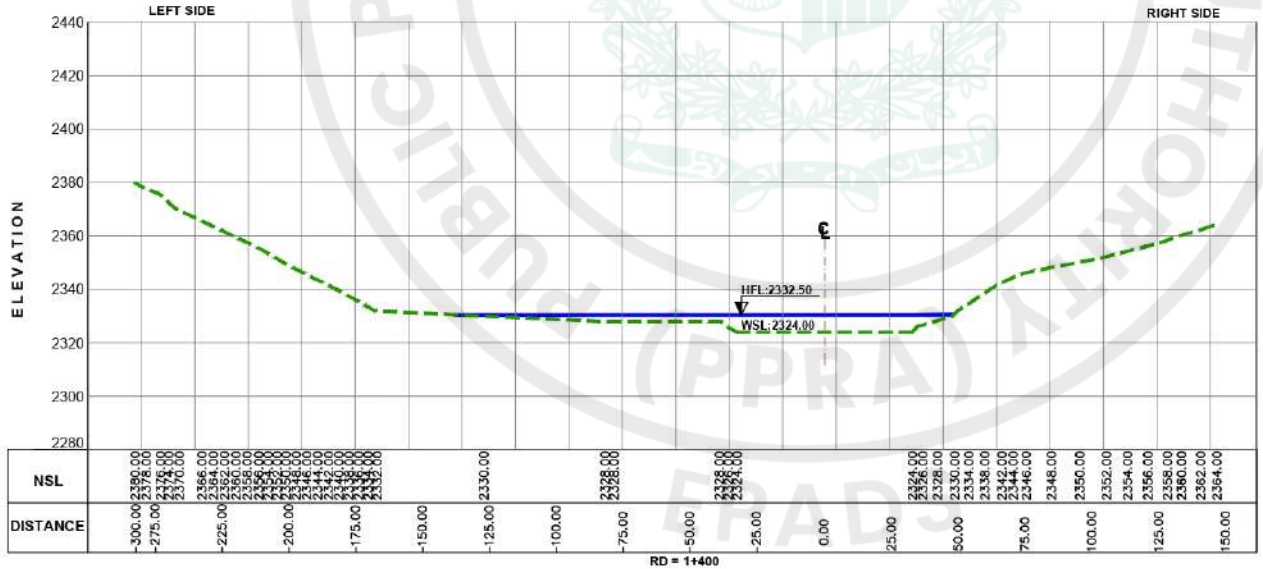


20 0 20 40 60 80 100 m

SCALE

**NOTE:**

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS UNLESS OTHERWISE SPECIFIED.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Ehsan | PROJECT | **ATTABAD LAKE HPP**<br>**FEASIBILITY STUDY REPORT** |
| DRAWN: Arshad | TITLE | **HUNZA RIVER**<br>**X - SECTION AT RD. 1+200 & 1+400**<br>(Sheet 4 of 10) |
| CHECKED: Ehsan | | |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 2,000 / 1 : 200 |
| | DWG No: APS-CS-2357 | REVISIONS |

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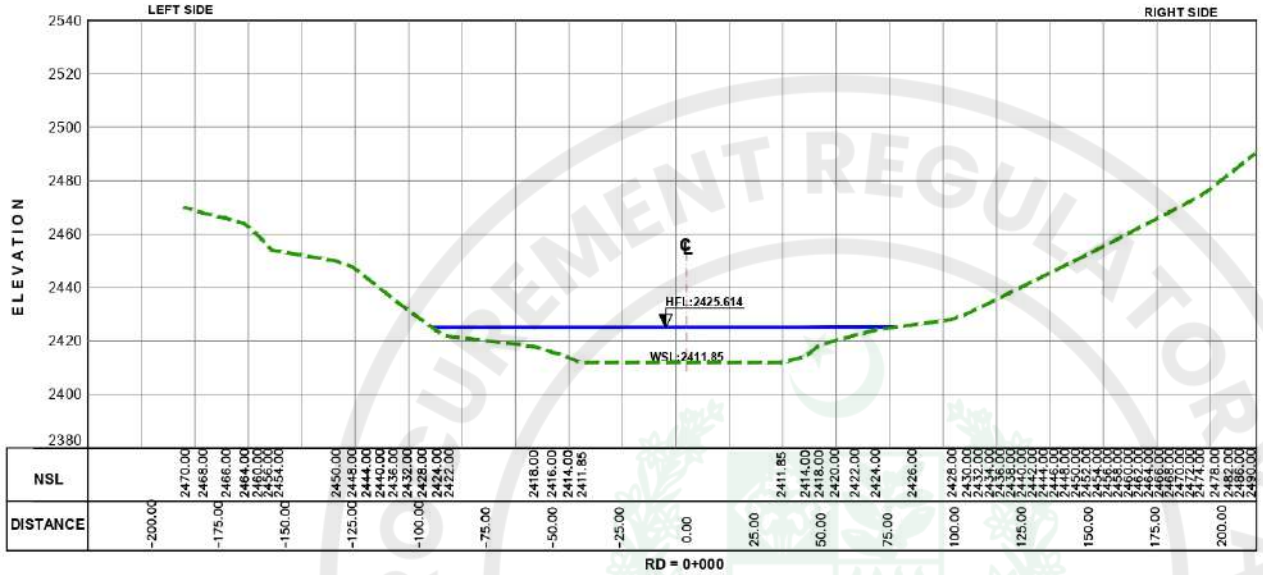


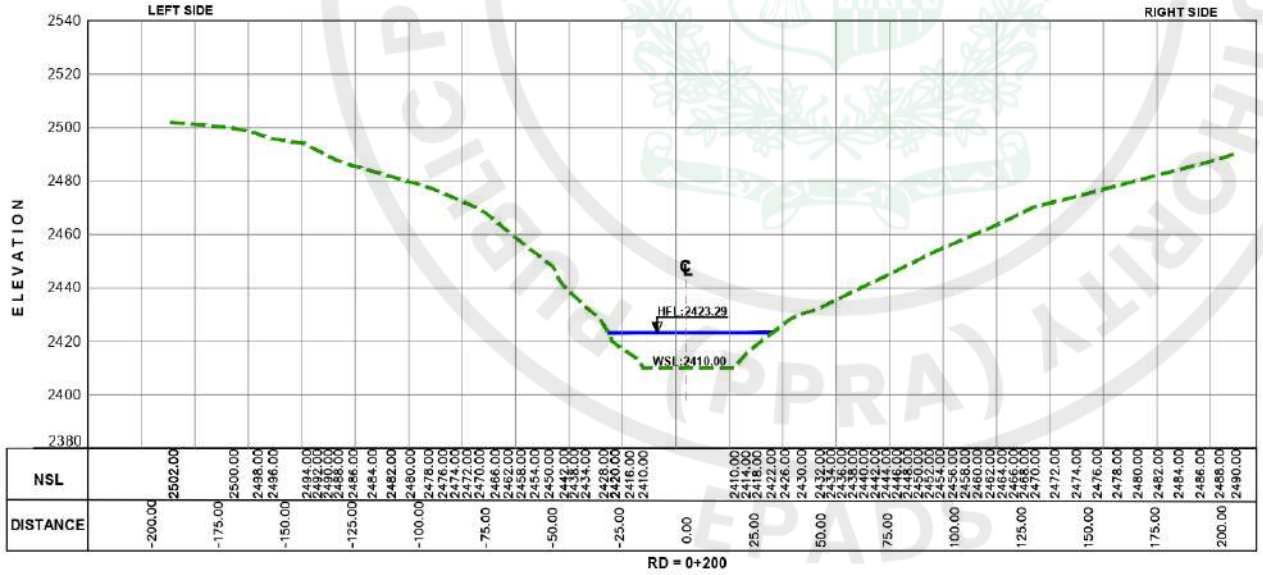


20 0 20 40 60 80 100 m

SCALE

**NOTE:**

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS UNLESS OTHERWISE SPECIFIED.

| | | |
|---|---|---|
| PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | | |
| PREPARED<br>Ehsan | PROJECT | **ATTABAD LAKE HPP**<br>**FEASIBILITY STUDY REPORT** |
| DRAWN<br>Arshad | TITLE | **HUNZA RIVER**<br>**X - SECTION AT RD. 0+000 & 0+200**<br>(Sheet 1 of 10) |
| CHECKED<br>Ehsan | | |
| APPROVED<br>Abid Sheikh | DATE<br>Jun: 2021 | SCALE<br>1 : 2,000 |
| | | DWG No.<br>APS-CS-232 |
| | | REVISIONS |

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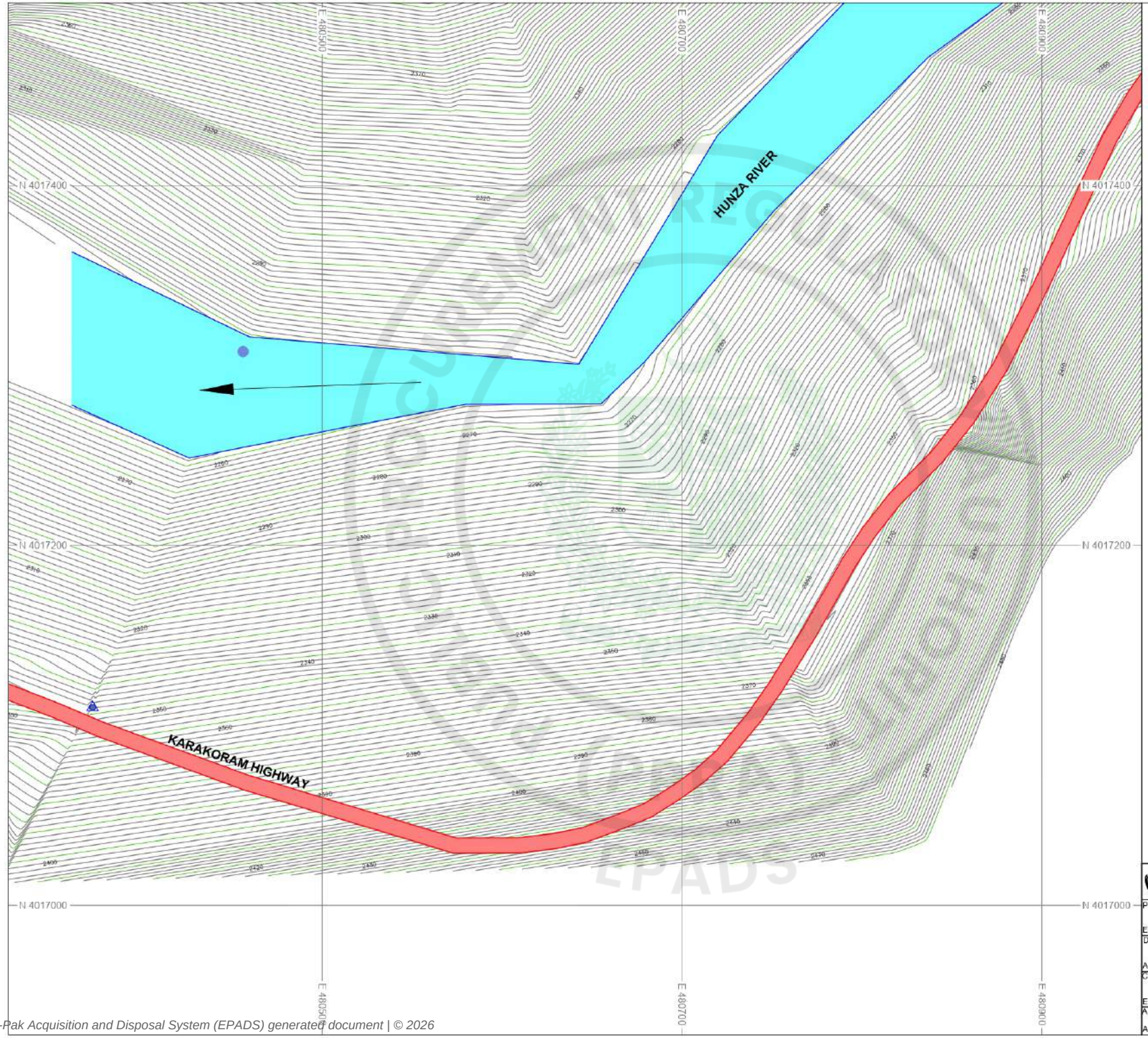
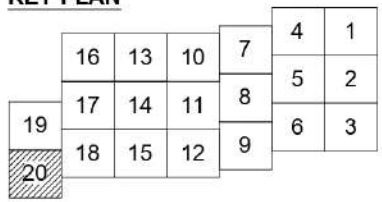



## KEY PLAN




## LEGENDS:

- RIVER/NALLA
- HOUSES/SHOPS
- ROADS
- KATCHA ROAD/TRACK
- CONTROL POINTS
- CONTOURS
- ELECTRIC POLE/T.POLE
- RETAINING WALL
- TREES AREA
- DRAIN AND NULLAH
- BRIDGE AND CULVERT
- BOULDERS
- WATER TANK
- SPRING
- JAMAT KHANA
- HFL
- HELIPAD
- SLIDING
- ROCK

0 25 50 75 100 125m

SCALE

NOTE.

1. ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED
2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FILED OBSERVATIONS.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Ehsan | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE | PROJECT AREA TOPOGRAPHIC SURVEY (Sheet 20 of 20) |
| CHECKED: Ehsan | | |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 2,000 |
| | | DWG No.: APS-TS-221 |
| | | REVISIONS |

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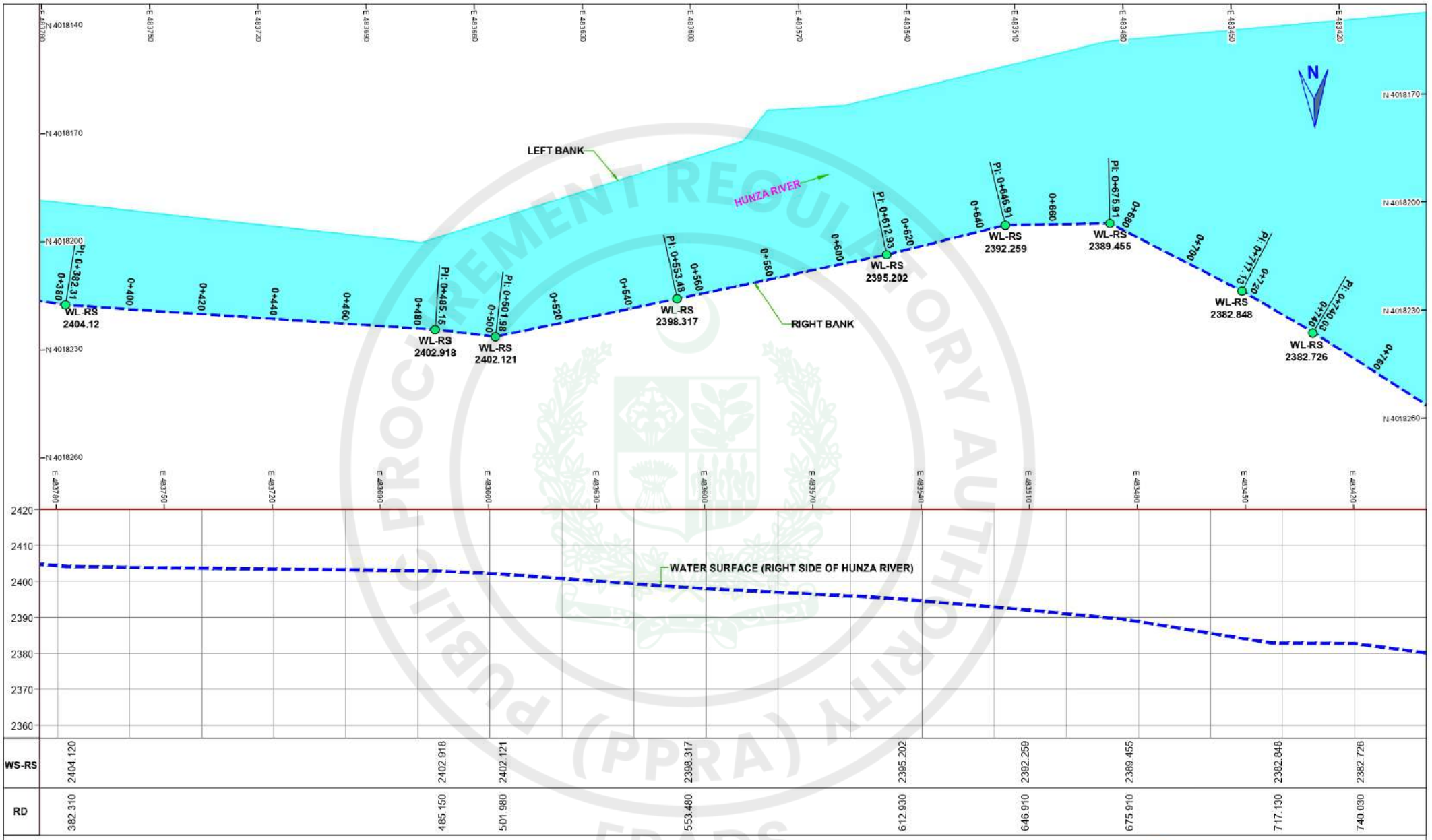


**NOTE:**

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS UNLESS OTHERWISE SPECIFIED.

10 0 10 20 30 40 50 m
SCALE

| | | |
|---|---|---|
| PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | | |
| PREPARED: Ehsan | PROJECT | ATTABAD LAKE HPP<br>FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE | WATER SURFACE PLAN AND PROFILE (HUNZA RIVER)<br>(Sheet 2 of 11) |
| CHECKED: Ehsan | | |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 1,000 / DWG No: APS-SP-282 / REVISIONS |

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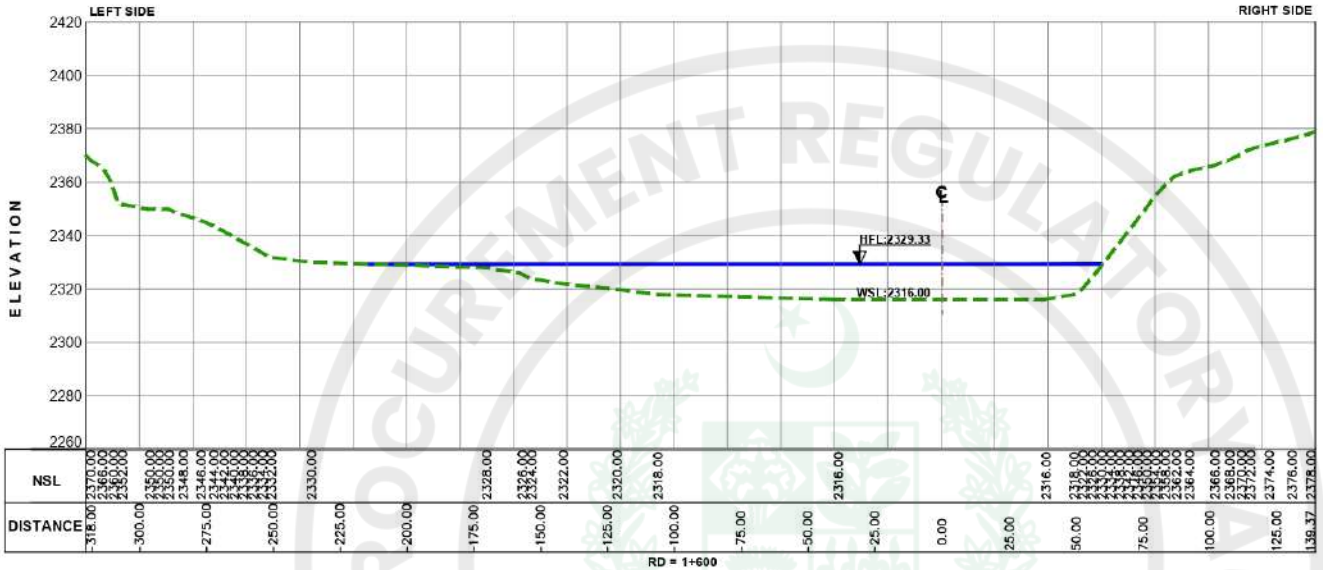
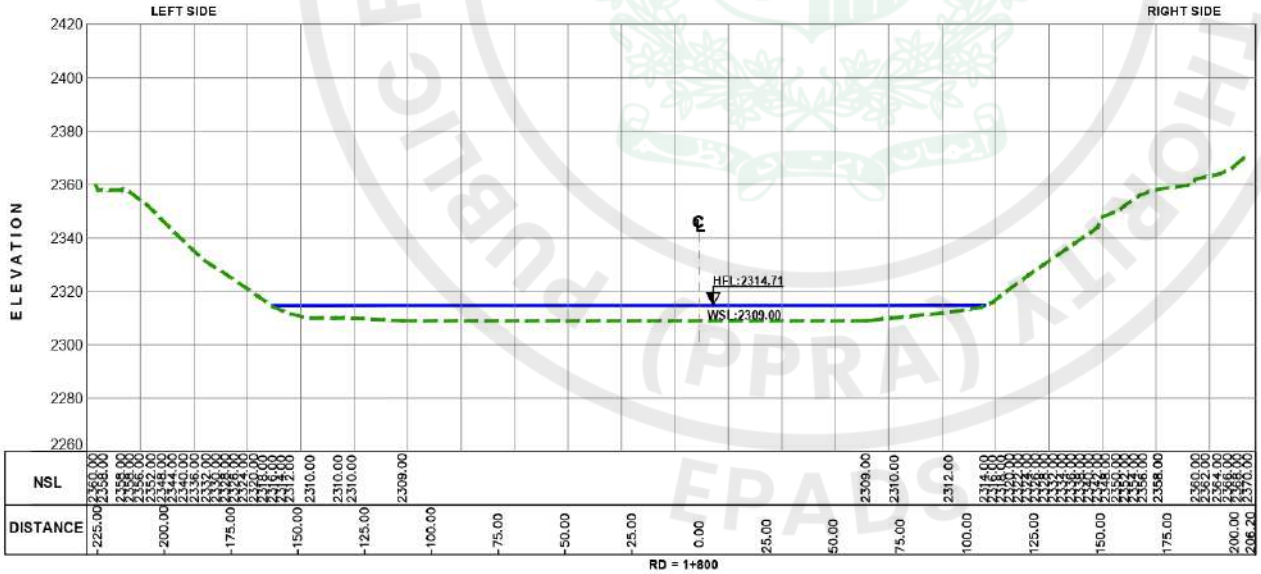
Page 1 of 1 | 270




20 0 20 40 60 80 100 m

SCALE

**NOTE:**

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS UNLESS OTHERWISE SPECIFIED.

| | | |
|---|---|---|
| | | PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION |
| PREPARED<br>Ehsan | PROJECT | **ATTABAD LAKE HPP**<br>**FEASIBILITY STUDY REPORT** |
| DRAWN<br>Arshad | TITLE | **HUNZA RIVER**<br>**X - SECTION AT RD. 1+600 & 1+800**<br>(Sheet 5 of 10) |
| CHECKED<br>Ehsan | | |
| APPROVED<br>Abid Sheikh | DATE<br>Jun: 2021 | SCALE<br>1 : 2,000 |
| | DWG No.<br>APS-CS-236 | REVISIONS |

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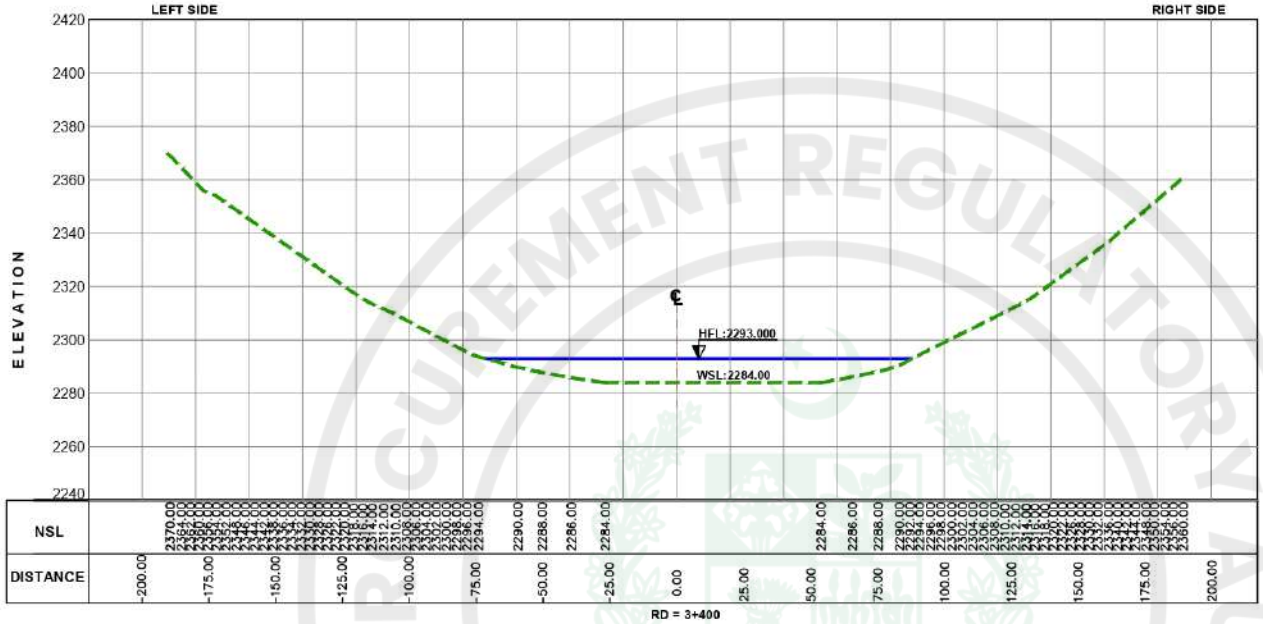


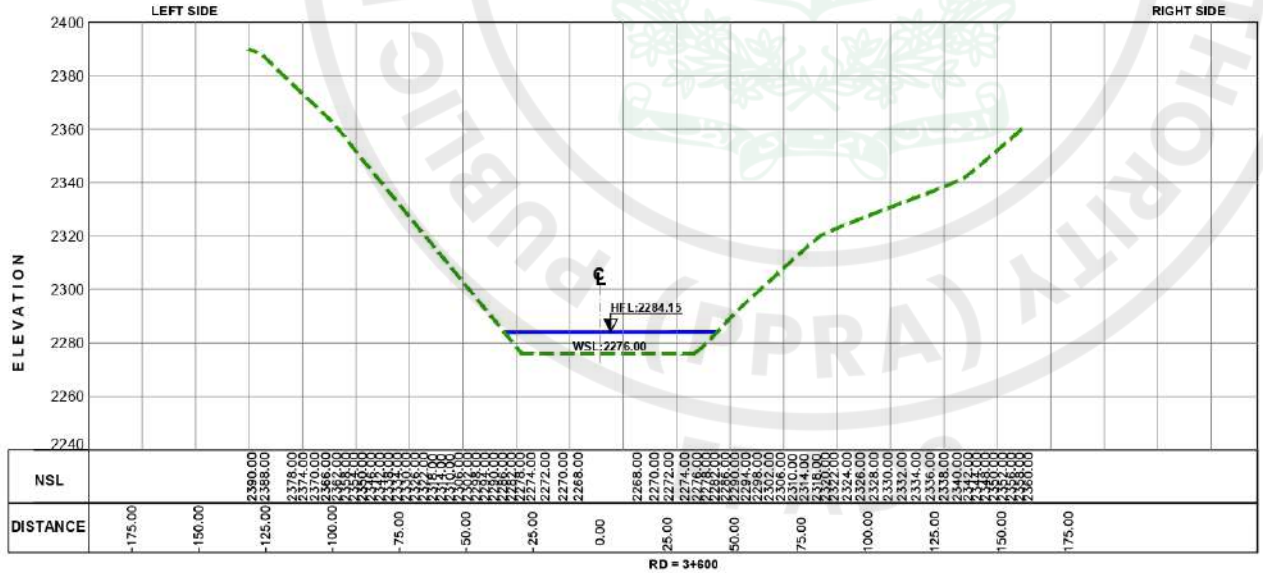


20 0 20 40 60 80 100 m

SCALE

**NOTE:**

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS UNLESS OTHERWISE SPECIFIED.

| | | |
|---|---|---|
| | PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | |
| PREPARED<br>Ehsan | PROJECT | **ATTABAD LAKE HPP**<br>**FEASIBILITY STUDY REPORT** |
| DRAWN<br>Arshad | TITLE | **HUNZA RIVER**<br>**X - SECTION AT RD. 3+400 & 3+600**<br>(Sheet 9 of 10) |
| CHECKED<br>Ehsan | | |
| APPROVED<br>Abid Sheikh | DATE<br>Jun: 2021 | SCALE<br>1 : 2,000 |
| | DWG No.<br>APS-CS-240 | REVISIONS |

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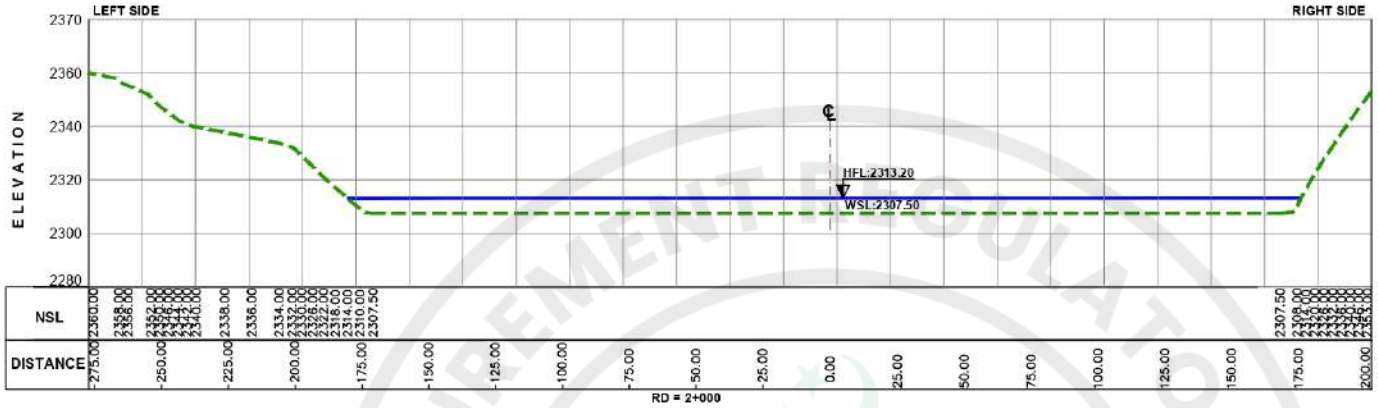


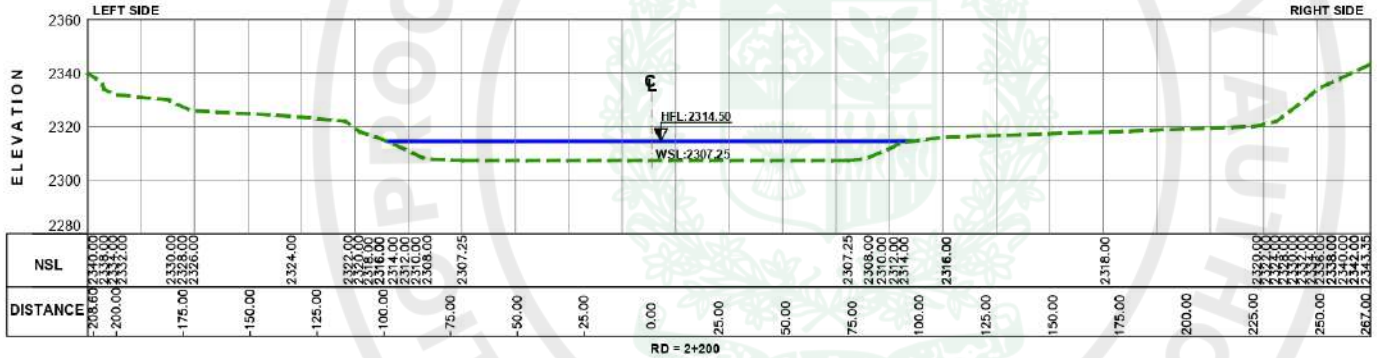


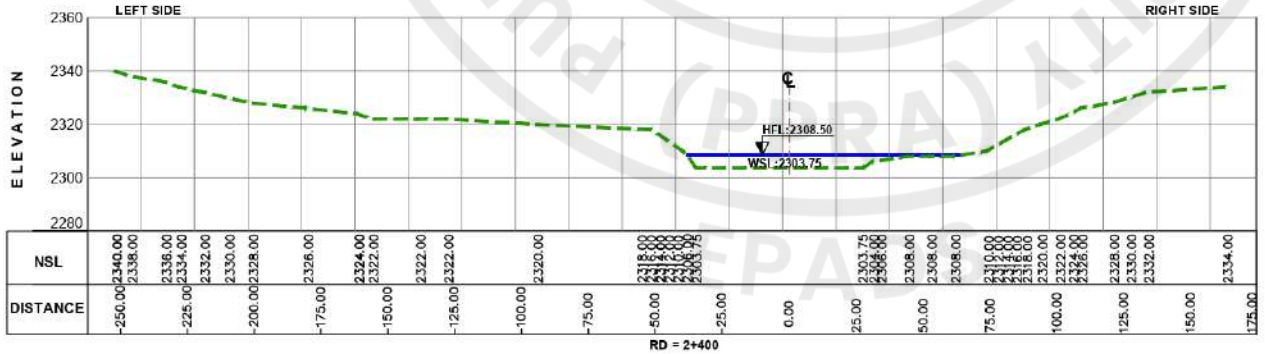


20 0 20 40 60 80 100 m

SCALE

**NOTE:**

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS UNLESS OTHERWISE SPECIFIED.

| | | |
|---|---|---|
| | PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | |
| PREPARED<br>Ehsan | PROJECT | **ATTABAD LAKE HPP**<br>**FEASIBILITY STUDY REPORT** |
| DRAWN<br>Arshad | TITLE | **HUNZA RIVER**<br>**X - SECTION AT RD. 2+000, 2+200 AND RD. 2+400**<br>(Sheet 6 of 10) |
| CHECKED<br>Ehsan | | |
| APPROVED<br>Abid Sheikh | DATE<br>Jun: 2021 | SCALE<br>1 : 2,000 |
| | DWG No.<br>APS-CS-237 | REVISIONS |

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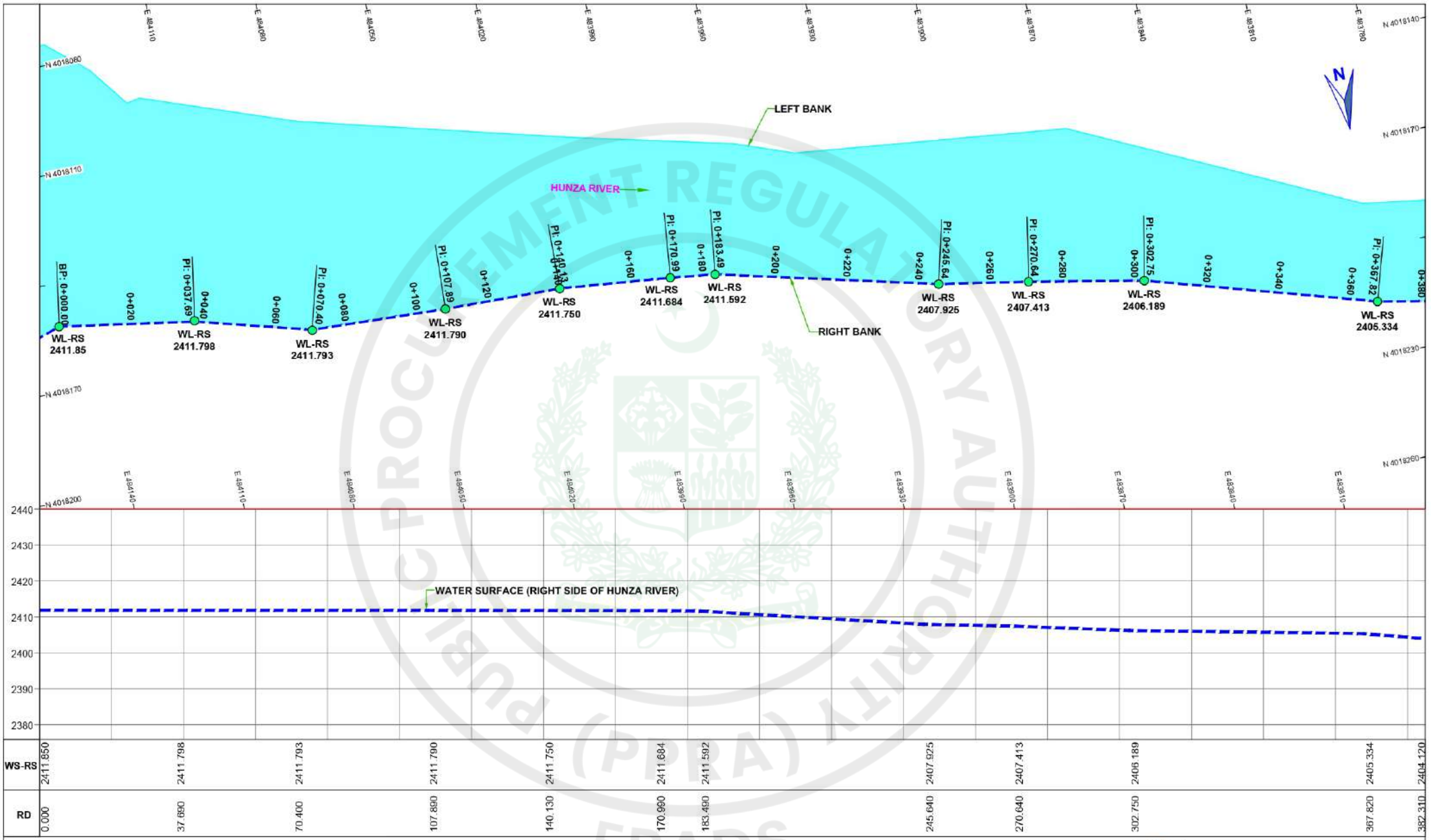


**NOTE:**

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS UNLESS OTHERWISE SPECIFIED.

10 0 10 20 30 40 50 m
SCALE

| | | |
|---|---|---|
| PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY | | |
| HYDRO PLANNING ORGANIZATION | | |
| PREPARED Ehsan | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN Arshad | TITLE | WATER SURFACE PLAN AND PROFILE (HUNZA RIVER) (Sheet 1 of 11) |
| CHECKED Ehsan | | |
| APPROVED Abid Sheikh | DATE Jun: 2021 | SCALE 1 : 1,000 |
| | | DWG No: AHS-SP-281 |
| | | REVISIONS |

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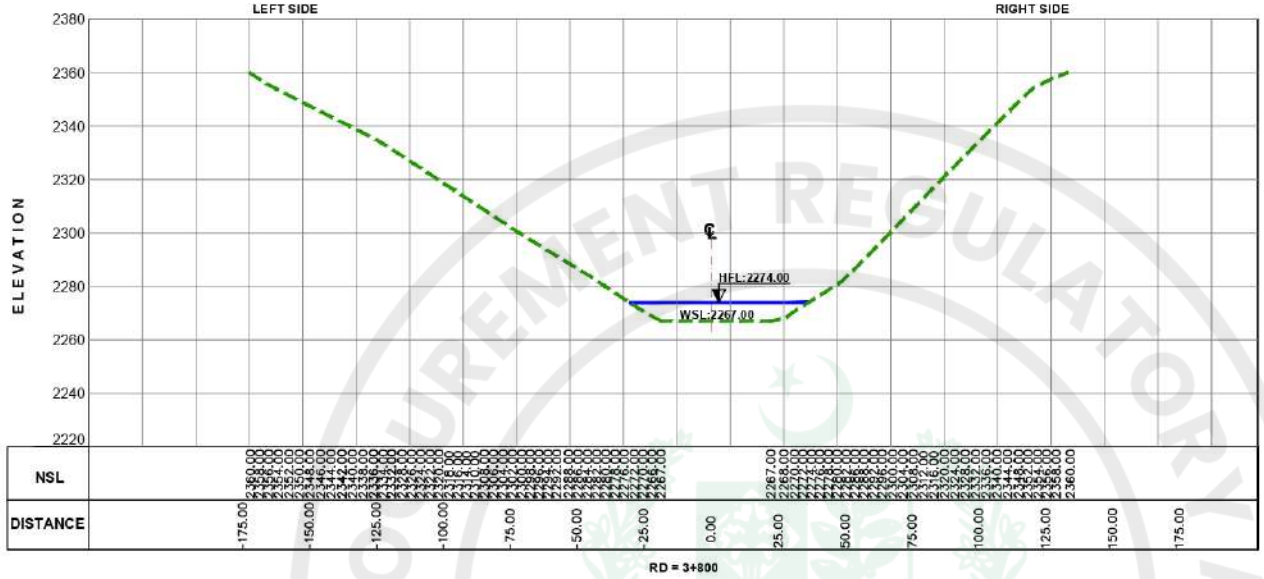


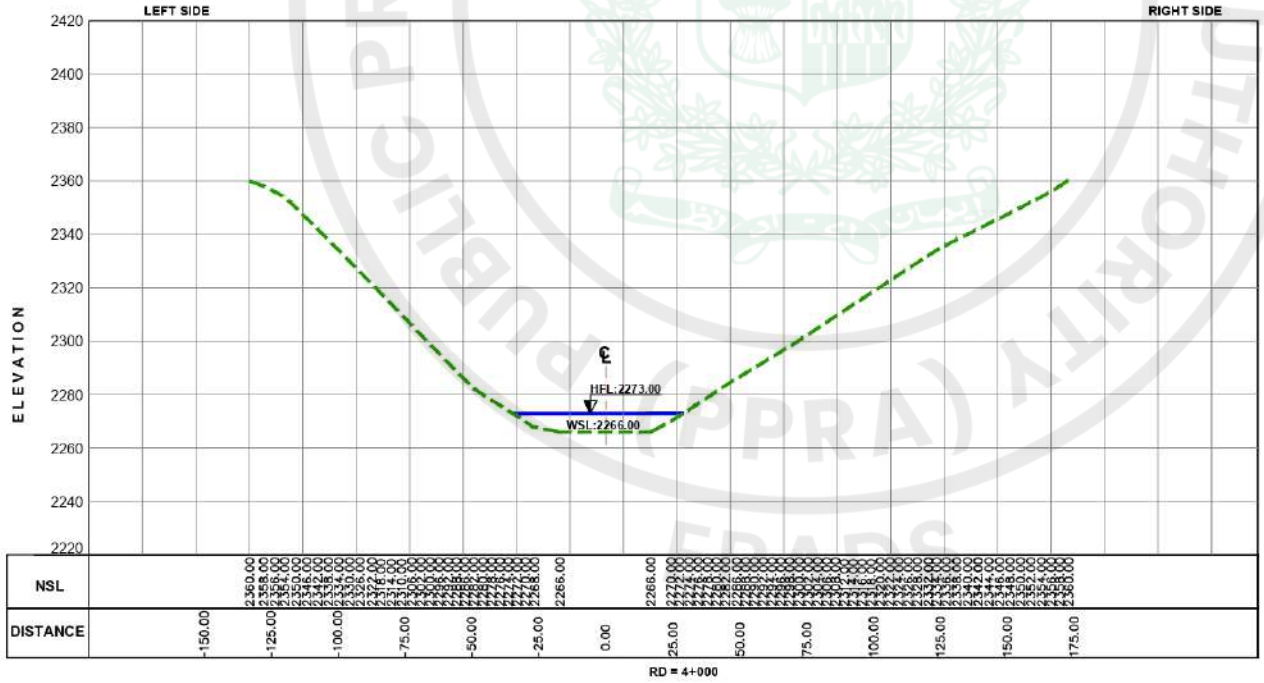


20 0 20 40 60 80 100 m
SCALE

**NOTE:**

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS UNLESS OTHERWISE SPECIFIED.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Ehsan | PROJECT | ATTABAD LAKE HPP<br>FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE | HUNZA RIVER<br>X - SECTION AT RD. 3+800 & 4+000<br>(Sheet 10 of 10) |
| CHECKED: Ehsan | | |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 2,000 / DWG No: APS-CS-241 / REVISIONS |

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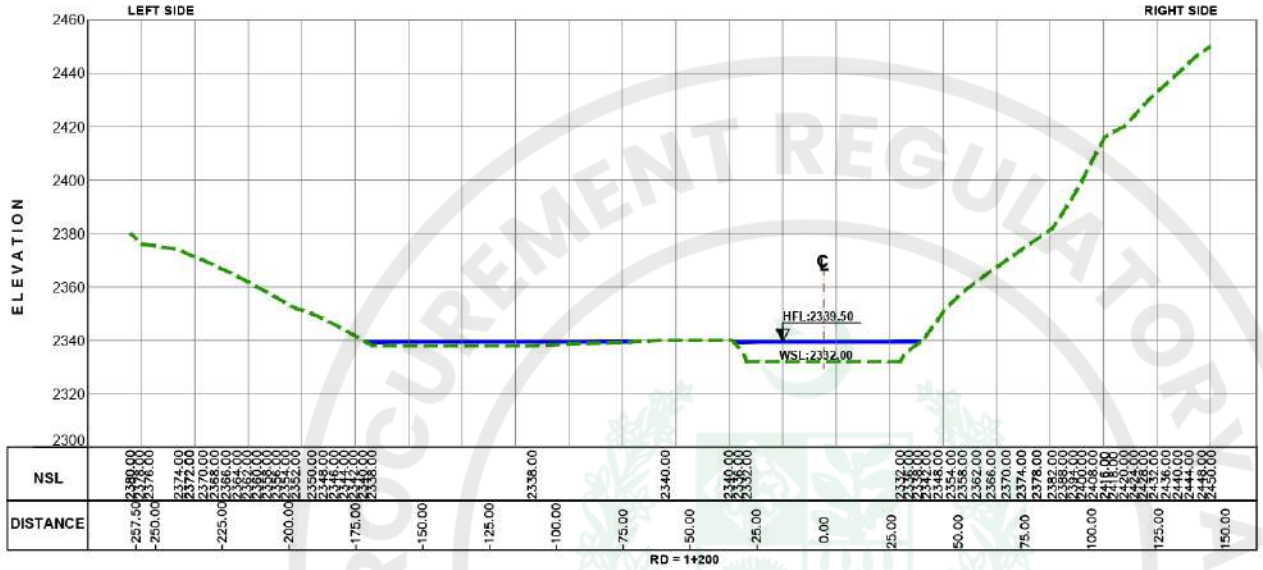


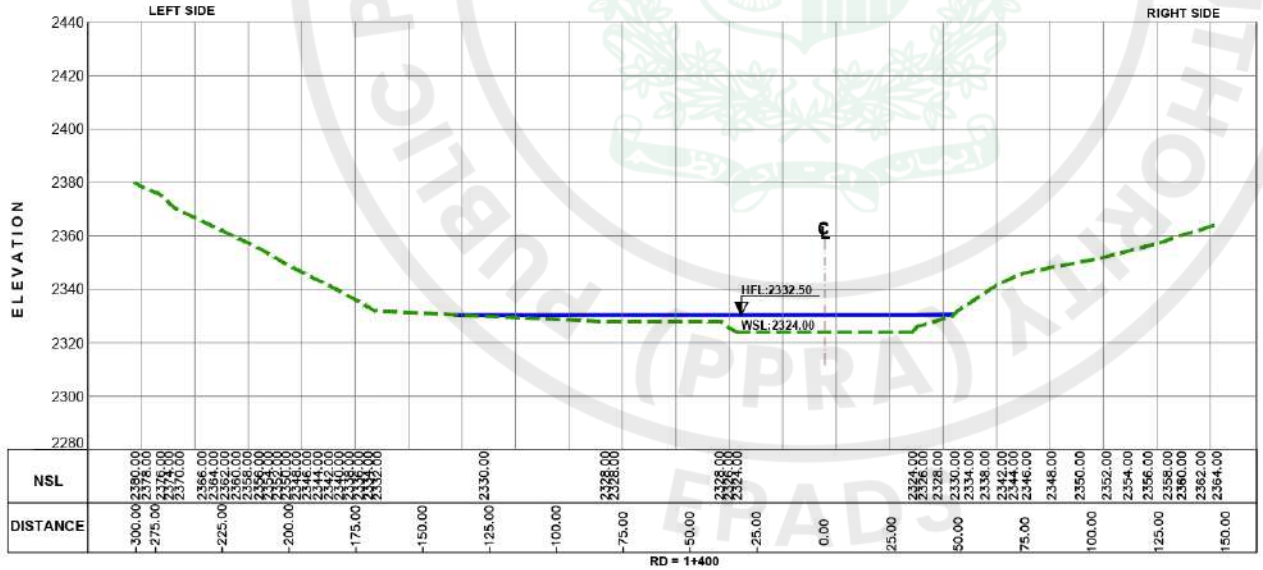


20 0 20 40 60 80 100 m

SCALE

**NOTE:**

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS UNLESS OTHERWISE SPECIFIED.

| | | |
|---|---|---|
| | PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | |
| PREPARED<br>Ehsan | PROJECT | **ATTABAD LAKE HPP**<br>**FEASIBILITY STUDY REPORT** |
| DRAWN<br>Arshad | TITLE | **HUNZA RIVER**<br>**X - SECTION AT RD. 1+200 & 1+400**<br>(Sheet 4 of 10) |
| CHECKED<br>Ehsan | | |
| APPROVED<br>Abid Sheikh | DATE<br>Jun: 2021 | SCALE<br>1 : 2,000 |
| | DWG No.<br>APS-CS-235 | REVISIONS |

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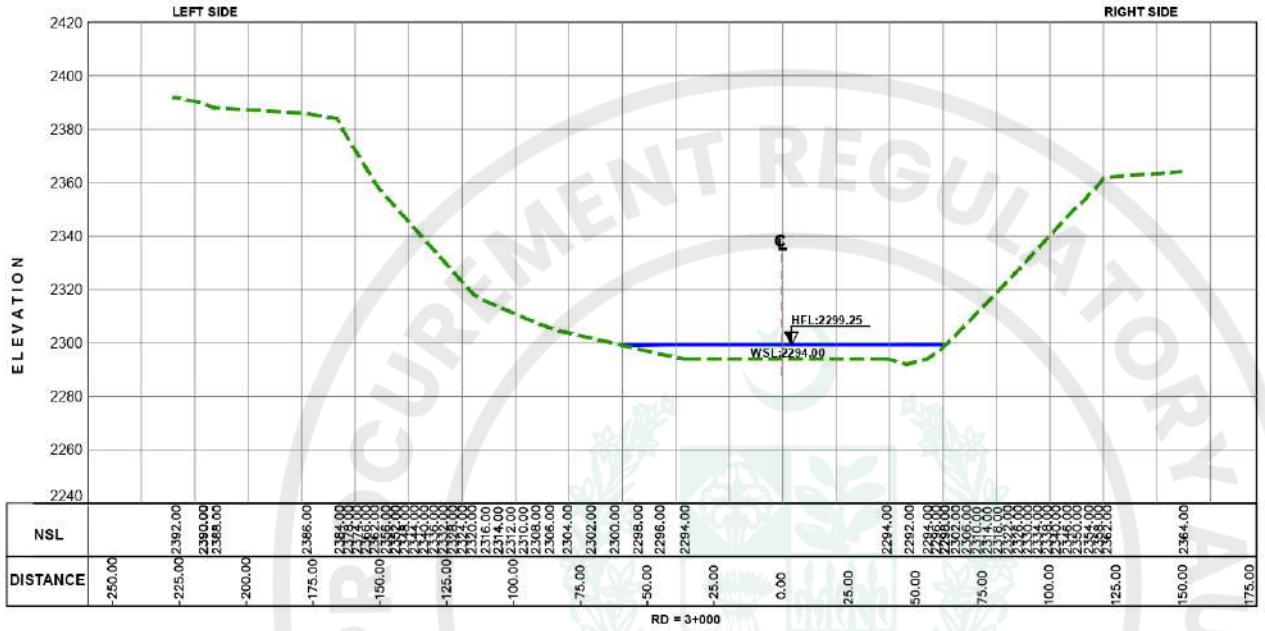


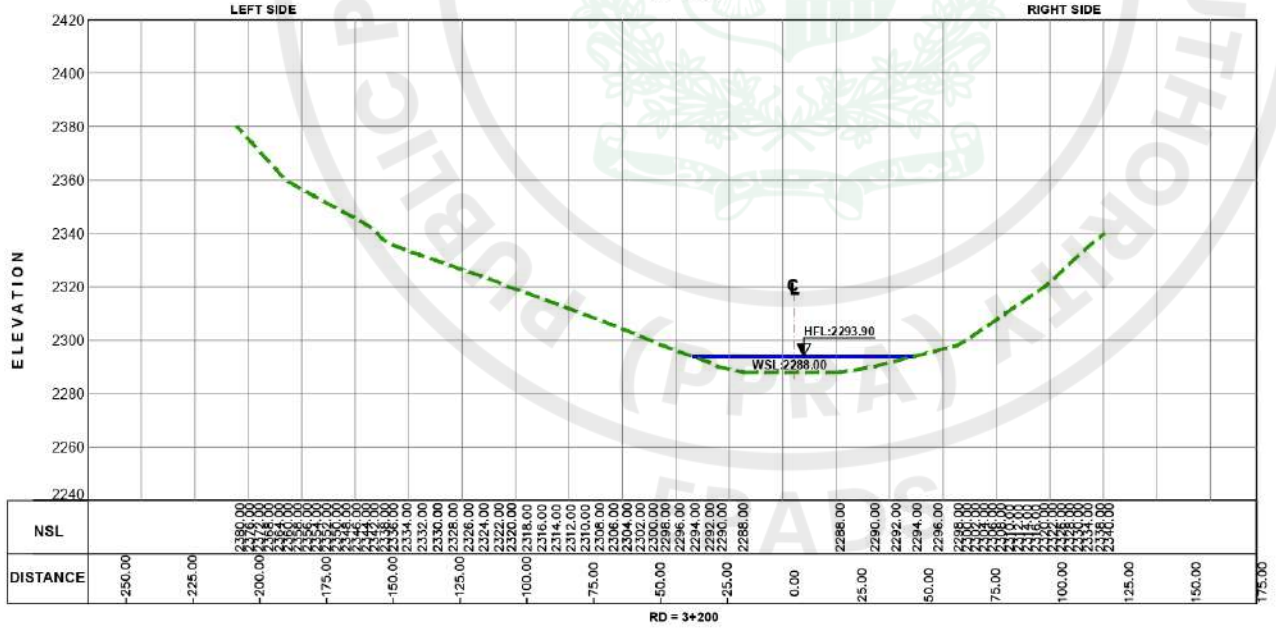


20 0 20 40 60 80 100 m

SCALE

**NOTE:**

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS UNLESS OTHERWISE SPECIFIED.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Ehsan | PROJECT | **ATTABAD LAKE HPP FEASIBILITY STUDY REPORT** |
| DRAWN: Arshad | TITLE | **HUNZA RIVER X - SECTION AT RD. 3+000 & 3+200** (Sheet 8 of 10) |
| CHECKED: Ehsan | | |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 2,000 / DWG No: APS-CS-239 / REVISIONS |

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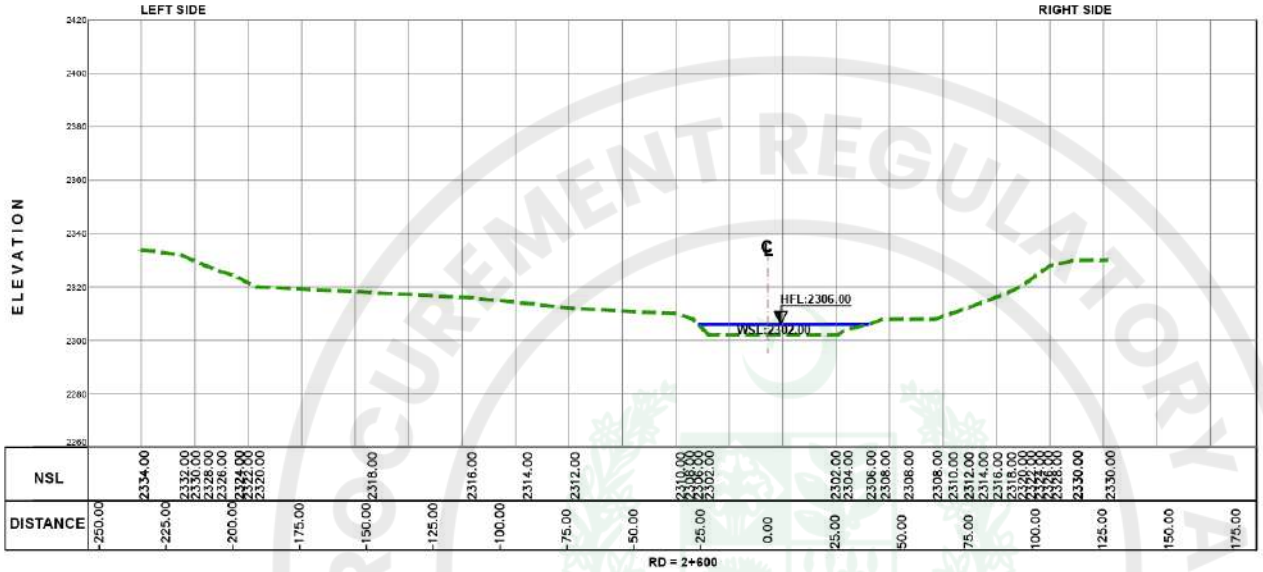


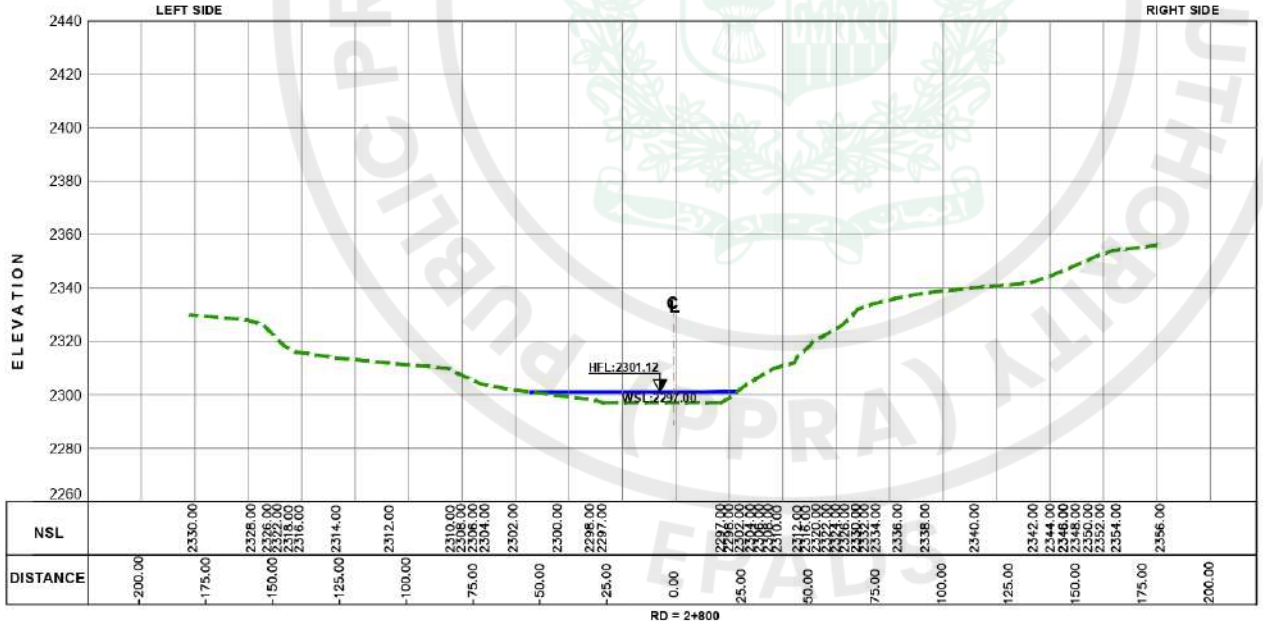


20 0 20 40 60 80 100 m

SCALE

**NOTE:**

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS UNLESS OTHERWISE SPECIFIED.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Ehsan | PROJECT | ATTABAD LAKE HPP<br>FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE | HUNZA RIVER<br>X - SECTION AT RD. 2+600 & 2+800<br>(Sheet 7 of 10) |
| CHECKED: Ehsan | | |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 2,000 / DWG No: APS-CS-238 / REVISIONS |

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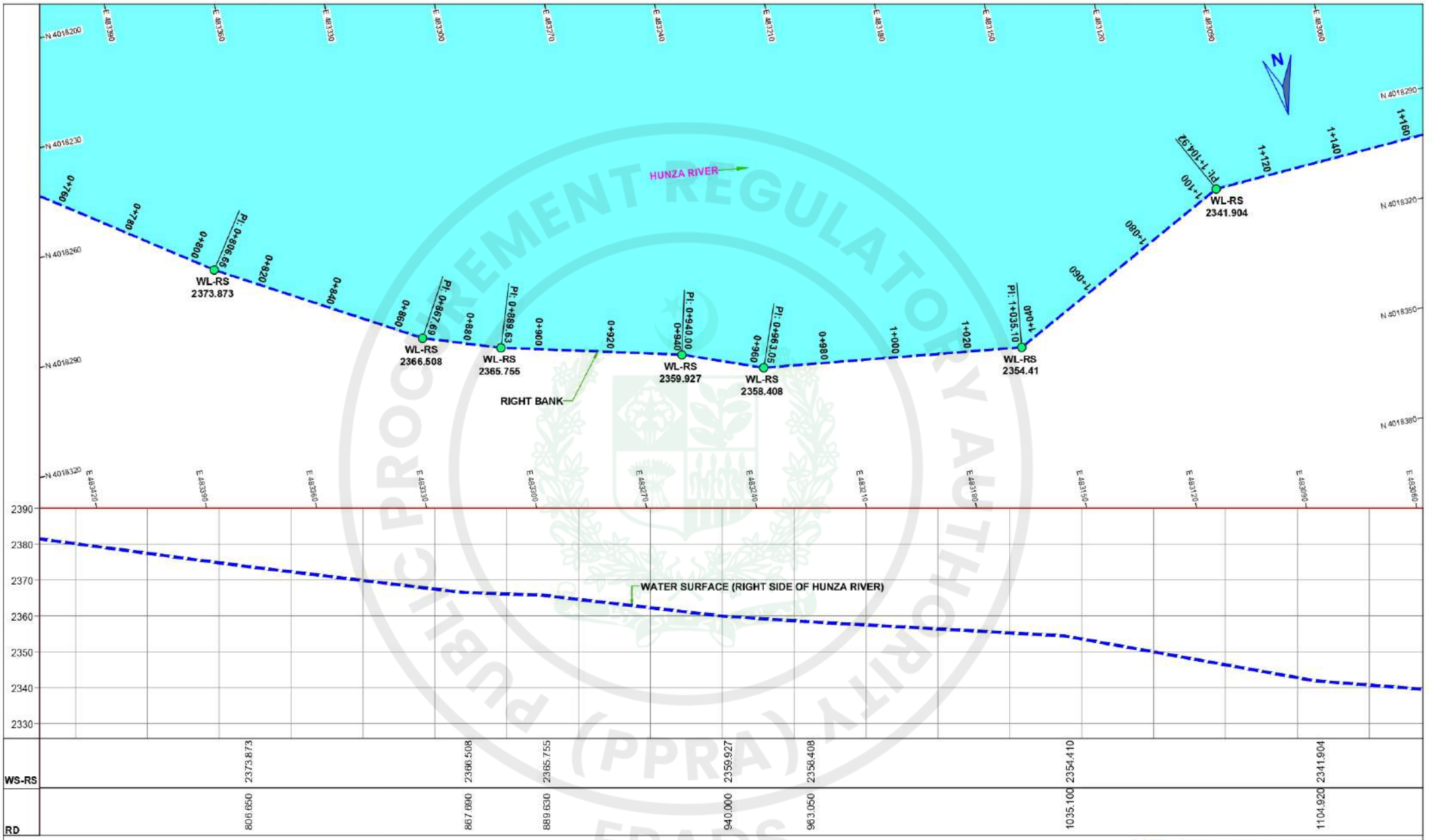


**NOTE:**

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS UNLESS OTHERWISE SPECIFIED.

10 0 10 20 30 40 50 m

SCALE

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

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|---|---|---|
| PREPARED Ehsan | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN Arshad | TITLE | WATER SURFACE PLAN AND PROFILE (HUNZA RIVER) (Sheet 3 of 11) |
| CHECKED Ehsan | | |
| APPROVED Abid Sheikh | DATE Jun: 2021 | SCALE 1 : 1,000 |
| | | DWG No: APS-SP-283 |
| | | REVISIONS |

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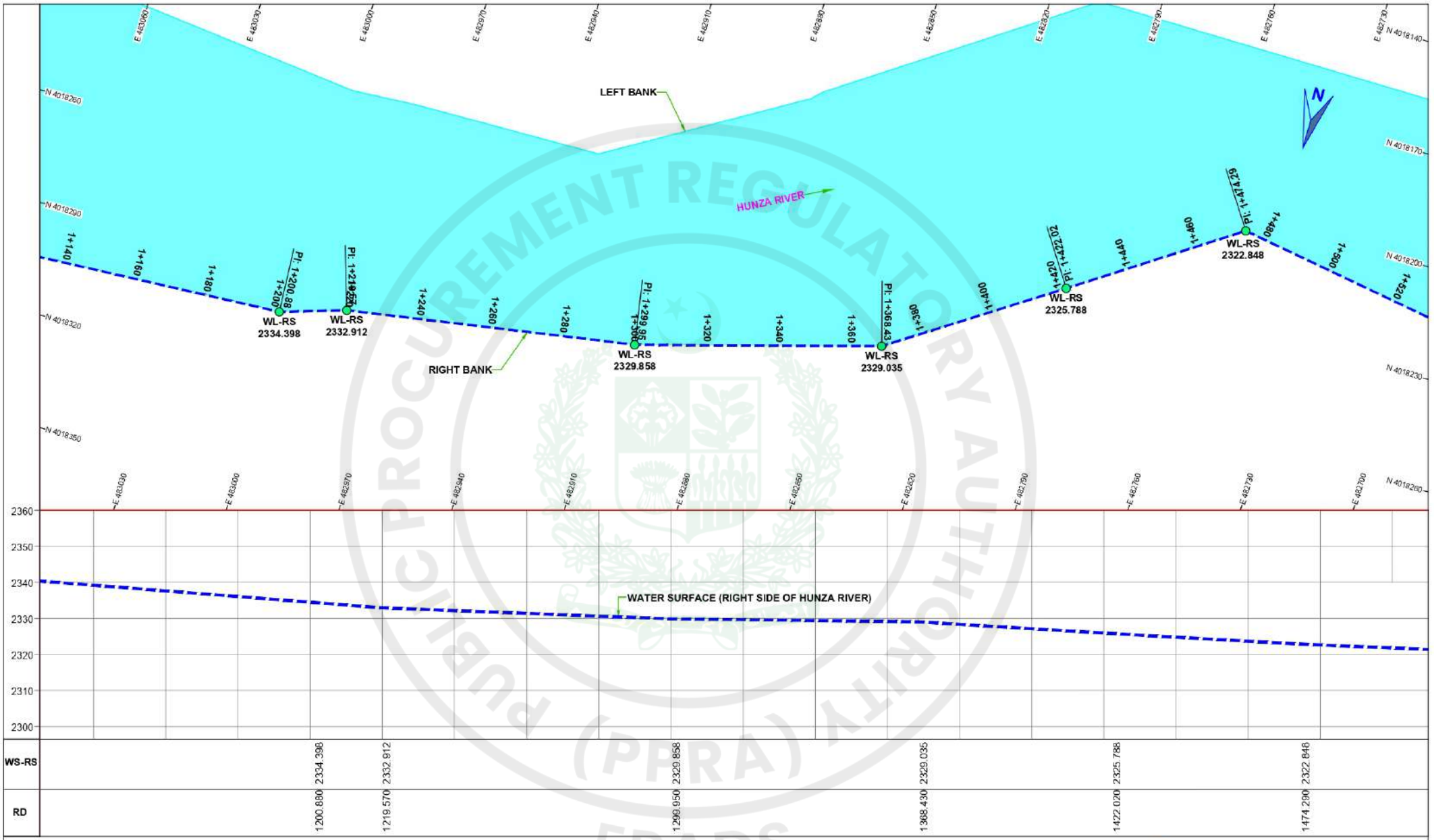


**NOTE:**

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS UNLESS OTHERWISE SPECIFIED.

10 0 10 20 30 40 50 m

SCALE

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

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|---|---|---|
| PREPARED Ehsan | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN Arshad | TITLE | WATER SURFACE PLAN AND PROFILE (HUNZA RIVER) (Sheet 4 of 11) |
| CHECKED Ehsan | | |
| APPROVED Abid Sheikh | DATE Jun: 2021 | SCALE 1 : 1,000 |
| | DWG No. APS-SP-284 | REVISIONS |

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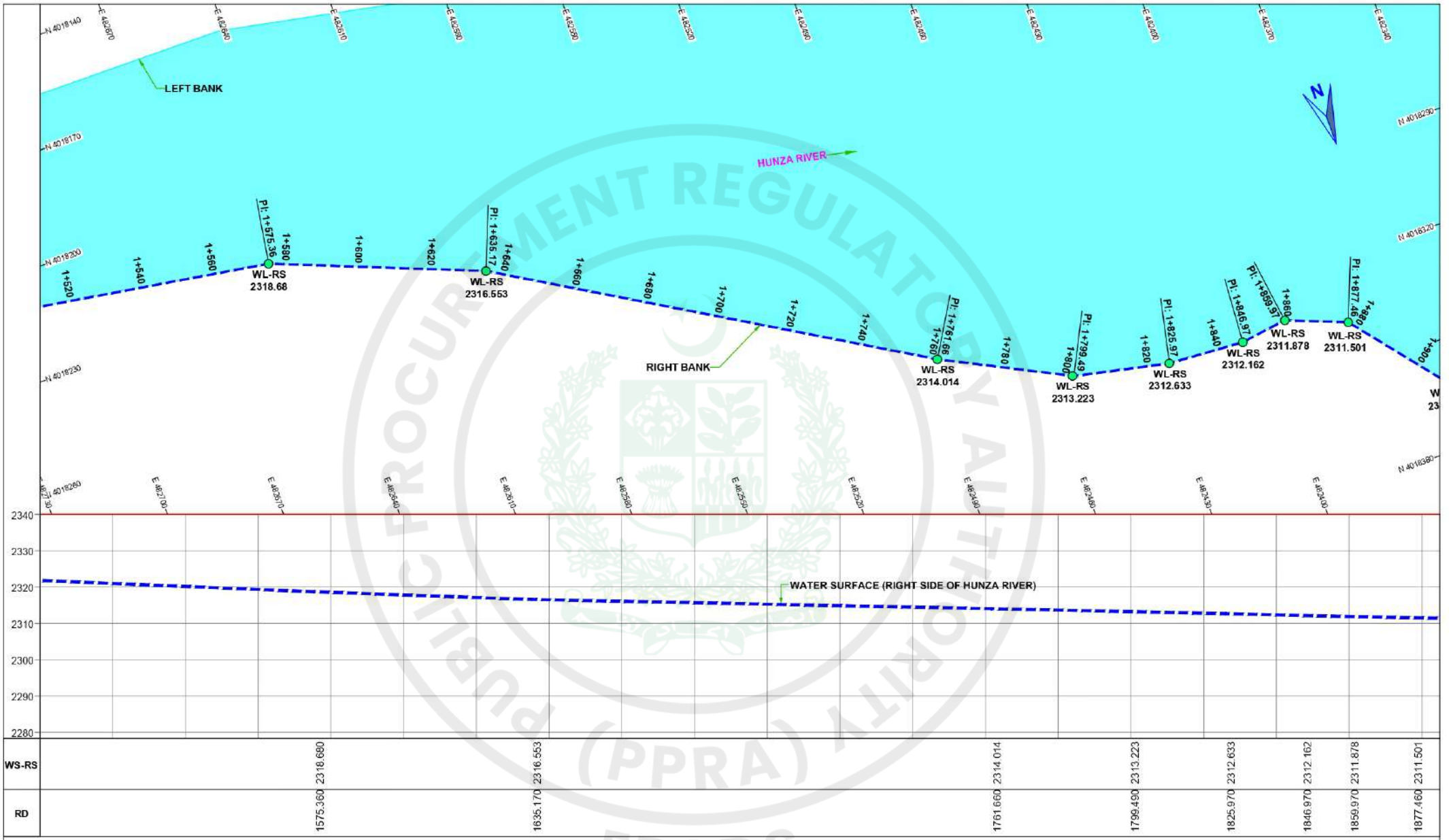


**NOTE:**

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS UNLESS OTHERWISE SPECIFIED.

10 0 10 20 30 40 50 m

SCALE

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

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|---|---|---|
| PREPARED Ehsan | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN Arshad | TITLE | WATER SURFACE PLAN AND PROFILE (HUNZA RIVER) (Sheet 5 of 11) |
| CHECKED Ehsan | | |
| APPROVED Abid Sheikh | DATE Jun: 2021 | SCALE 1 : 1,000 |
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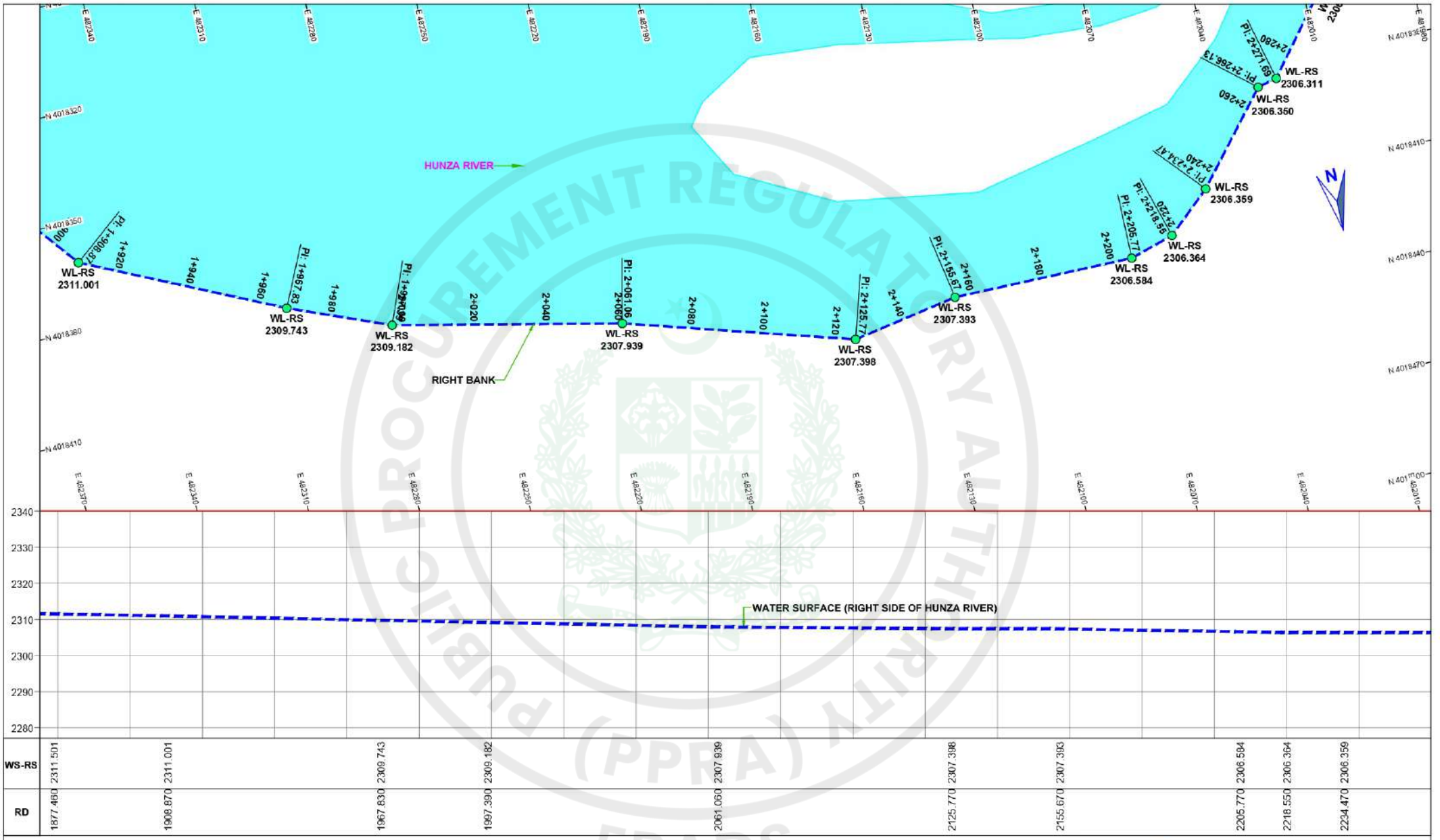


**NOTE:**

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS UNLESS OTHERWISE SPECIFIED.

10 0 10 20 30 40 50 m

SCALE

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

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|---|---|---|
| PREPARED Ehsan | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN Arshad | TITLE | WATER SURFACE PLAN AND PROFILE (HUNZA RIVER) (Sheet 6 of 11) |
| CHECKED Ehsan | | |
| APPROVED Abid Sheikh | DATE Jun: 2021 | SCALE 1 : 1,000 |
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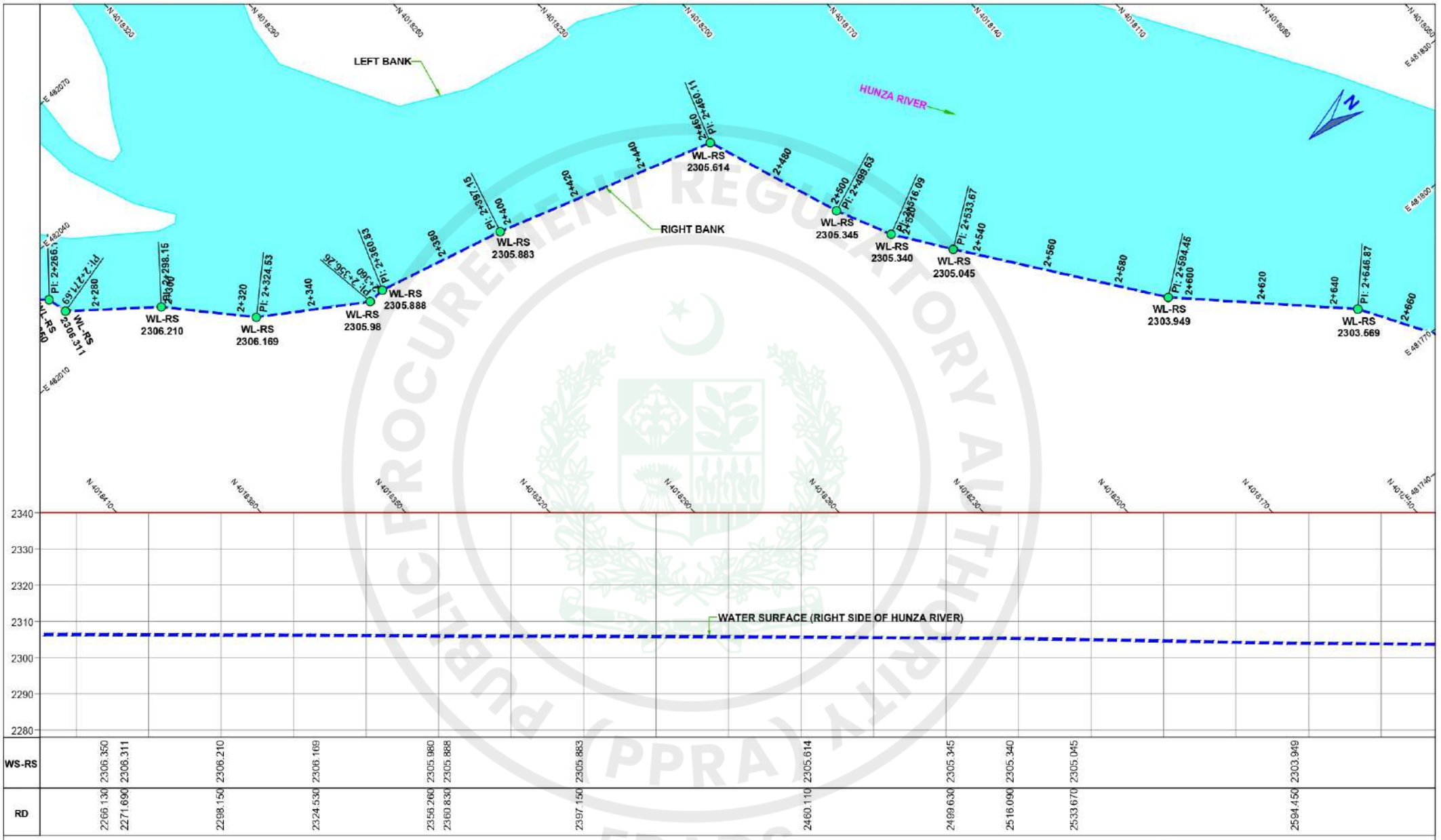


**NOTE:**

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS UNLESS OTHERWISE SPECIFIED.

10 0 10 20 30 40 50 m

SCALE

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED Ehsan | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN Arshad | TITLE | WATER SURFACE PLAN AND PROFILE (HUNZA RIVER) (Sheet 7 of 11) |
| CHECKED Ehsan | | |
| APPROVED Abid Sheikh | DATE Jun: 2021 | SCALE 1 : 1,000 |
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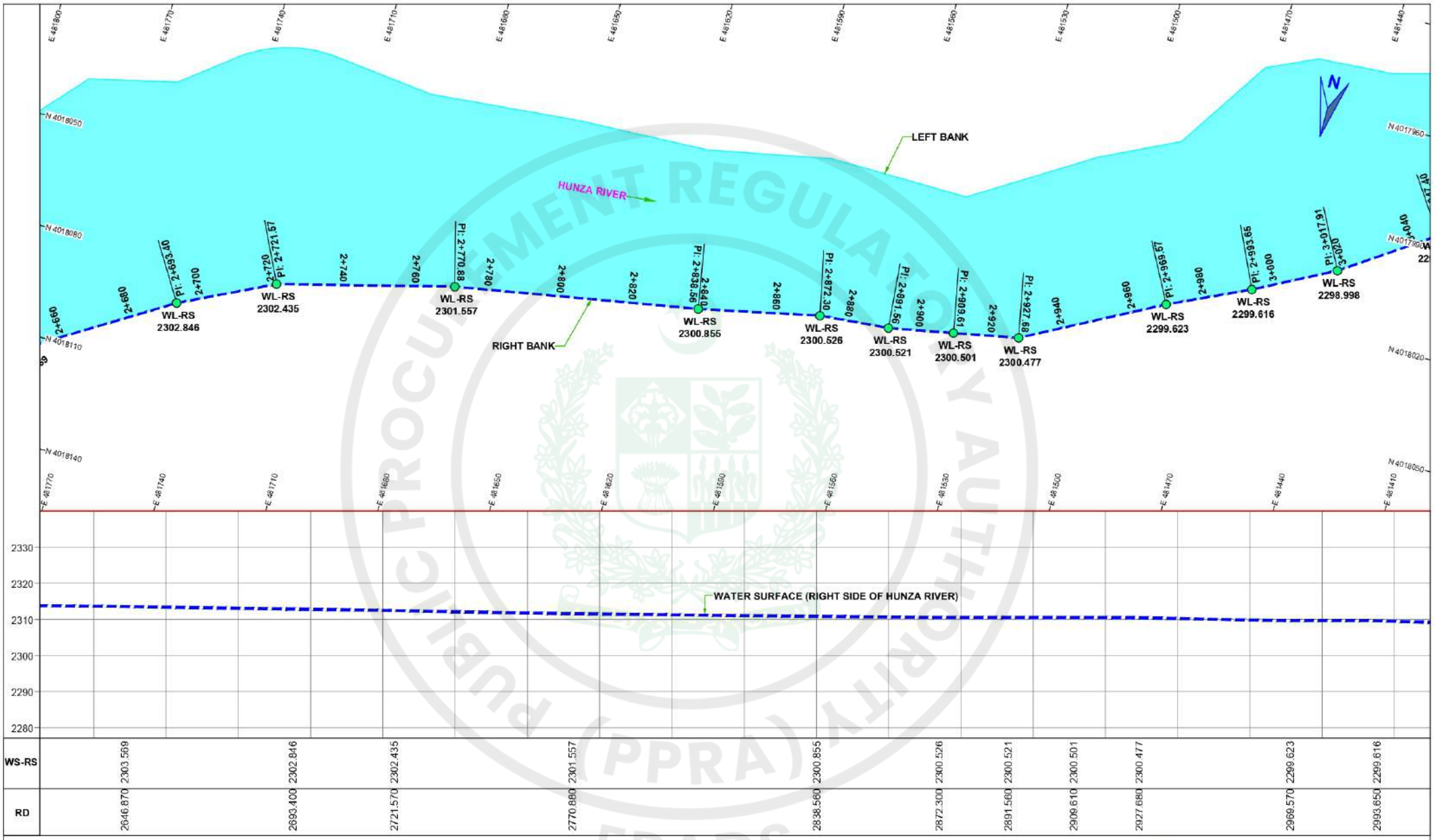


**NOTE:**

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS UNLESS OTHERWISE SPECIFIED.

10 0 10 20 30 40 50 m
SCALE

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

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|---|---|---|
| PREPARED Ehsan | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN Arshad | TITLE | WATER SURFACE PLAN AND PROFILE (HUNZA RIVER) (Sheet 8 of 11) |
| CHECKED Ehsan | | |
| APPROVED Abid Sheikh | DATE Jun: 2021 | SCALE 1 : 1,000 |
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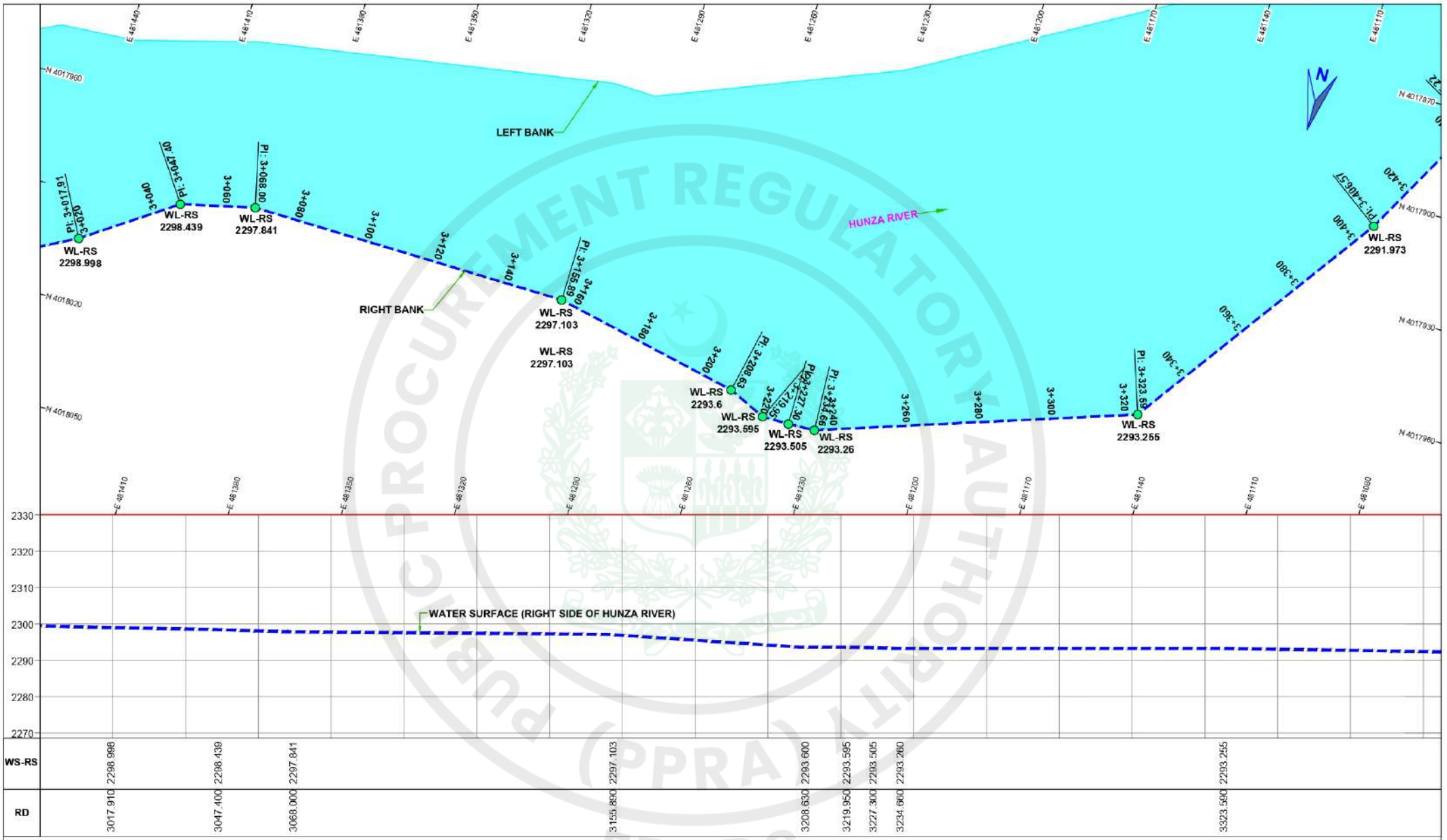


**NOTE:**

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS UNLESS OTHERWISE SPECIFIED.

10 0 10 20 30 40 50 m
SCALE

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Ehsan | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE | WATER SURFACE PLAN AND PROFILE (HUNZA RIVER) (Sheet 9 of 11) |
| CHECKED: Ehsan | | |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 1,000 |
| | | DWG No: APS-SP-289 |
| | | REVISIONS |

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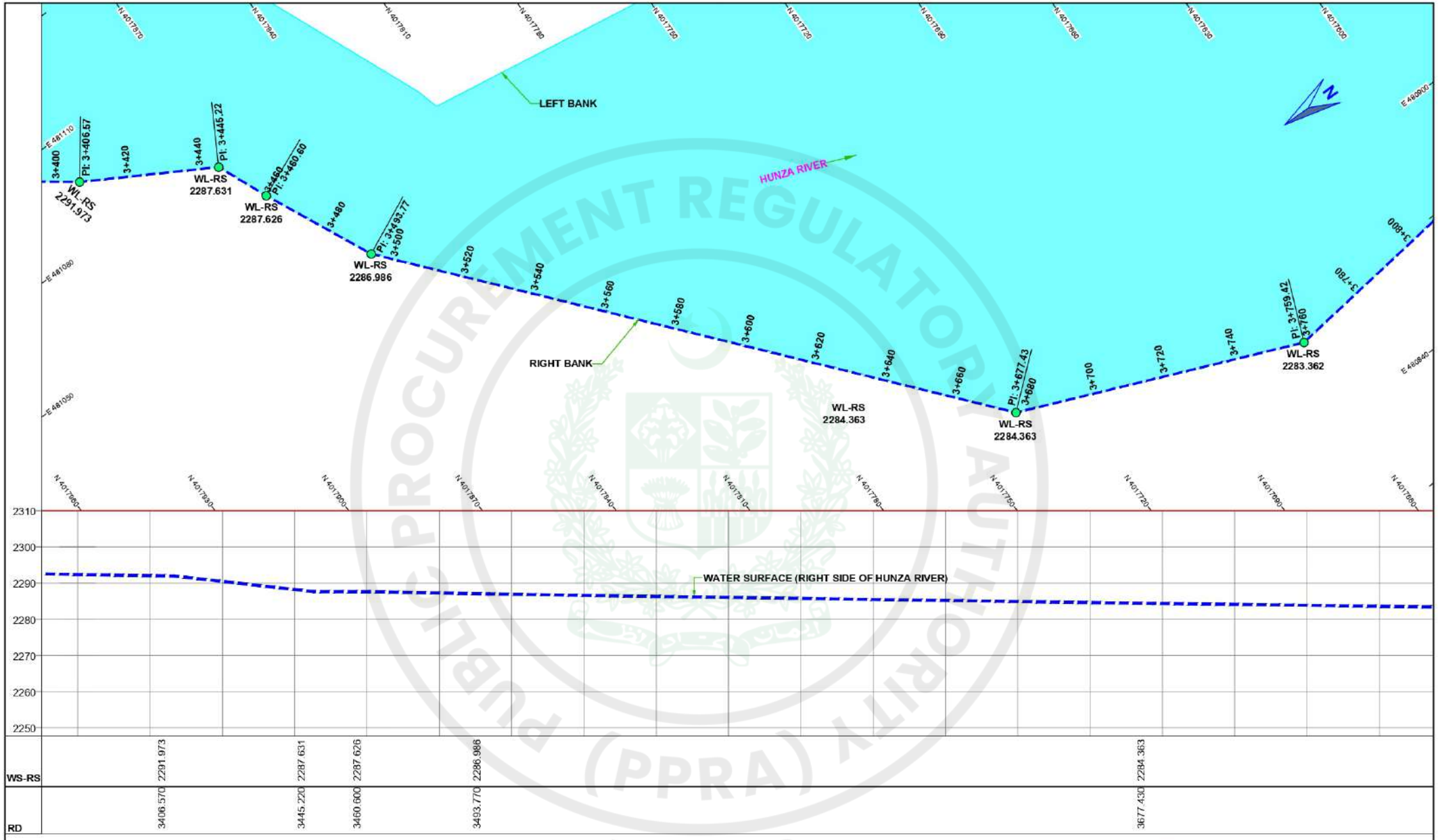



**NOTE:**

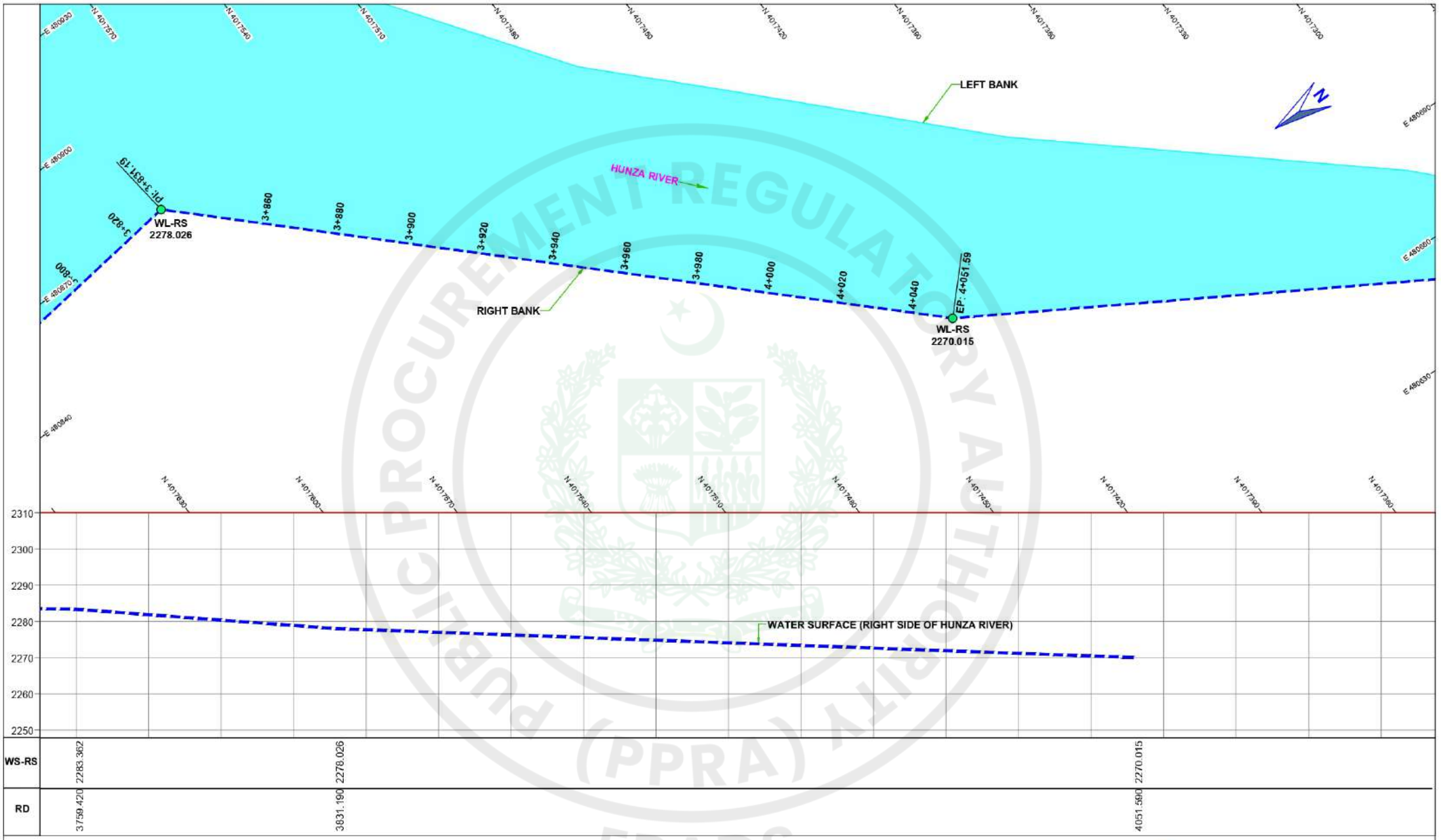
1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS UNLESS OTHERWISE SPECIFIED.

10 0 10 20 30 40 50 m
SCALE

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Ehsan | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE | WATER SURFACE PLAN AND PROFILE (HUNZA RIVER) (Sheet 10 of 11) |
| CHECKED: Ehsan | | |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 1,000 |
| | DWG No: AFS-SP-260 | REVISIONS |

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS




**NOTE:**

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS UNLESS OTHERWISE SPECIFIED.

10 0 10 20 30 40 50 m

SCALE

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| | PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY | |
| | HYDRO PLANNING ORGANIZATION | |
| PREPARED: Ehsan | PROJECT | ATTABAD LAKE HPP<br>FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE | WATER SURFACE PLAN AND PROFILE (HUNZA RIVER) |
| CHECKED: Ehsan | | (Sheet 11 of 11) |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 1,000 / DWG No: APS-SP-261 / REVISIONS |

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

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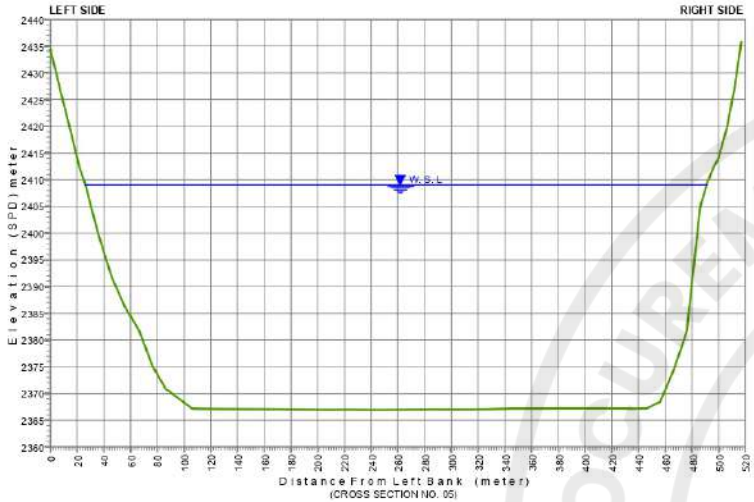


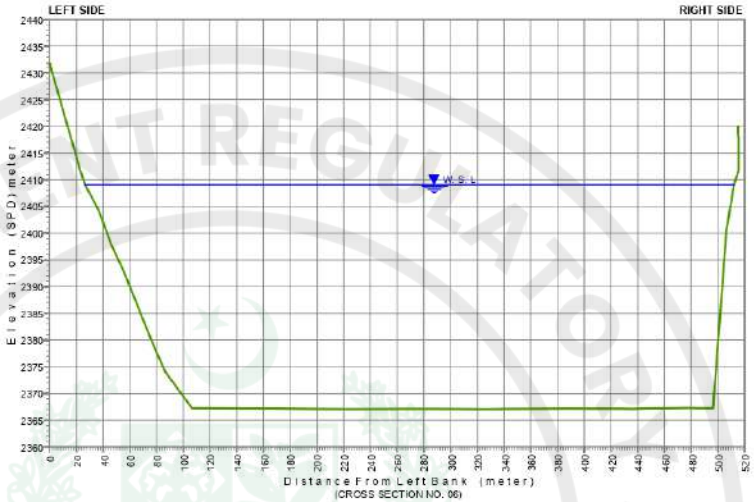


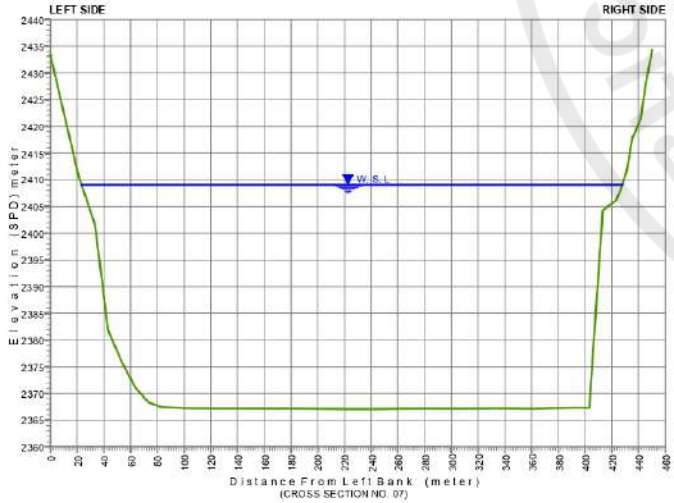


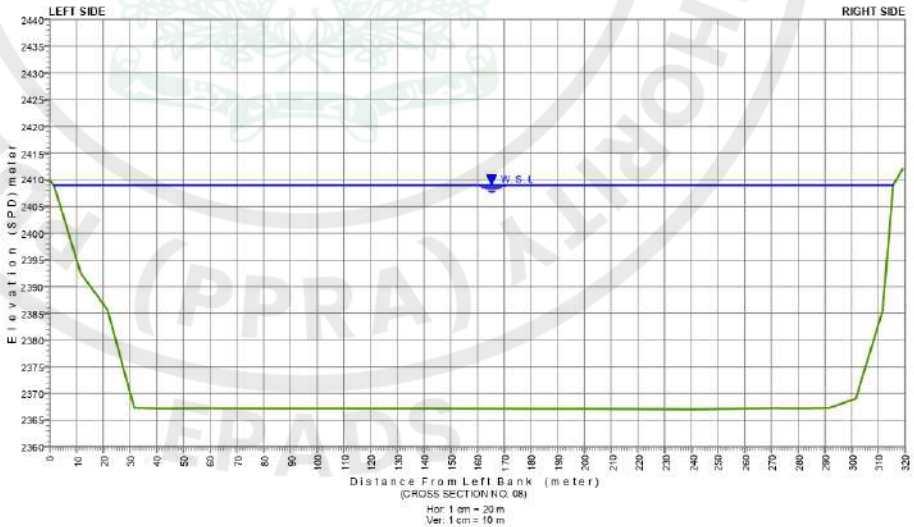


## LEGEND

OBSERVED WATER LEVEL

OBSERVED BED LEVEL

## NOTE:

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS UNLESS OTHERWISE SPECIFIED.
2. HYDROGRAPHIC SURVEY BY **ISRIP** - WAPDA.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Ehsan | PROJECT | **ATTABAD LAKE HPP**<br>**FEASIBILITY STUDY REPORT** |
| DRAWN: Arshad | TITLE | **HYDROGRAPHIC SURVEY OF ATTABAD LAKE**<br>**X - Sections No. 05,06,07 & 08** |
| CHECKED: Ehsan | | |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: Hor: 1 cm = 40 m, Ver: 1 cm = 10 m |
| | | DWG No: AFS-HS-272 |
| | | REVISIONS |

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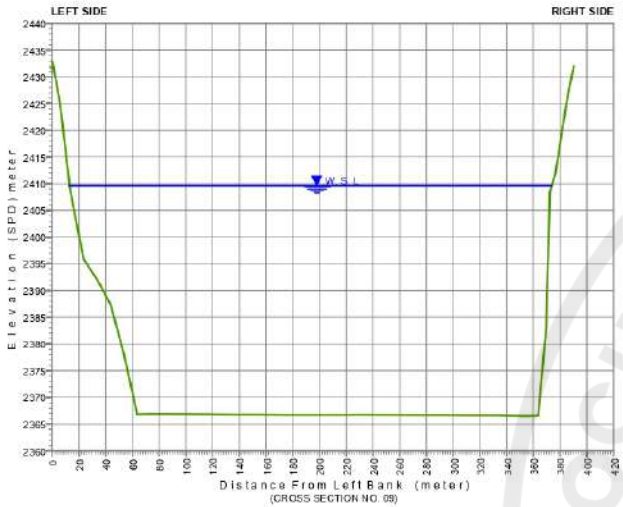


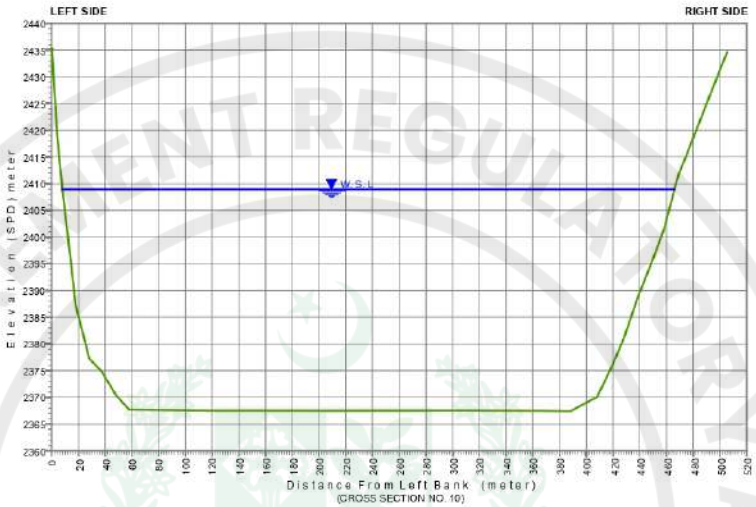


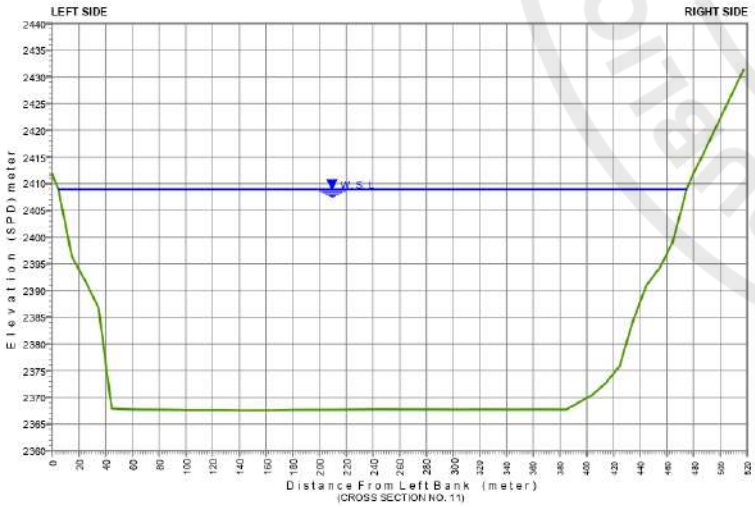


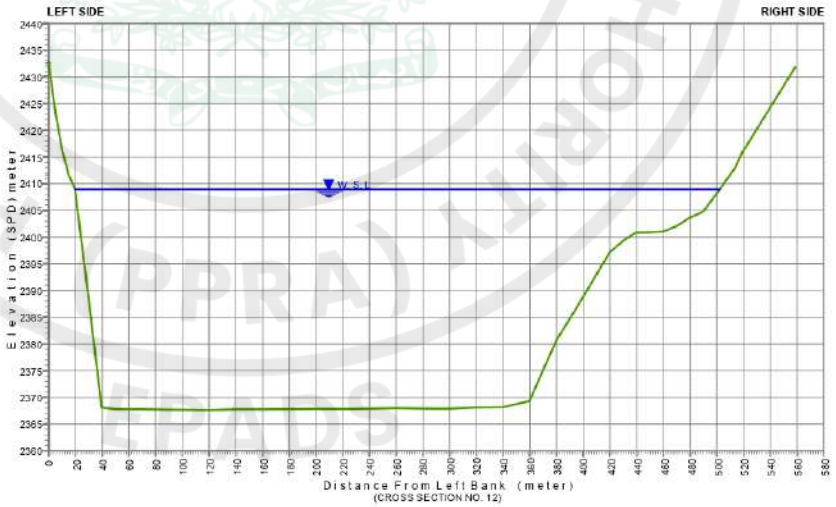


## LEGEND

OBSERVED WATER LEVEL

OBSERVED BED LEVEL

## NOTE:

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS UNLESS OTHERWISE SPECIFIED.
2. HYDROGRAPHIC SURVEY BY **ISRIP** - WAPDA.

**PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY**

HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Ehsan | PROJECT | **ATTABAD LAKE HPP FEASIBILITY STUDY REPORT** |
| DRAWN: Arshad | TITLE | **HYDROGRAPHIC SURVEY OF ATTABAD LAKE** |
| CHECKED: Ehsan | | **X - Sections No. 09,10,11 & 12** |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: Hor: 1 cm = 40 m, Ver: 1 cm = 10 m |
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| | | REVISIONS |

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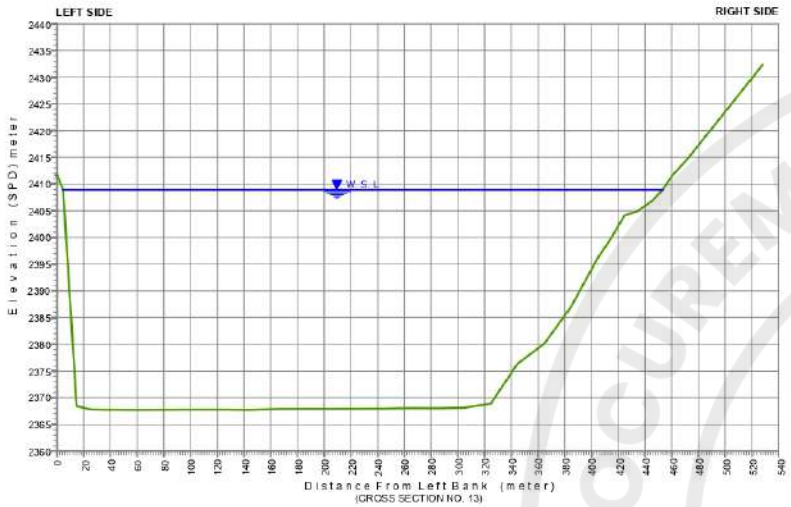


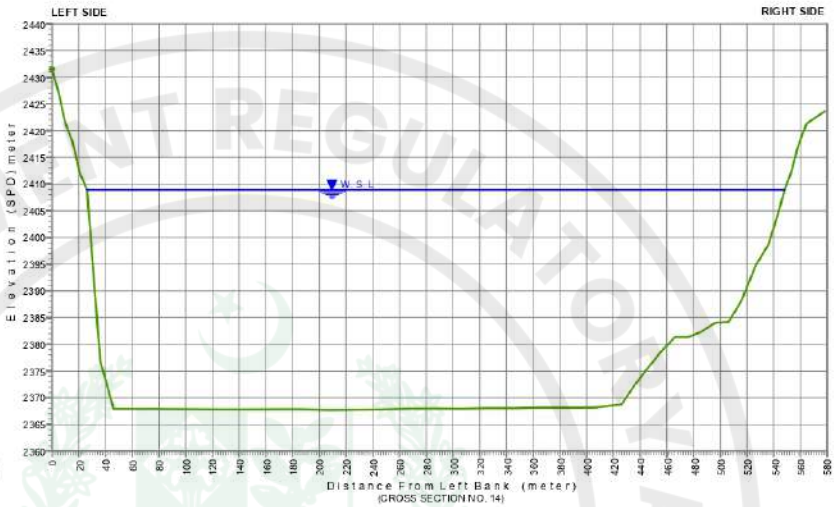


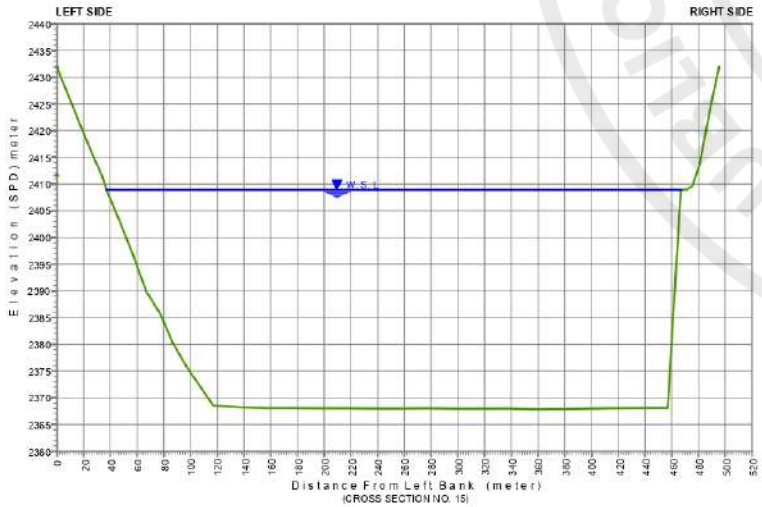


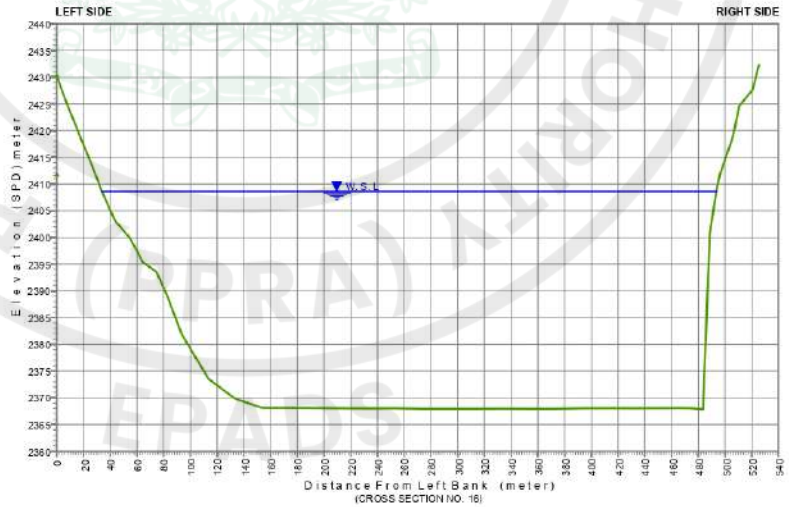


## LEGEND

OBSERVED WATER LEVEL

OBSERVED BED LEVEL

## NOTE:

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS UNLESS OTHERWISE SPECIFIED.
2. HYDROGRAPHIC SURVEY BY **ISRIP** - WAPDA.

**PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY**

HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Ehsan | PROJECT | **ATTABAD LAKE HPP FEASIBILITY STUDY REPORT** |
| DRAWN: Arshad | TITLE | **HYDROGRAPHIC SURVEY OF ATTABAD LAKE** |
| CHECKED: Ehsan | | **X - Sections No. 13,14,15 & 16** |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: Hor: 1 cm = 40 m, Ver: 1 cm = 10 m |
| | | DWG No: ARS-HS-214 |
| | | REVISIONS |

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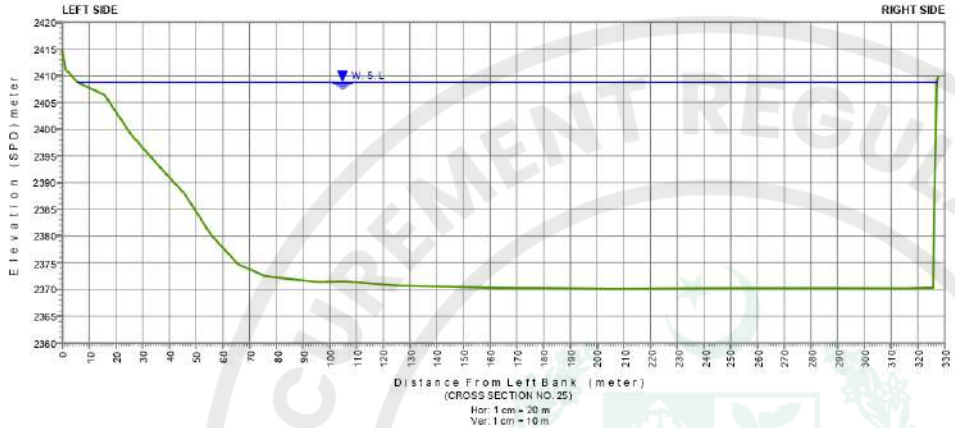


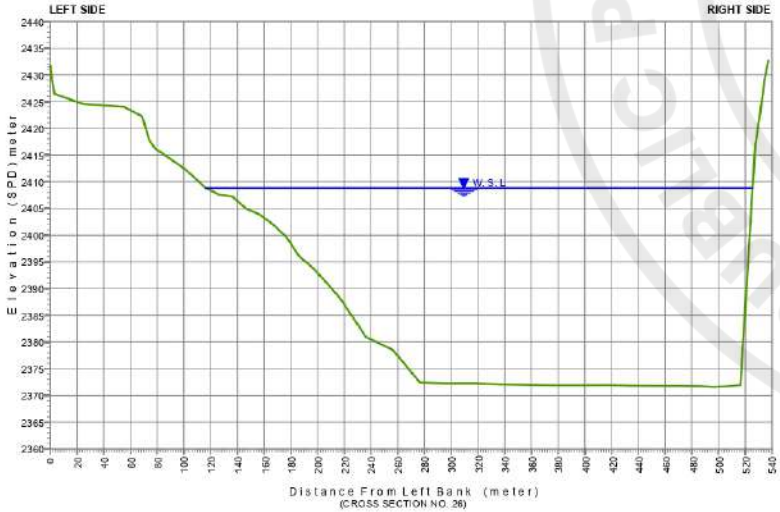


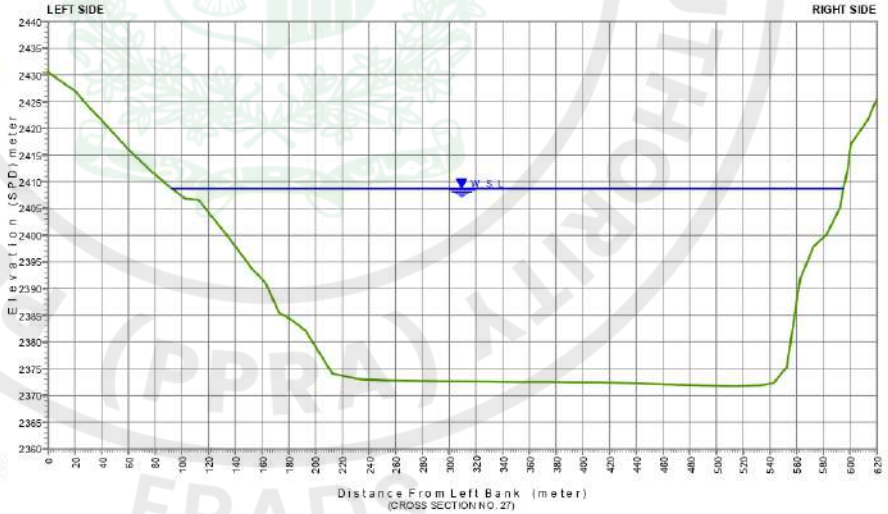


## LEGEND

OBSERVED WATER LEVEL

OBSERVED BED LEVEL

## NOTE:

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS UNLESS OTHERWISE SPECIFIED.
2. HYDROGRAPHIC SURVEY BY **ISRIP** - WAPDA.

**PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY**
HYDRO PLANNING ORGANIZATION

| PREPARED | PROJECT | ATTABAD LAKE HPP<br>FEASIBILITY STUDY REPORT | |
|---|---|---|---|
| Ehsan | | | |
| DRAWN | TITLE | HYDROGRAPHIC SURVEY OF ATTABAD LAKE<br>X - Sections No. 25,26, & 27 | |
| Arshad | | | |
| CHECKED | | | |
| Ehsan | | | |
| APPROVED | DATE | SCALE | DWG No: / REVISIONS |
| Abid Sheikh | Jun: 2021 | Hor: 1 cm = 40 m<br>Ver: 1 cm = 10 m | AFS-HS-277 |

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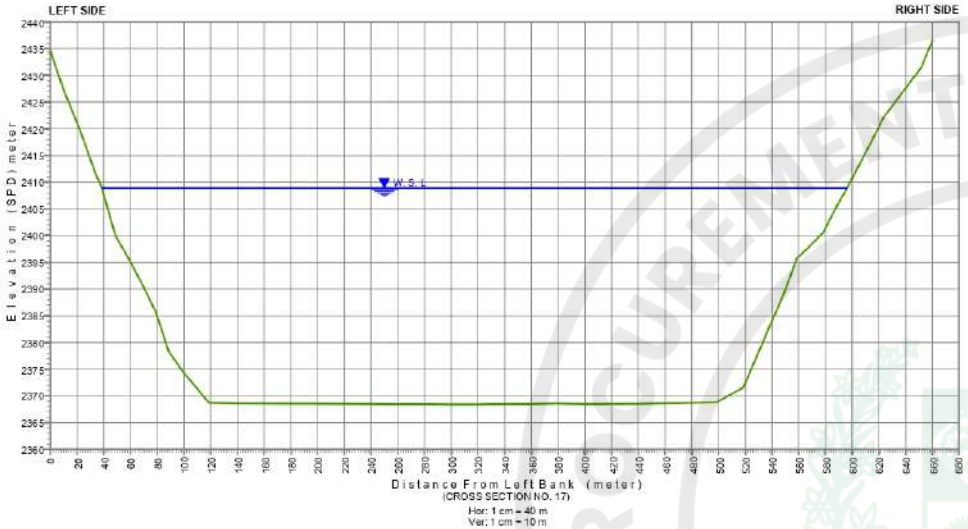

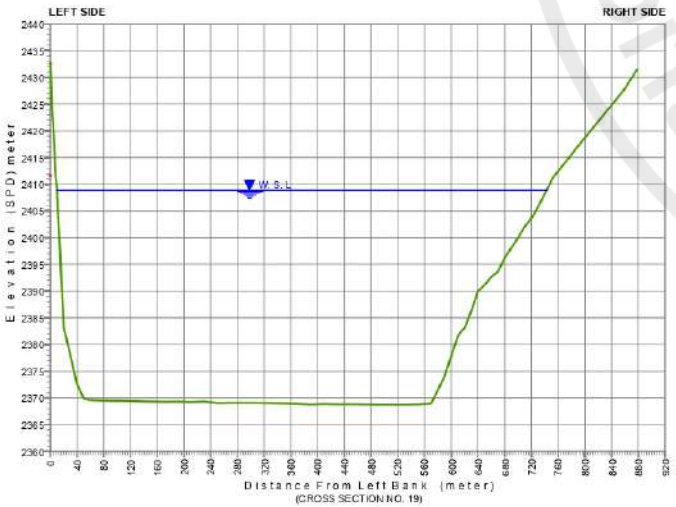


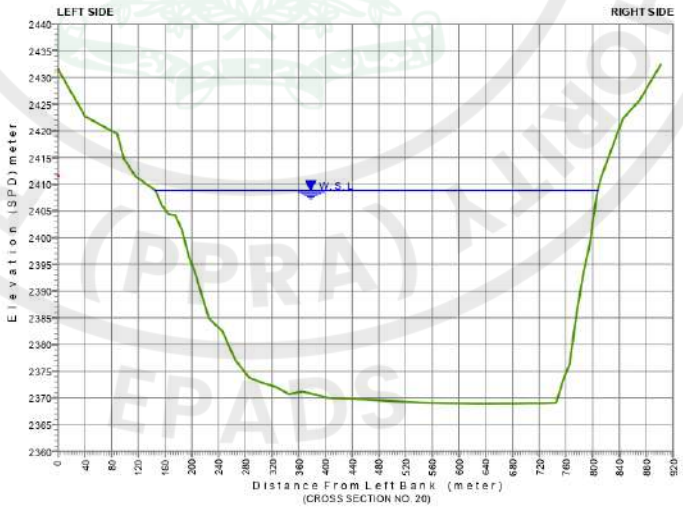


## LEGEND

OBSERVED WATER LEVEL

OBSERVED BED LEVEL

## NOTE:

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS UNLESS OTHERWISE SPECIFIED.
2. HYDROGRAPHIC SURVEY BY **ISRIP** - WAPDA.

**PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY**

HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Ehsan | PROJECT | **ATTABAD LAKE HPP FEASIBILITY STUDY REPORT** |
| DRAWN: Arshad | TITLE | **HYDROGRAPHIC SURVEY OF ATTABAD LAKE** |
| CHECKED: Ehsan | | **X - Sections No. 17,18,19 & 20** |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: Hor: 1 cm = 80 m, Ver: 1 cm = 10 m |
| | | DWG No: ABS-HS-275 |
| | | REVISIONS |

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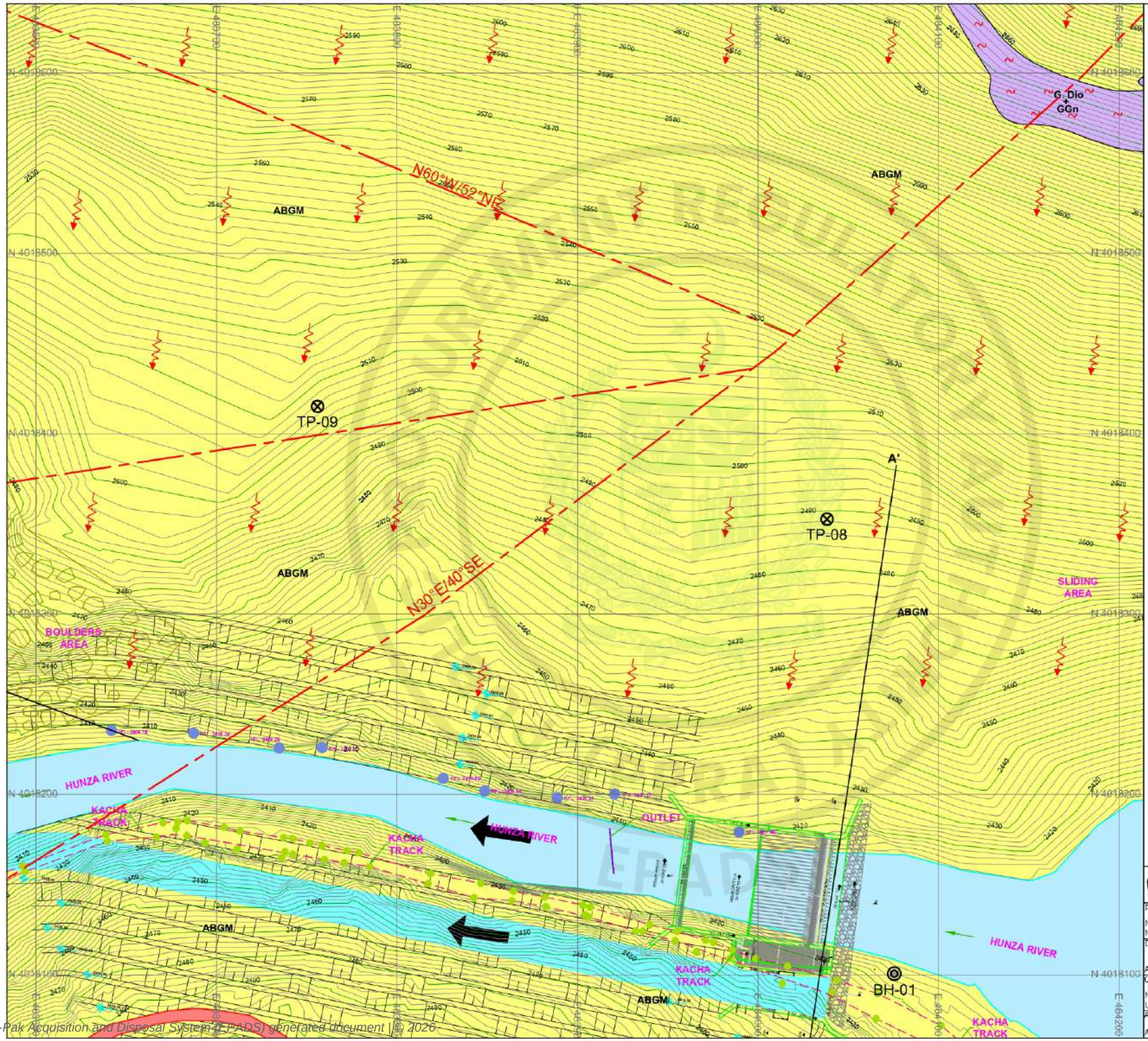


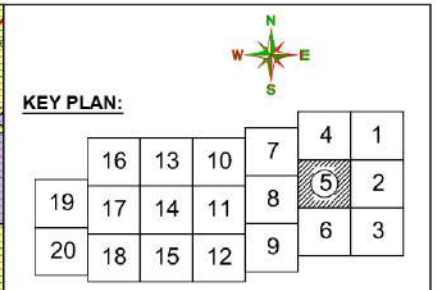


## LEGEND (GEOLOGY)

### SOIL UNITS:

- ABGM — Angular boulders and gravel with sand and appreciable amount of fines.
- RBGM — Rounded boulders and gravel with sand and appreciable amount of fines.
- CT — Cultivated Terrace.
- Mor — Morainic Material
- CS — Clayey Silt.

### ROCK UNITS:

- G.Dio — Granodiorite
- G.Dio + GGn — Granodiorite + Granitic Gneiss.
- BR — Fault Breccia.
- Dip and Strike of joint sets in rock.
- Dip and Strike of foliation.
- Active slide.
- Shear zone.
- Fault
- BH — Bore Hole.
- TP — Test Pit.
- River
- Confirmed Contact
- Inferred Contact

0 25 50 75 100 125 m
SCALE

## NOTE.

1. ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED
2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FILED OBSERVATIONS.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Nauman Naseer | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE | SURFACE GEOLOGICAL MAP |
| CHECKED: Nasiruddin, Umar Tariq | | Sheet 5 of 20 |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 2,000 |
| | DWG No: APS-GE-297 | REVISIONS |

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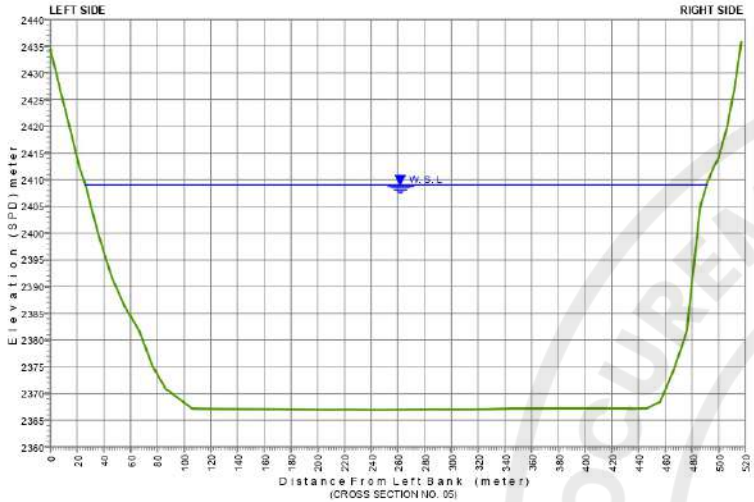


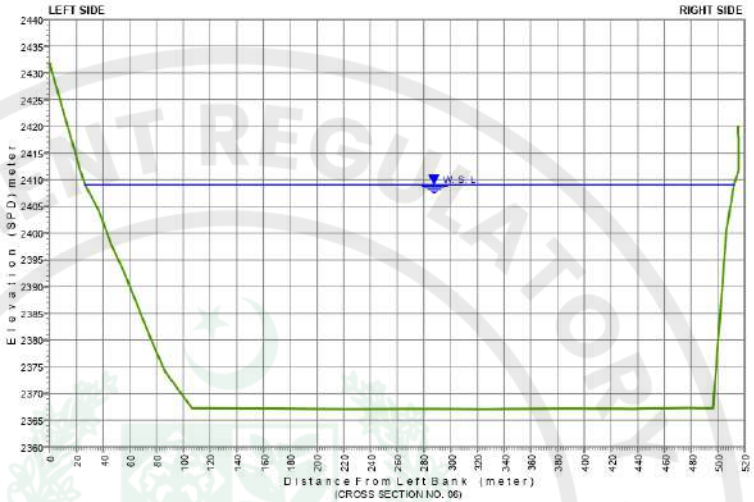


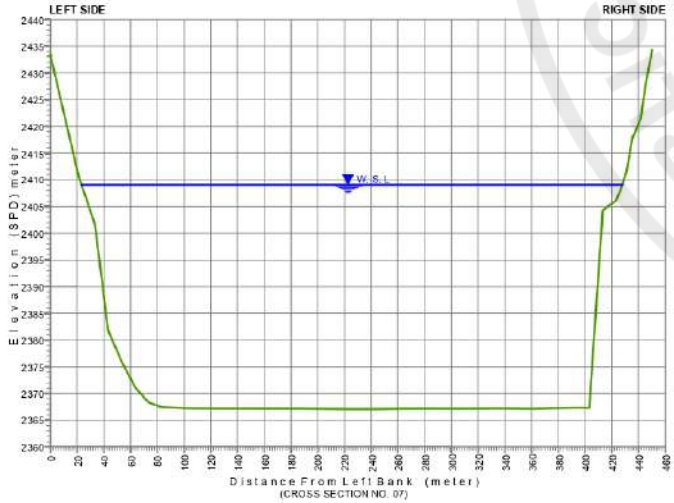


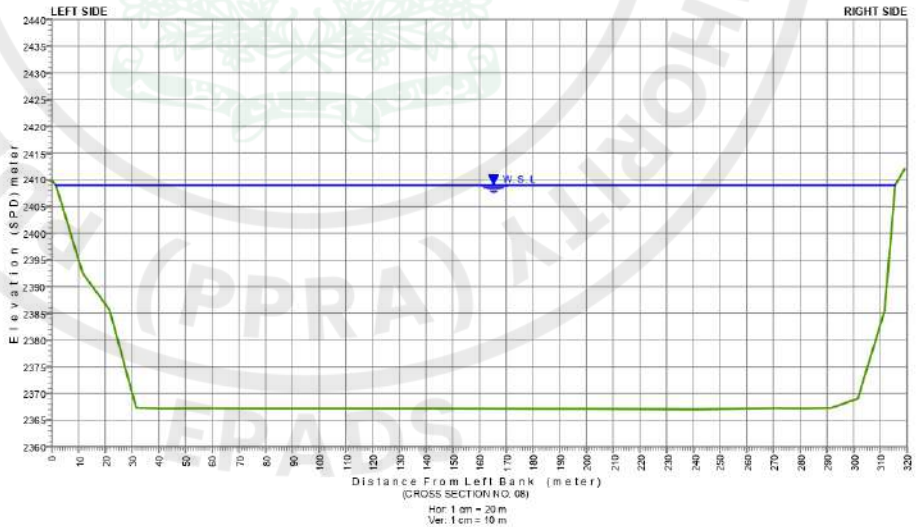


## LEGEND

OBSERVED WATER LEVEL

OBSERVED BED LEVEL

## NOTE:

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS UNLESS OTHERWISE SPECIFIED.
2. HYDROGRAPHIC SURVEY BY **ISRIP** - WAPDA.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Ehsan | PROJECT | **ATTABAD LAKE HPP**<br>**FEASIBILITY STUDY REPORT** |
| DRAWN: Arshad | TITLE | **HYDROGRAPHIC SURVEY OF ATTABAD LAKE**<br>**X - Sections No. 05,06,07 & 08** |
| CHECKED: Ehsan | | |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: Hor: 1 cm = 40 m, Ver: 1 cm = 10 m |
| | | DWG No: AFS-HS-272 |
| | | REVISIONS |

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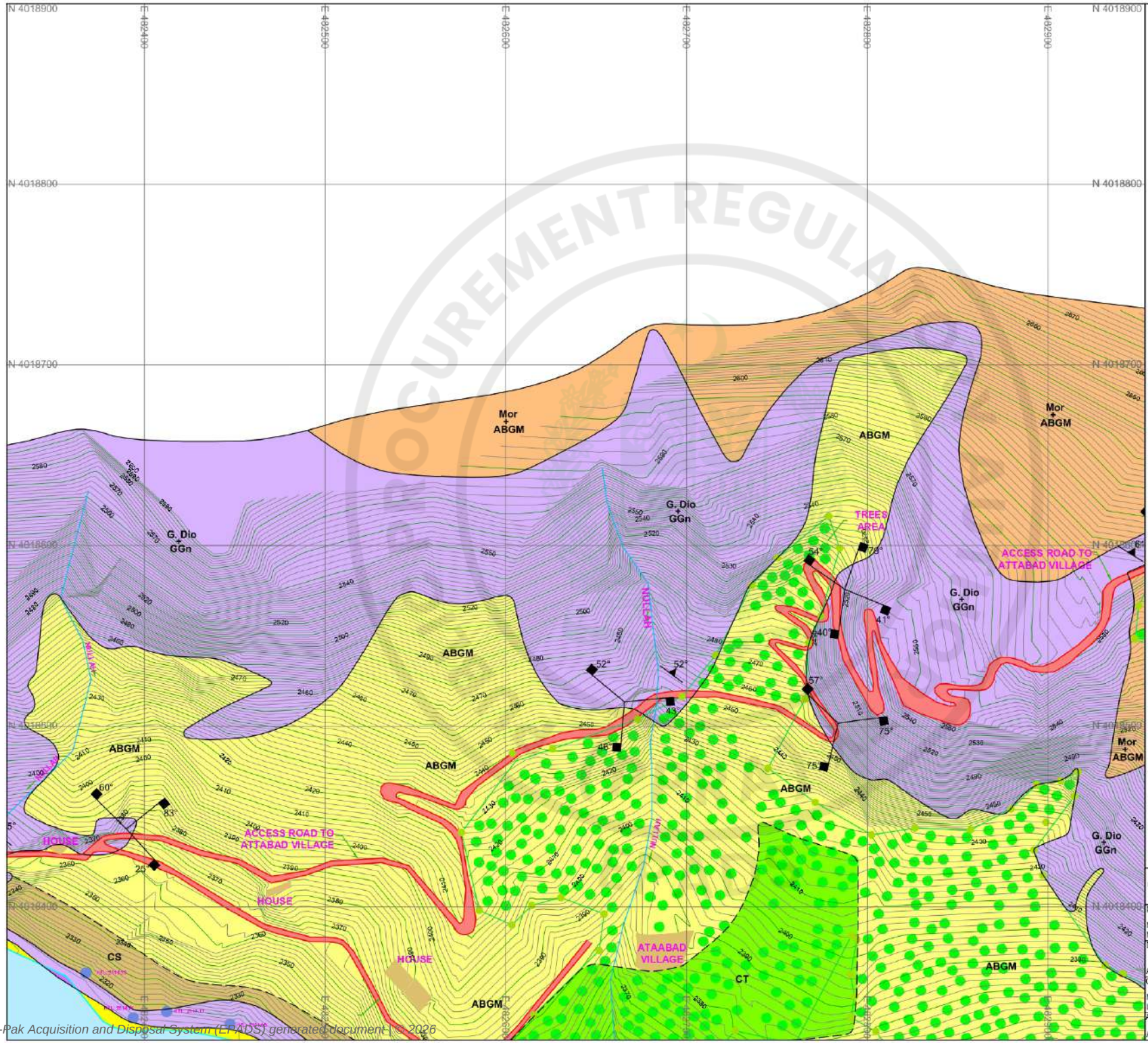


PROCUREMENT REGULA

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**KEY PLAN:**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | 4 | 1 | |
| | | 16 | 13 | 10 | 7 | 5 | 2 | |
| 19 | | 17 | 14 | 11 | 8 | 6 | 3 | |
| 20 | | 18 | 15 | 12 | 9 | | | |

## LEGEND (GEOLOGY)

**SOIL UNITS:**

- ABGM — Angular boulders and gravel with sand and appreciable amount of fines.
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- CT — Cultivated Terrace.
- Mor — Morainic Material
- CS — Clayey Silt.

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- G.Dio — Granodiorite
- G.Dio + GGn — Granodiorite + Granitic Gneiss.
- BR — Fault Breccia.
- Dip and Strike of joint sets in rock.
- Dip and Strike of foliation.
- Active slide.
- Shear zone.
- Fault
- BH — Bore Hole.
- TP — Test Pit.
- River
- Confirmed Contact
- Inferred Contact

0 25 50 75 100 125 m

SCALE

NOTE.

1. ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED
2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FILED OBSERVATIONS.

**PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY**
HYDRO PLANNING ORGANIZATION

| PREPARED | PROJECT | |
|---|---|---|
| Nauman Naseer | | **ATTABAD LAKE HPP FEASIBILITY STUDY REPORT** |
| DRAWN | TITLE | |
| Arshad | | **SURFACE GEOLOGICAL MAP** |
| CHECKED | | Sheet 10 of 20 |
| Nasiruddin, Umar Tariq | | |

| APPROVED | DATE | SCALE | DWG No. | REVISIONS |
|---|---|---|---|---|
| Abid Sheikh | Jun: 2021 | 1 : 2,000 | APS-GE-302 | |

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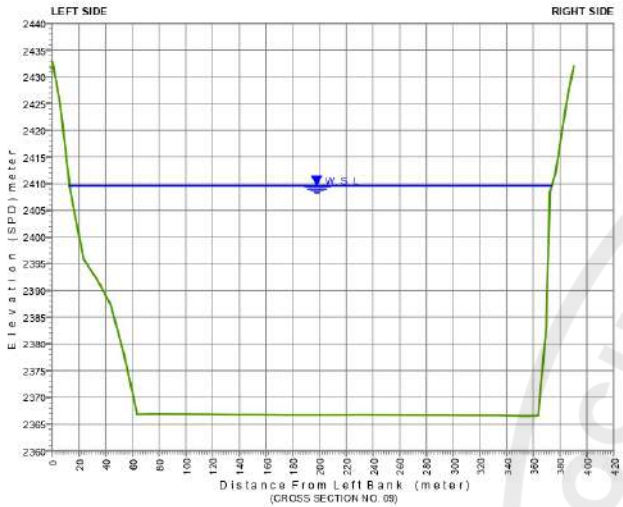


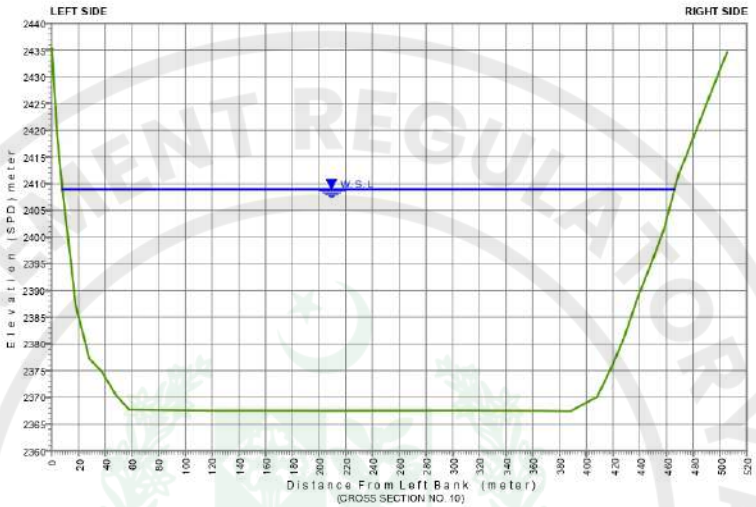


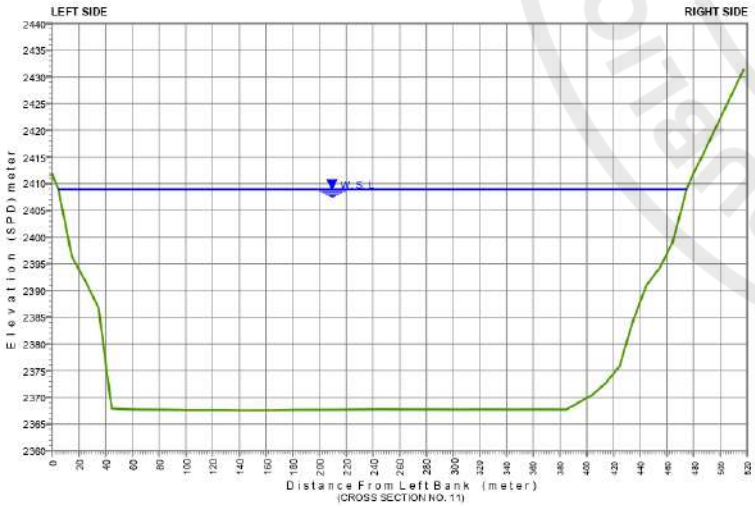


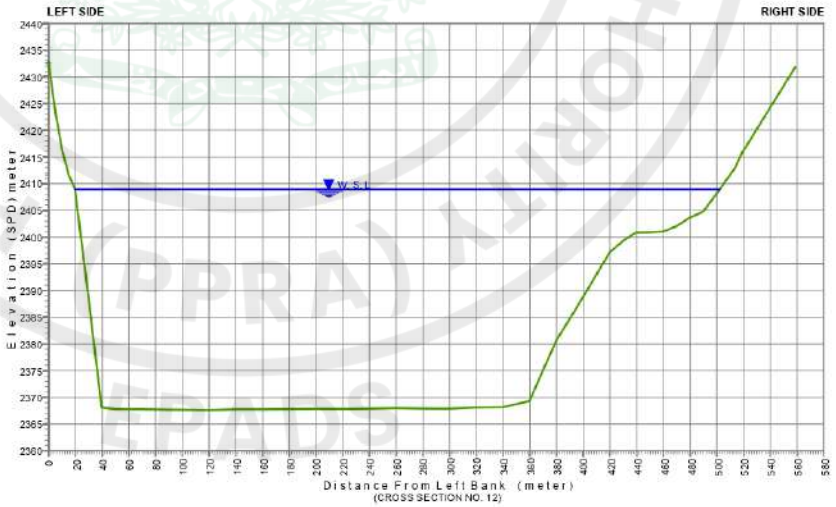


## LEGEND

OBSERVED WATER LEVEL

OBSERVED BED LEVEL

## NOTE:

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS UNLESS OTHERWISE SPECIFIED.
2. HYDROGRAPHIC SURVEY BY **ISRIP** - WAPDA.

| | | |
|---|---|---|
| PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | | |
| PREPARED<br>Ehsan | PROJECT | **ATTABAD LAKE HPP**<br>**FEASIBILITY STUDY REPORT** |
| DRAWN<br>Arshad | TITLE | **HYDROGRAPHIC SURVEY OF ATTABAD LAKE** |
| CHECKED<br>Ehsan | | **X - Sections No. 09,10,11 & 12** |
| APPROVED<br>Abid Sheikh | DATE<br>Jun: 2021 | SCALE<br>Hor: 1 cm = 40 m<br>Ver: 1 cm = 10 m |
| | | DWG No:<br>APS-HC-273 |
| | | REVISIONS |

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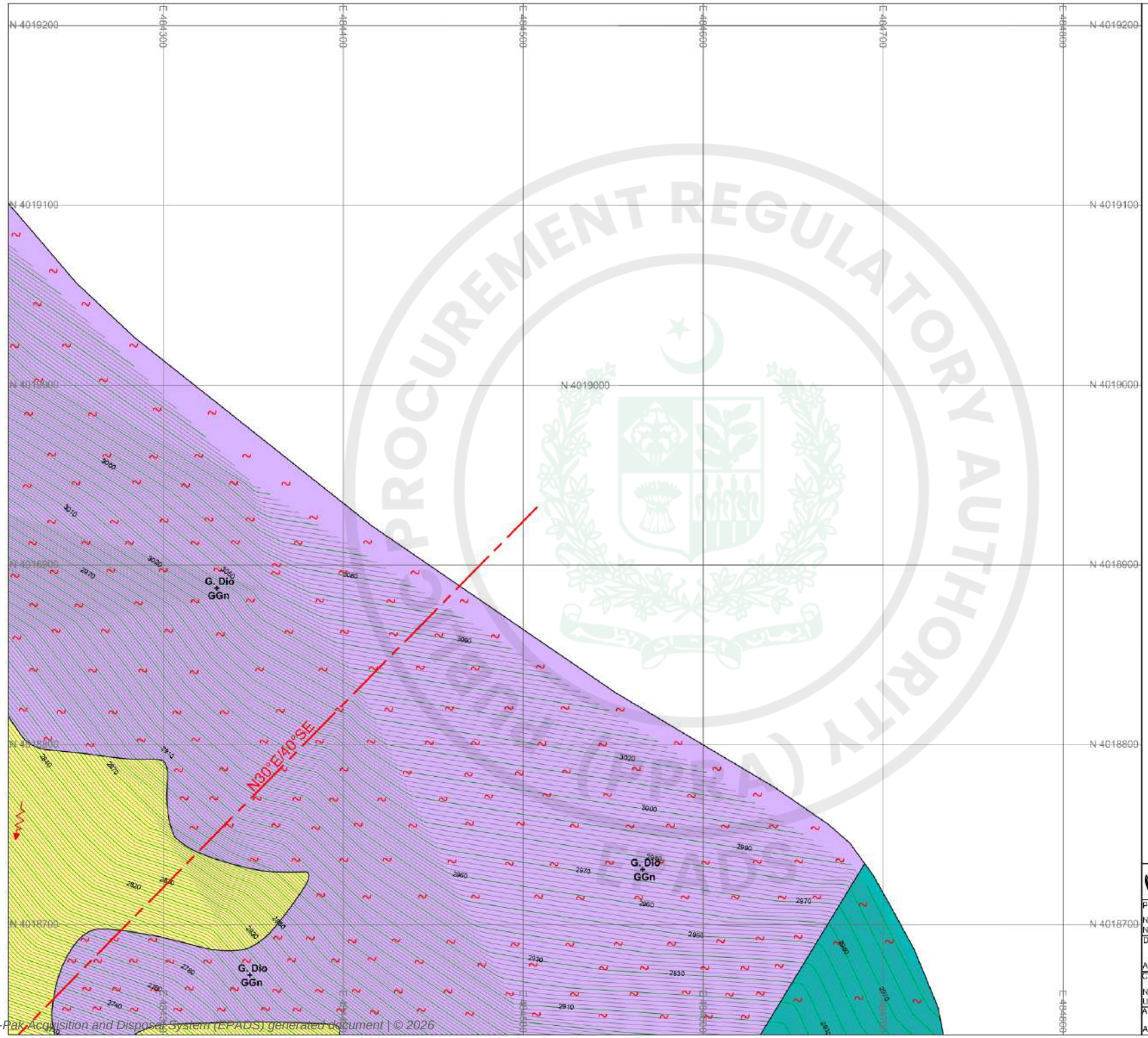


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**KEY PLAN:**

| | | | | | | |
|---|---|---|---|---|---|---|
| | 16 | 13 | 10 | 7 | 4 | 1 |
| 19 | 17 | 14 | 11 | 8 | 5 | 2 |
| 20 | 18 | 15 | 12 | 9 | 6 | 3 |

## LEGEND (GEOLOGY)

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- G.Dio + GGn — Granodiorite + Granitic Gneiss.
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- Dip and Strike of joint sets in rock.
- Dip and Strike of foliation.
- Active slide.
- Shear zone.
- Fault
- BH — Bore Hole.
- TP — Test Pit.
- River
- Confirmed Contact
- Inferred Contact

0 25 50 75 100 125 m

SCALE

## NOTE.

1. ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED
2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FILED OBSERVATIONS.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| PREPARED | PROJECT | |
|---|---|---|
| Nauman Naseer | | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN | TITLE | |
| Arshad | | SURFACE GEOLOGICAL MAP |
| CHECKED | | Sheet 1 of 20 |
| Nasiruddin Umar Tariq | | |
| APPROVED | DATE | SCALE / DWG No. / REVISIONS |
| Abid Sheikh | Jun: 2021 | 1 : 2,000 / APS-GE-295 |

PROCUREMENT REGULATORY AUTHORITY (PPRA) PAKISTAN

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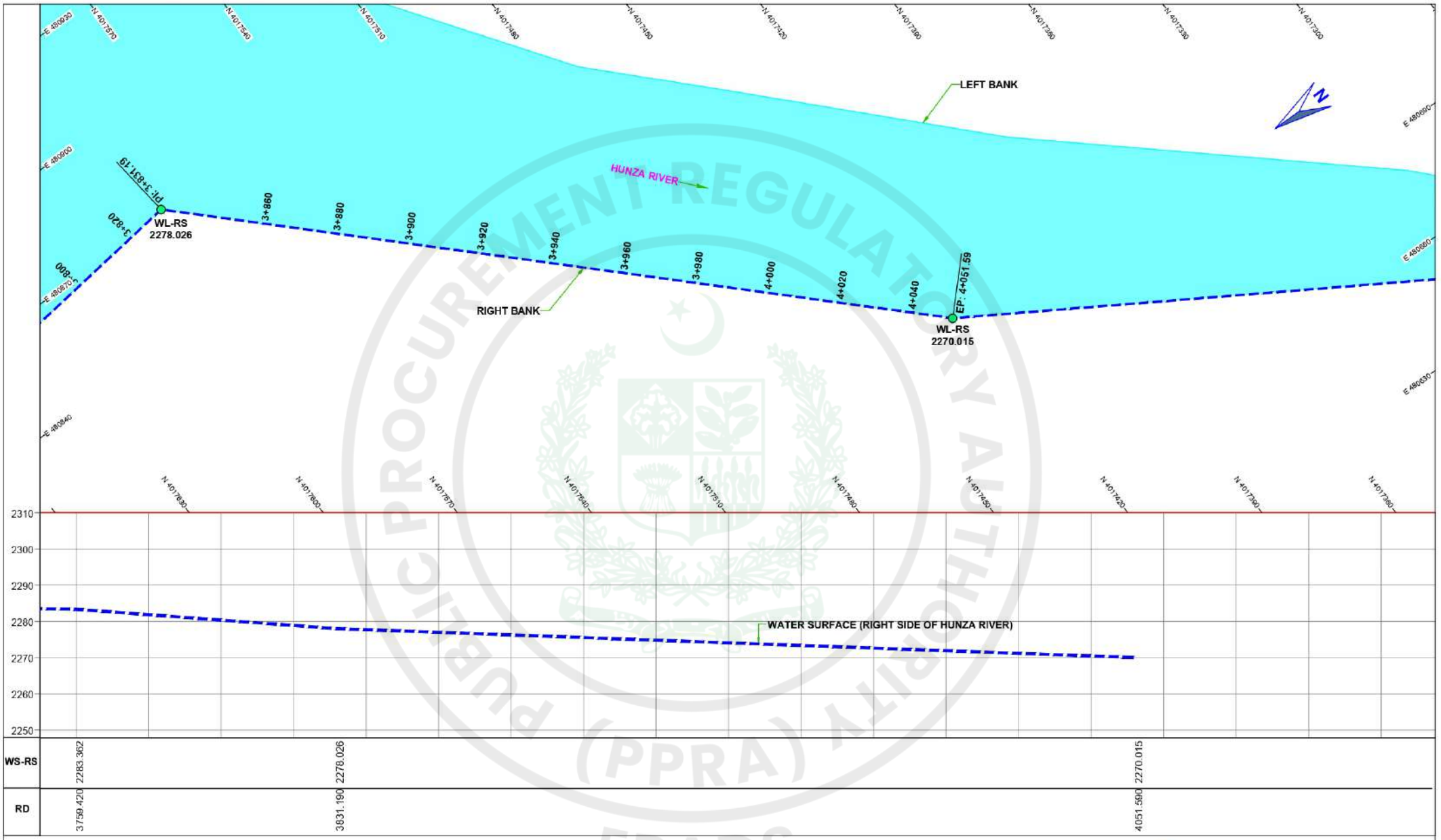


**NOTE:**

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS UNLESS OTHERWISE SPECIFIED.

10 0 10 20 30 40 50 m

SCALE

| | | | | |
|---|---|---|---|---|
| PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | | | | |
| PREPARED<br>Ehsan | PROJECT | ATTABAD LAKE HPP<br>FEASIBILITY STUDY REPORT | | |
| DRAWN<br>Arshad | TITLE | WATER SURFACE PLAN AND PROFILE (HUNZA RIVER)<br>(Sheet 11 of 11) | | |
| CHECKED<br>Ehsan | | | | |
| APPROVED<br>Abid Sheikh | DATE<br>Jun: 2021 | SCALE<br>1 : 1,000 | DWG No:<br>APS-SP-261 | REVISIONS |

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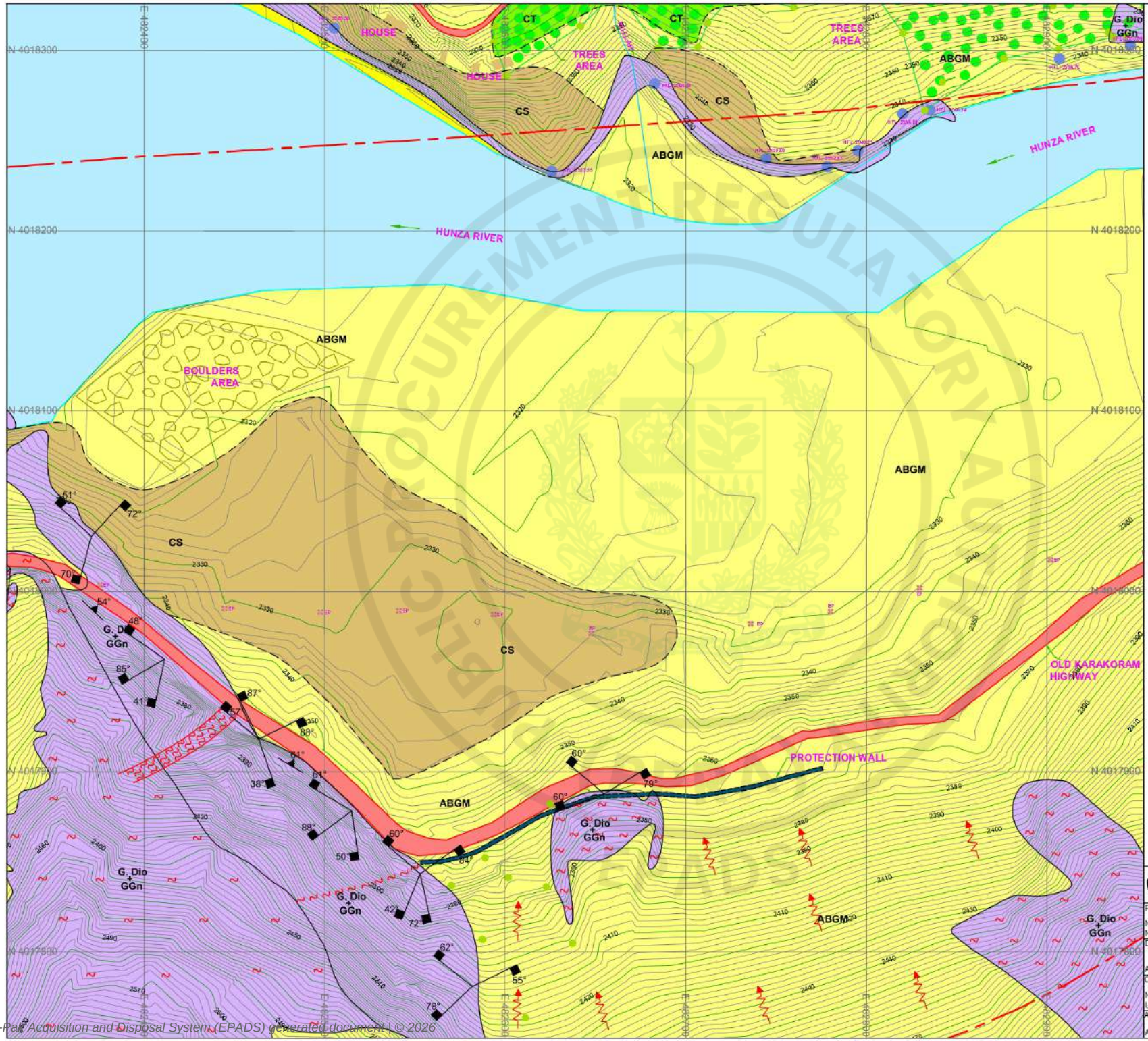


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**KEY PLAN:**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 16 | 13 | 10 | 7 | 4 | 1 |
| 19 | 17 | 14 | 11 | 8 | 5 | 2 |
| 20 | 18 | 15 | 12 | 9 | 6 | 3 |

## LEGEND (GEOLOGY)

**SOIL UNITS:**

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- Dip and Strike of joint sets in rock.
- Dip and Strike of foliation.
- Active slide.
- Shear zone.
- Fault
- BH — Bore Hole.
- TP — Test Pit.
- River
- Confirmed Contact
- Inferred Contact

0 25 50 75 100 125 m

SCALE

NOTE.

1. ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED
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**PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY**
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Nauman Naseer | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE | SURFACE GEOLOGICAL MAP |
| CHECKED: Nasiruddin, Umar Tariq | | Sheet 11 of 20 |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 2,000 / DWG No: APS-GE-303 / REVISIONS |

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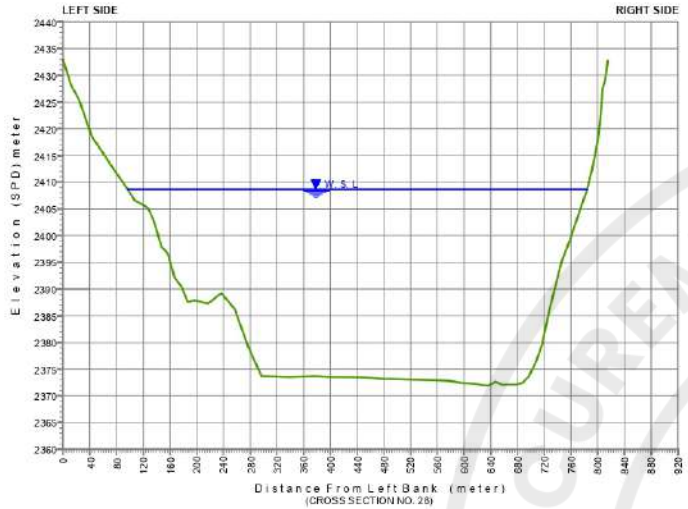


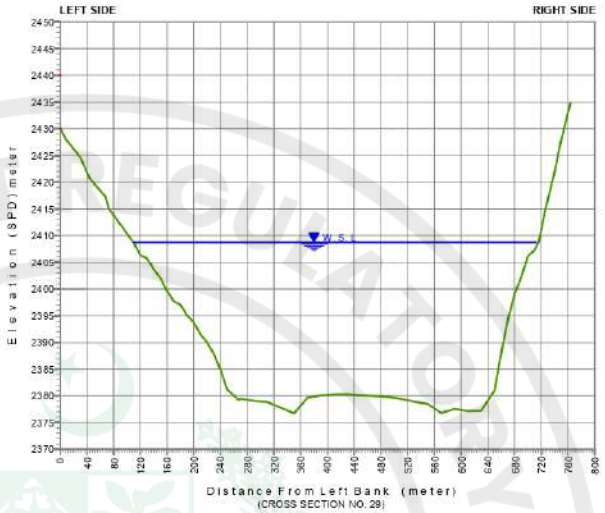


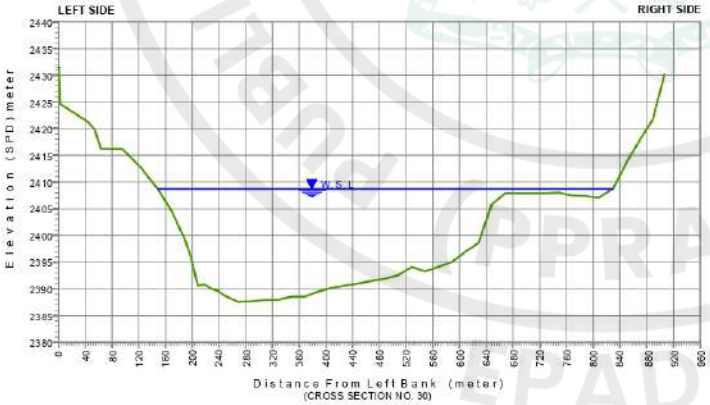


## LEGEND

OBSERVED WATER LEVEL

OBSERVED BED LEVEL

## NOTE:

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS UNLESS OTHERWISE SPECIFIED.
2. HYDROGRAPHIC SURVEY BY **ISRIP** - WAPDA.

**PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY**

HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Ehsan | PROJECT | **ATTABAD LAKE HPP FEASIBILITY STUDY REPORT** |
| DRAWN: Arshad | TITLE | **HYDROGRAPHIC SURVEY OF ATTABAD LAKE** |
| CHECKED: Ehsan | | **X - Sections No. 28,29 & 30** |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: Hor: 1 cm = 80 m, Ver: 1 cm = 10 m |
| | DWG No: ARSHHS-278 | REVISIONS |

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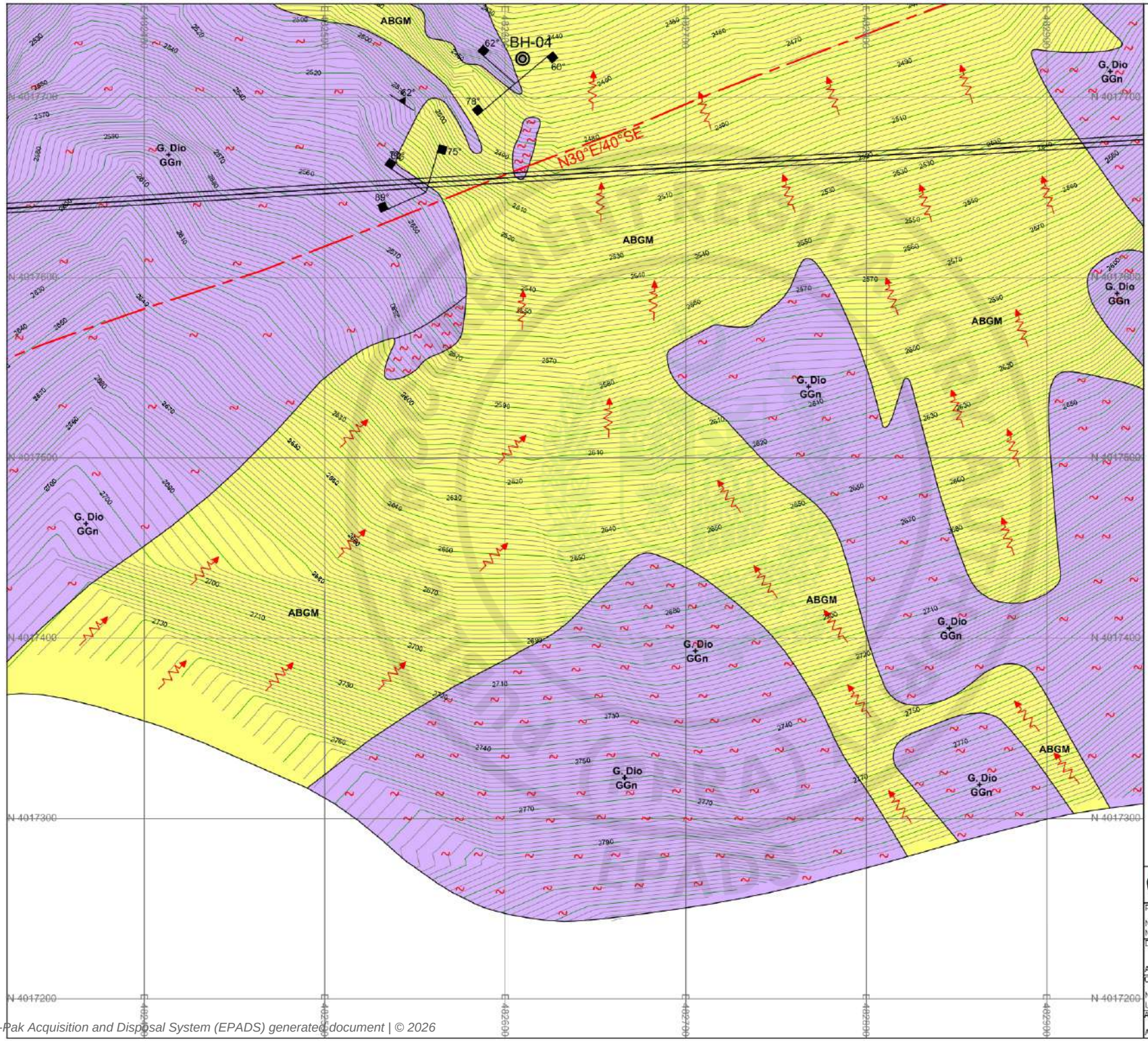


**KEY PLAN:**

| | | | | | | |
|---|---|---|---|---|---|---|
| | 16 | 13 | 10 | 7 | 4 | 1 |
| 19 | 17 | 14 | 11 | 8 | 5 | 2 |
| 20 | 18 | 15 | 12 | 9 | 6 | 3 |

## LEGEND (GEOLOGY)

**SOIL UNITS:**

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- RBGM — Rounded boulders and gravel with sand and appreciable amount of fines.
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- Dip and Strike of joint sets in rock.
- Dip and Strike of foliation.
- Active slide.
- Shear zone.
- Fault
- BH — Bore Hole.
- TP — Test Pit.
- River
- Confirmed Contact
- Inferred Contact

0 25 50 75 100 125 m
SCALE

**NOTE.**

1. ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED
2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FILED OBSERVATIONS.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Nauman Naseer | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE | SURFACE GEOLOGICAL MAP |
| CHECKED: Nasiruddin, Umar Tariq | | Sheet 12 of 20 |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 2,000 / DWG No: APS-GE-304 / REVISIONS |

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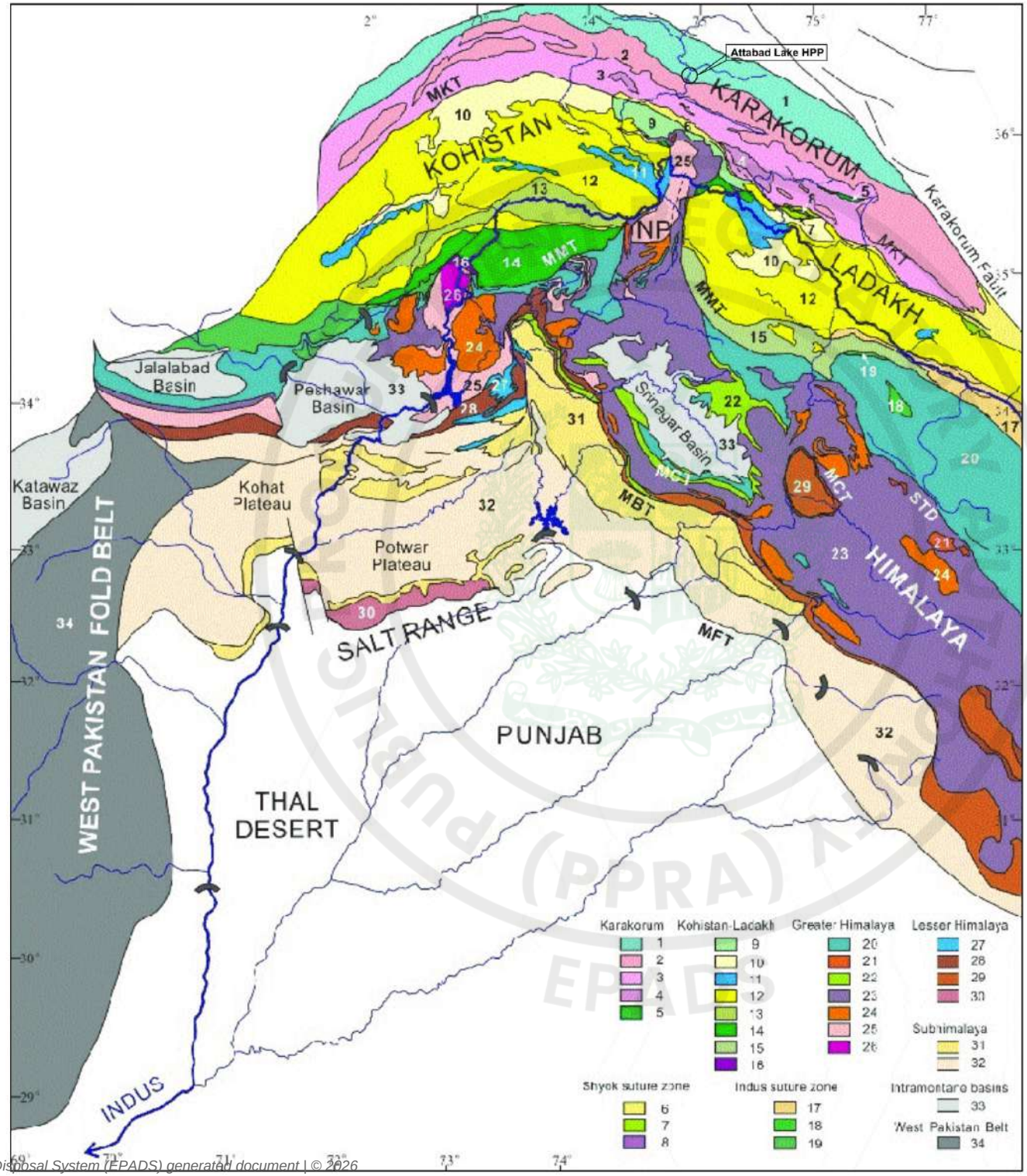


**MKT** Main Karakuram Thrust
**MMT** Main MantleThrust
**MCT** Main Central Thrust
**MBT** Main Boundary Thrust
**PT** Panjal Thrust
**DF** Darban Fault
**KBT/** Kashmir Boundary Thrust /
**HFT** Himalayan Frontal Thrust
**SRT** Salt Range Thrust

**SOURCE:**

**Pecher et al. 2008**

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Nauman Naseer | PROJECT: ATTABAD LAKE HPP FEASIBILITY STUDY REPORT | |
| DRAWN: Arshad | TITLE: REGIONAL GEOLOGICAL MAP | |
| CHECKED: Nasiruddin, Umar Tariq | | |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: N.T.S |
| | | DWG No: APS-GE-291 |
| | | REVISIONS |

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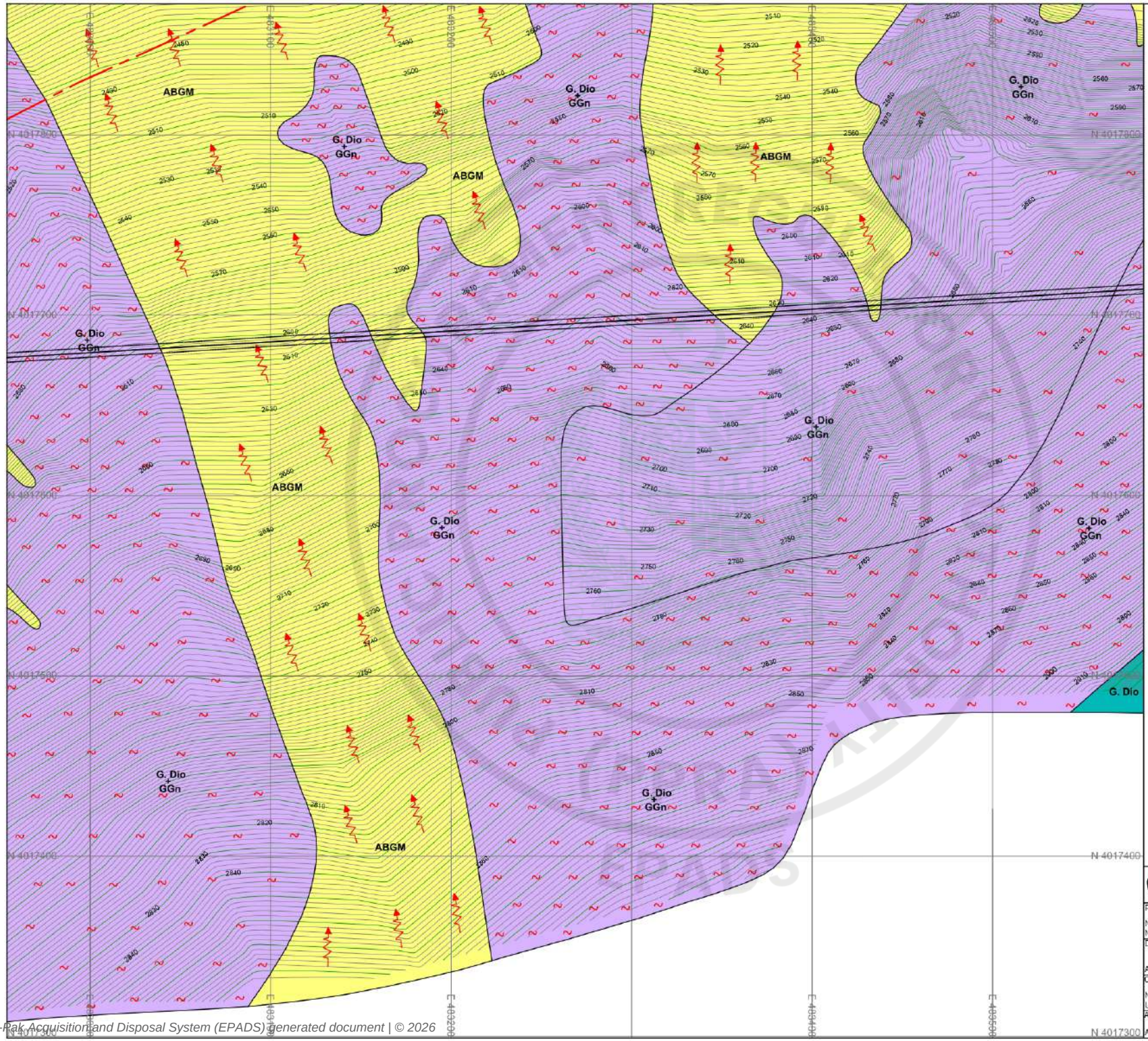


**KEY PLAN:**

| | | | | | | |
|---|---|---|---|---|---|---|
| | 16 | 13 | 10 | 7 | 4 | 1 |
| 19 | 17 | 14 | 11 | 8 | 5 | 2 |
| 20 | 18 | 15 | 12 | 9 | 6 | 3 |

## LEGEND (GEOLOGY)

**SOIL UNITS:**

- ABGM — Angular boulders and gravel with sand and appreciable amount of fines.
- RBGM — Rounded boulders and gravel with sand and appreciable amount of fines.
- CT — Cultivated Terrace.
- Mor — Morainic Material
- CS — Clayey Silt.

**ROCK UNITS:**

- G.Dio — Granodiorite
- G.Dio + GGn — Granodiorite + Granitic Gneiss.
- BR — Fault Breccia.
- Dip and Strike of joint sets in rock.
- Dip and Strike of foliation.
- Active slide.
- Shear zone.
- Fault
- BH — Bore Hole.
- TP — Test Pit.
- River
- Confirmed Contact
- Inferred Contact

0 25 50 75 100 125 m
SCALE

## NOTE.

1. ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED
2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FILED OBSERVATIONS.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Nauman Naseer | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE | SURFACE GEOLOGICAL MAP |
| CHECKED: Nasiruddin, Umar Tariq | | Sheet 9 of 20 |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 2,000 / DWG No: APS-GE-301 / REVISIONS |

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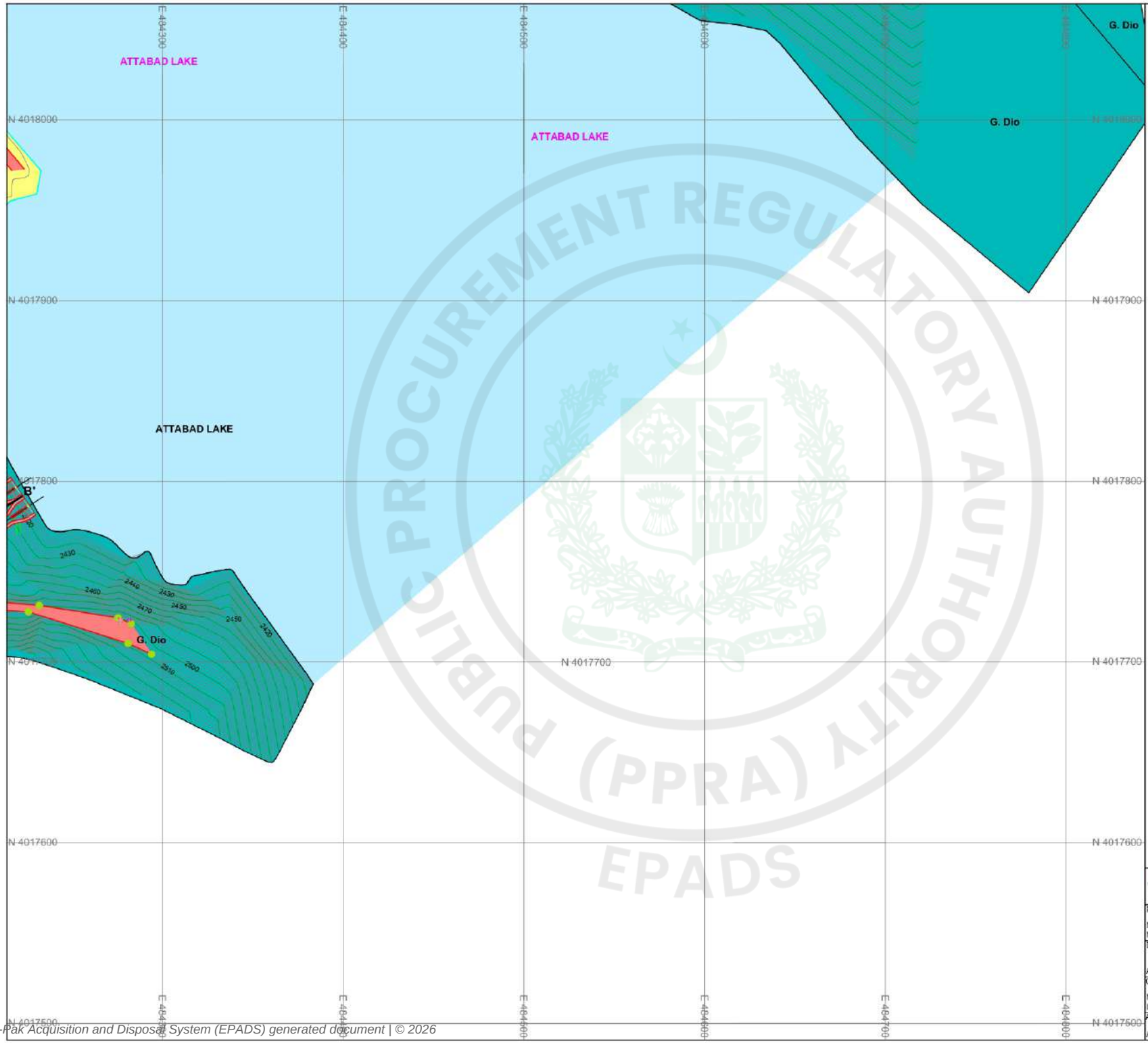


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**KEY PLAN:**

| | | | | | | |
|---|---|---|---|---|---|---|
| | 16 | 13 | 10 | 7 | 4 | 1 |
| 19 | 17 | 14 | 11 | 8 | 5 | 2 |
| 20 | 18 | 15 | 12 | 9 | 6 | 3 |

## LEGEND (GEOLOGY)

**SOIL UNITS:**

- ABGM — Angular boulders and gravel with sand and appreciable amount of fines.
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- Shear zone.
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- River
- Confirmed Contact
- Inferred Contact

0 25 50 75 100 125 m

SCALE

## NOTE.

1. ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED
2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FILED OBSERVATIONS.

**PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY**
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Nauman Naseer | PROJECT | **ATTABAD LAKE HPP FEASIBILITY STUDY REPORT** |
| DRAWN: Arshad | TITLE | **SURFACE GEOLOGICAL MAP** |
| CHECKED: Nasiruddin, Umar Tariq | | Sheet 3 of 20 |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 2,000 / DWG No.: APS-GE-295 / REVISIONS |

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

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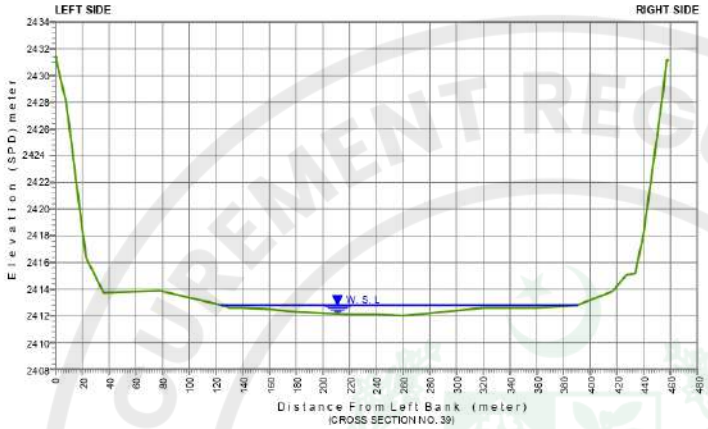

## LEGEND

OBSERVED WATER LEVEL

OBSERVED BED LEVEL

## NOTE:

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS UNLESS OTHERWISE SPECIFIED.
2. HYDROGRAPHIC SURVEY BY **ISRIP** - WAPDA.

**PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY**

HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Ehsan | PROJECT | **ATTABAD LAKE HPP FEASIBILITY STUDY REPORT** |
| DRAWN: Arshad | TITLE | **HYDROGRAPHIC SURVEY OF ATTABAD LAKE** |
| CHECKED: Ehsan | | **X - Sections No. 39 & 40** |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: Hor: 1 cm = 40 m, Ver: 1 cm = 04 m |
| | | DWG No: AP-S-HS-281 |
| | | REVISIONS |

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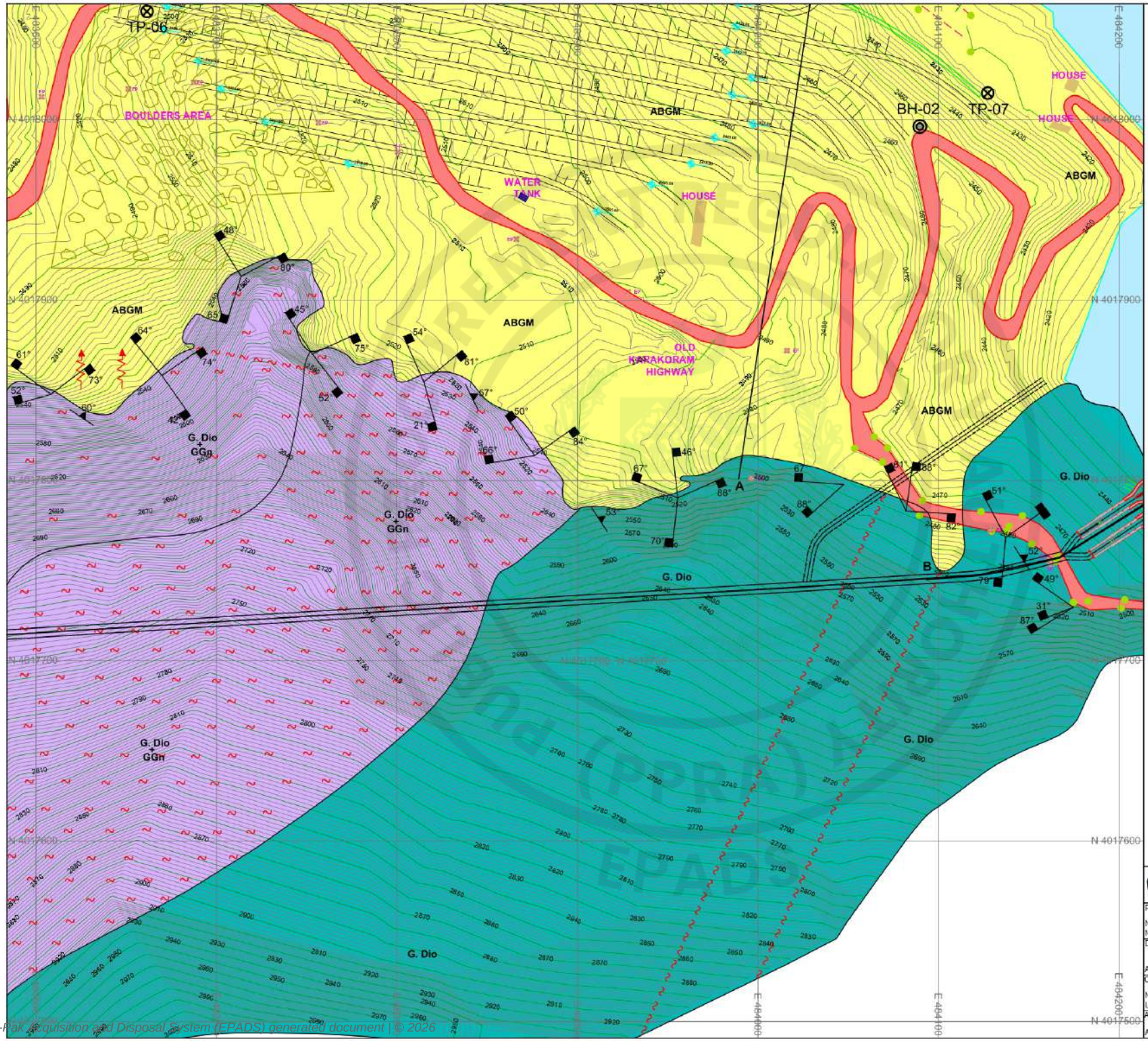


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**KEY PLAN:**

| | | | | | | |
|---|---|---|---|---|---|---|
| | 16 | 13 | 10 | 7 | 4 | 1 |
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## LEGEND (GEOLOGY)

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- Active slide.
- Shear zone.
- Fault
- BH — Bore Hole.
- TP — Test Pit.
- River
- Confirmed Contact
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0 25 50 75 100 125 m

SCALE

## NOTE.

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**PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY**
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Nauman Naseer | PROJECT | **ATTABAD LAKE HPP FEASIBILITY STUDY REPORT** |
| DRAWN: Arshad | TITLE | **SURFACE GEOLOGICAL MAP** Sheet 6 of 20 |
| CHECKED: Nasiruddin, Umar Tariq | | |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 2,000 / DWG No.: APS-GE-298 / REVISIONS |

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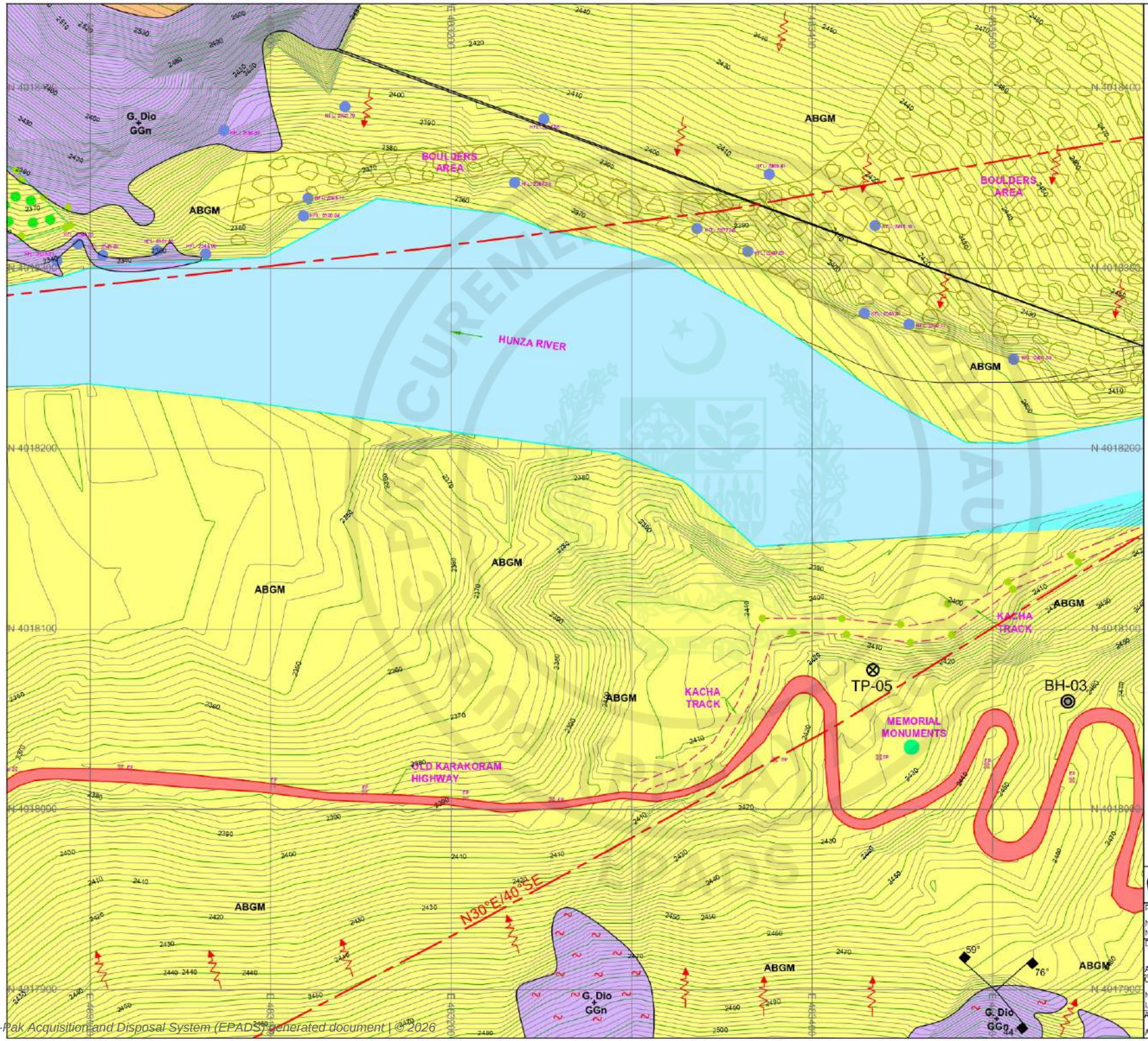


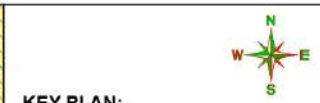


**KEY PLAN:**

| | | | | | | |
|---|---|---|---|---|---|---|
| | 16 | 13 | 10 | 7 | 4 | 1 |
| 19 | 17 | 14 | 11 | 8 | 5 | 2 |
| 20 | 18 | 15 | 12 | 9 | 6 | 3 |

## LEGEND (GEOLOGY)

**SOIL UNITS:**

| | |
|---|---|
| ABGM | Angular boulders and gravel with sand and appreciable amount of fines. |
| RBGM | Rounded boulders and gravel with sand and appreciable amount of fines. |
| CT | Cultivated Terrace. |
| Mor | Morainic Material |
| CS | Clayey Silt. |

**ROCK UNITS:**

| | |
|---|---|
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| G.Dio + GGn | Granodiorite + Granitic Gneiss. |
| BR | Fault Breccia. |

Dip and Strike of joint sets in rock.

Dip and Strike of foliation.

Active slide.

Shear zone.

Fault

BH Bore Hole.

TP Test Pit.

River

Confirmed Contact

Inferred Contact

0 25 50 75 100 125 m

SCALE

## NOTE.

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2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FILED OBSERVATIONS.

**PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY**
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Nauman Naseer | PROJECT: | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE: | SURFACE GEOLOGICAL MAP |
| CHECKED: Nasiruddin, Umar Tariq | | Sheet 8 of 20 |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 2,000 |
| | | DWG No: APS-GE-300 |
| | | REVISIONS |

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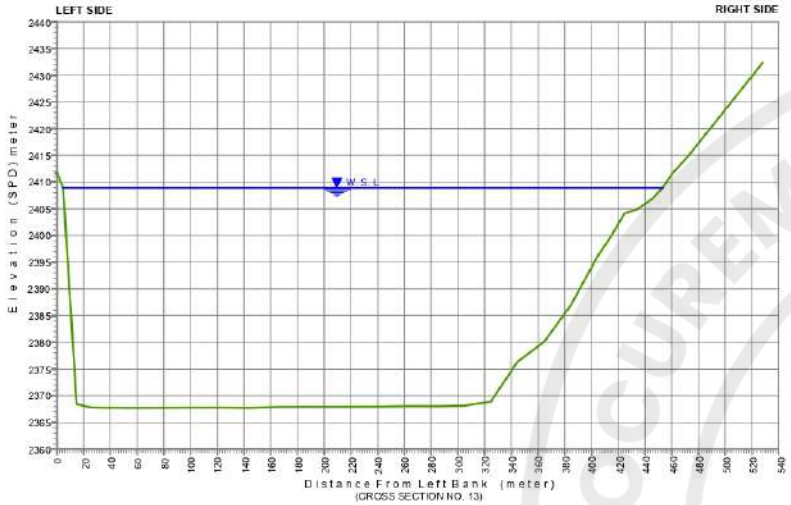


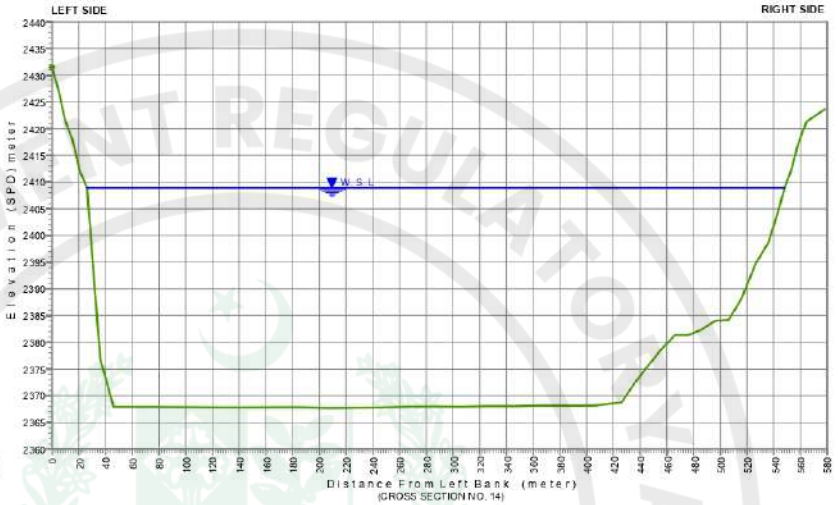


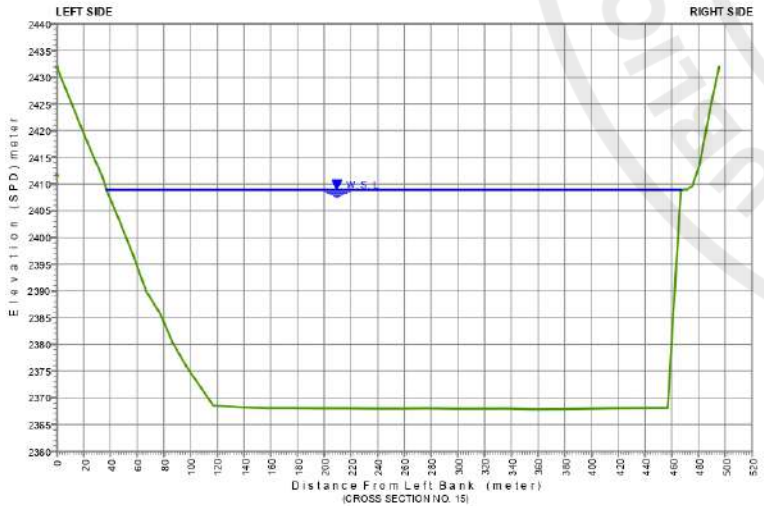


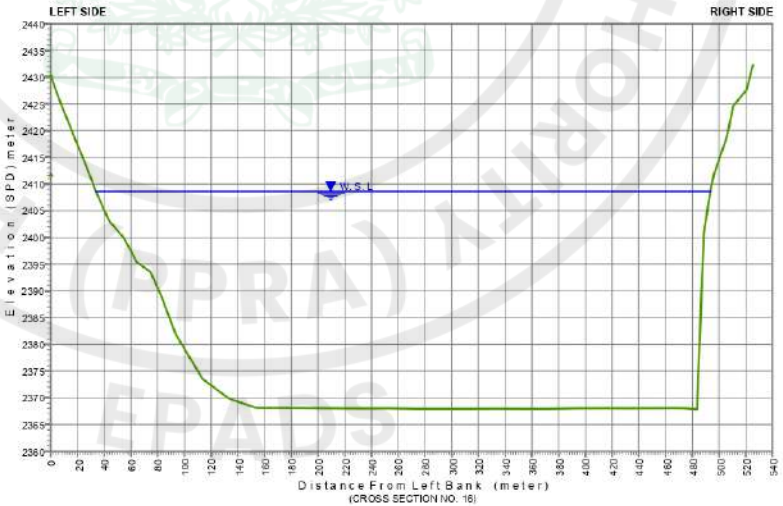


## LEGEND

OBSERVED WATER LEVEL

OBSERVED BED LEVEL

## NOTE:

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS UNLESS OTHERWISE SPECIFIED.
2. HYDROGRAPHIC SURVEY BY **ISRIP** - WAPDA.

**PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY**

HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Ehsan | PROJECT | **ATTABAD LAKE HPP FEASIBILITY STUDY REPORT** |
| DRAWN: Arshad | TITLE | **HYDROGRAPHIC SURVEY OF ATTABAD LAKE** |
| CHECKED: Ehsan | | **X - Sections No. 13,14,15 & 16** |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: Hor: 1 cm = 40 m, Ver: 1 cm = 10 m |
| | | DWG No: ARS-HS-274 |
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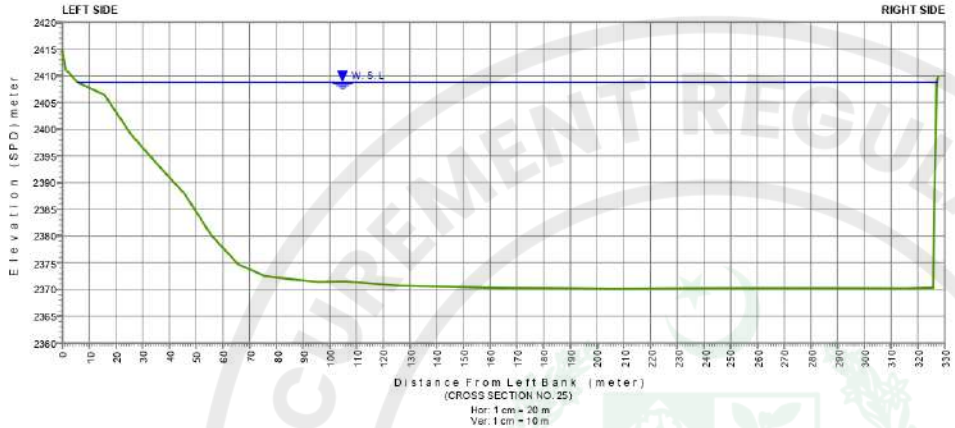


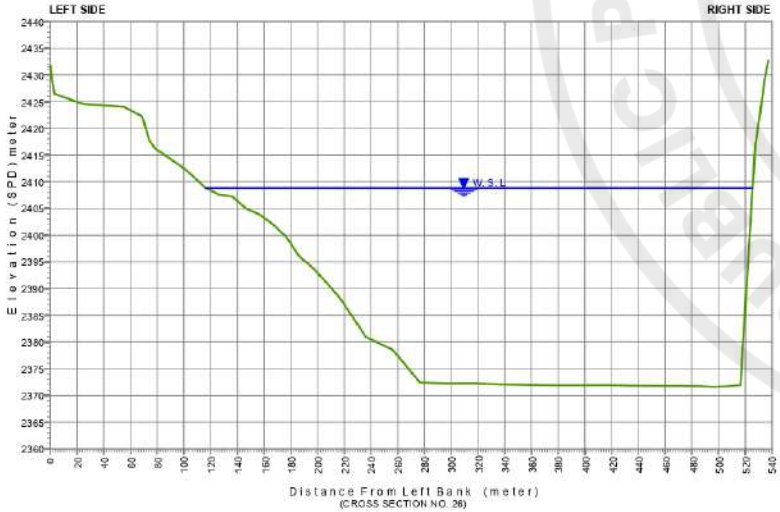


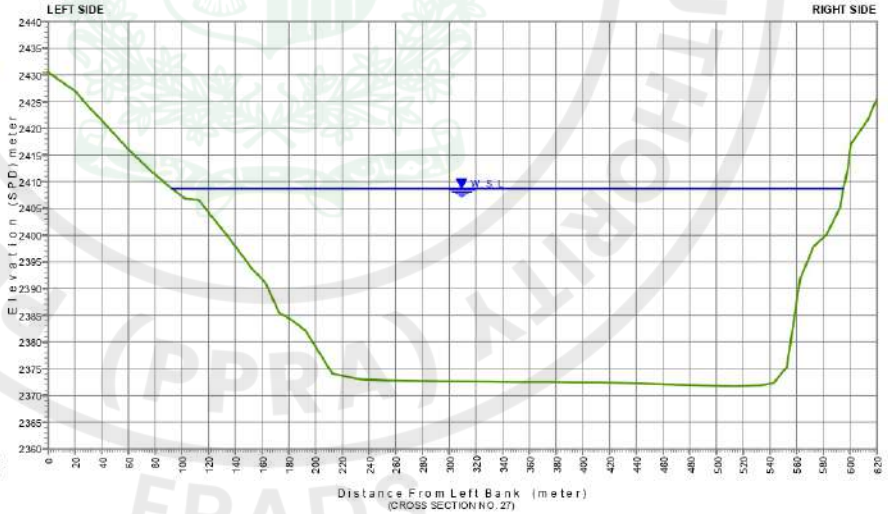


## LEGEND

OBSERVED WATER LEVEL

OBSERVED BED LEVEL

## NOTE:

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS UNLESS OTHERWISE SPECIFIED.
2. HYDROGRAPHIC SURVEY BY **ISRIP** - WAPDA.

**PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY**
HYDRO PLANNING ORGANIZATION

| PREPARED | PROJECT | ATTABAD LAKE HPP<br>FEASIBILITY STUDY REPORT | |
|---|---|---|---|
| Ehsan | | | |
| DRAWN | TITLE | HYDROGRAPHIC SURVEY OF ATTABAD LAKE<br>X - Sections No. 25,26, & 27 | |
| Arshad | | | |
| CHECKED | | | |
| Ehsan | | | |
| APPROVED | DATE | SCALE | DWG No: / REVISIONS |
| Abid Sheikh | Jun: 2021 | Hor: 1 cm = 40 m<br>Ver: 1 cm = 10 m | AFS-HS-277 |

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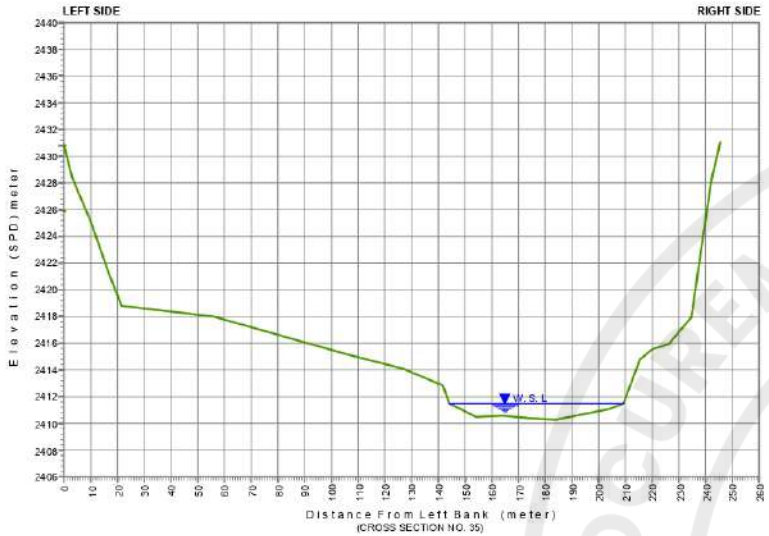


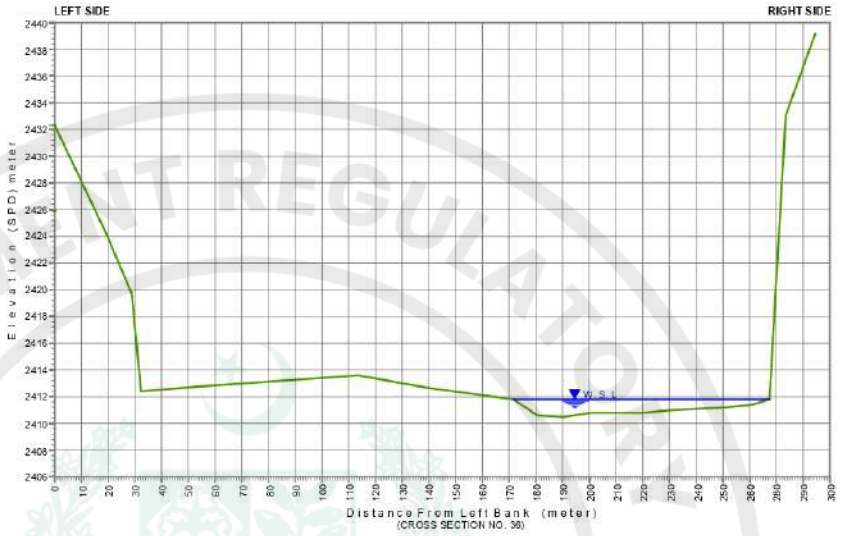


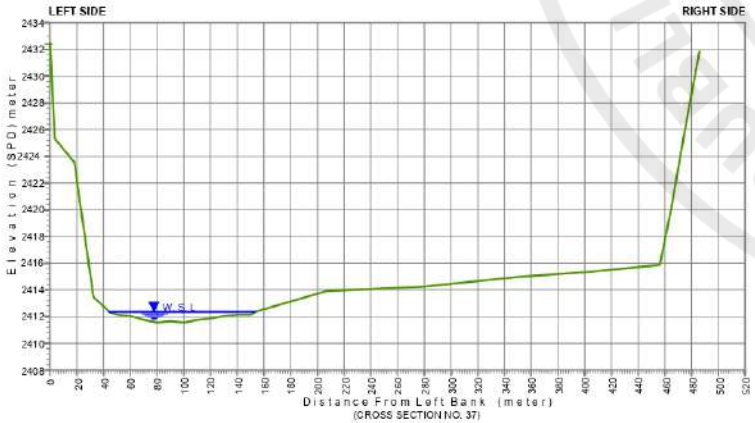


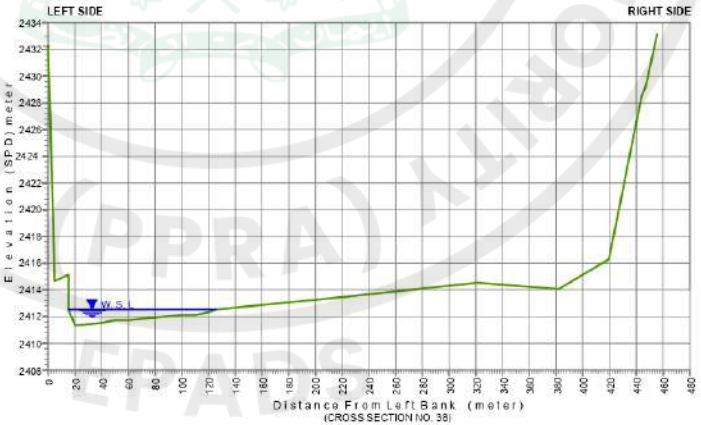


## LEGEND

OBSERVED WATER LEVEL

OBSERVED BED LEVEL

## NOTE:

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS UNLESS OTHERWISE SPECIFIED.
2. HYDROGRAPHIC SURVEY BY **ISRIP** - WAPDA.

**PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY**

HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Ehsan | PROJECT | **ATTABAD LAKE HPP**<br>**FEASIBILITY STUDY REPORT** |
| DRAWN: Arshad<br>CHECKED: Ehsan | TITLE | **HYDROGRAPHIC SURVEY OF ATTABAD LAKE**<br>**X - Sections No. 35,36,37 & 38** |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: Hor: 1 cm = 40 m, Ver: 1 cm = 04 m |
| | | DWG No: AFS-HS-280 |
| | | REVISIONS |

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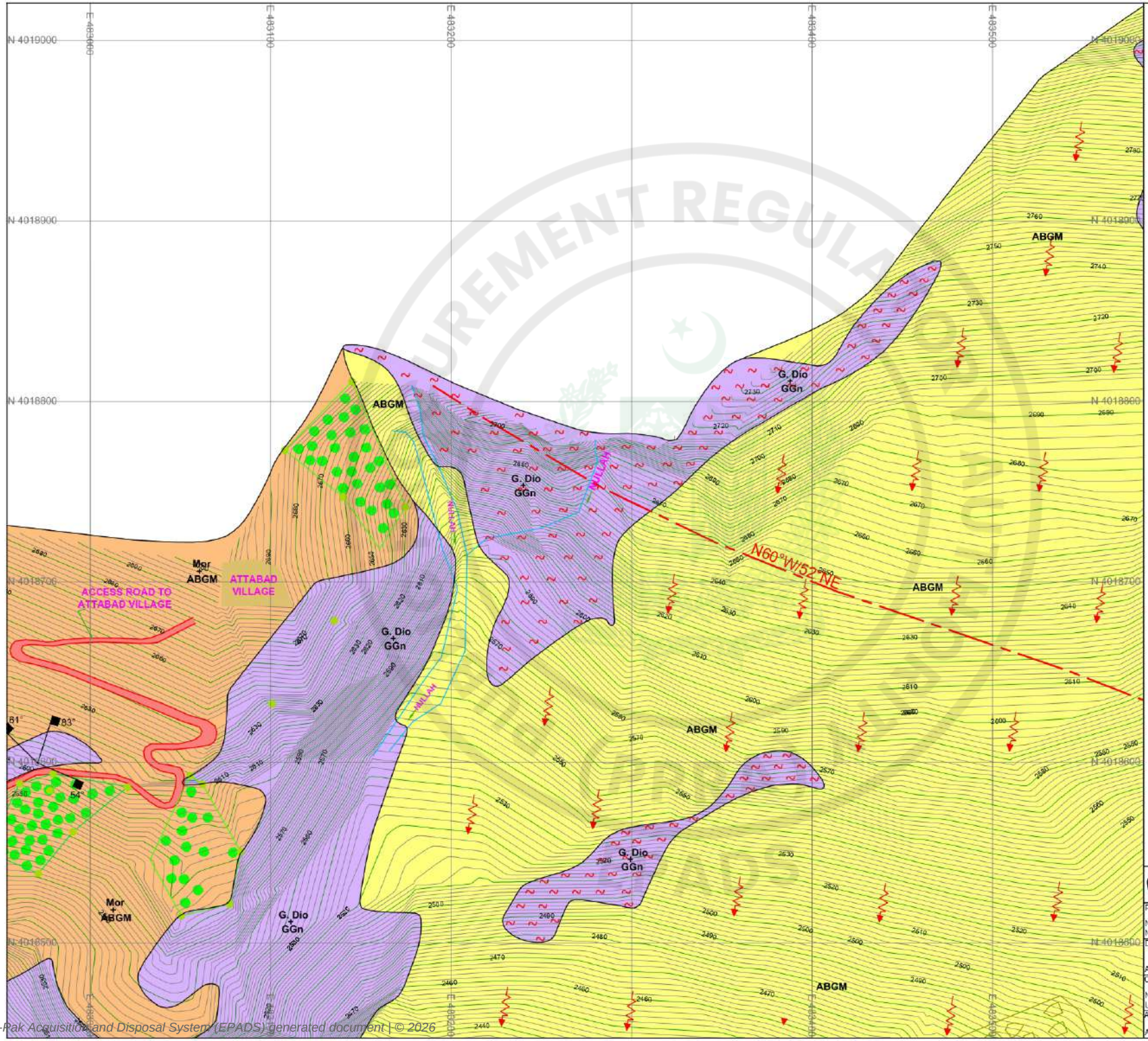


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**KEY PLAN:**

| | | | | | | |
|---|---|---|---|---|---|---|
| | 16 | 13 | 10 | 7 | 4 | 1 |
| 19 | 17 | 14 | 11 | 8 | 5 | 2 |
| 20 | 18 | 15 | 12 | 9 | 6 | 3 |

## LEGEND (GEOLOGY)

**SOIL UNITS:**

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- Active slide.
- Shear zone.
- Fault
- BH — Bore Hole.
- TP — Test Pit.
- River
- Confirmed Contact
- Inferred Contact

0 25 50 75 100 125 m

SCALE

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2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FILED OBSERVATIONS.

**PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY**
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Nauman Naseer | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE | SURFACE GEOLOGICAL MAP |
| CHECKED: Nasiruddin, Umar Tariq | | Sheet 7 of 20 |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 2,000 / DWG No: APS-GE-298 / REVISIONS |

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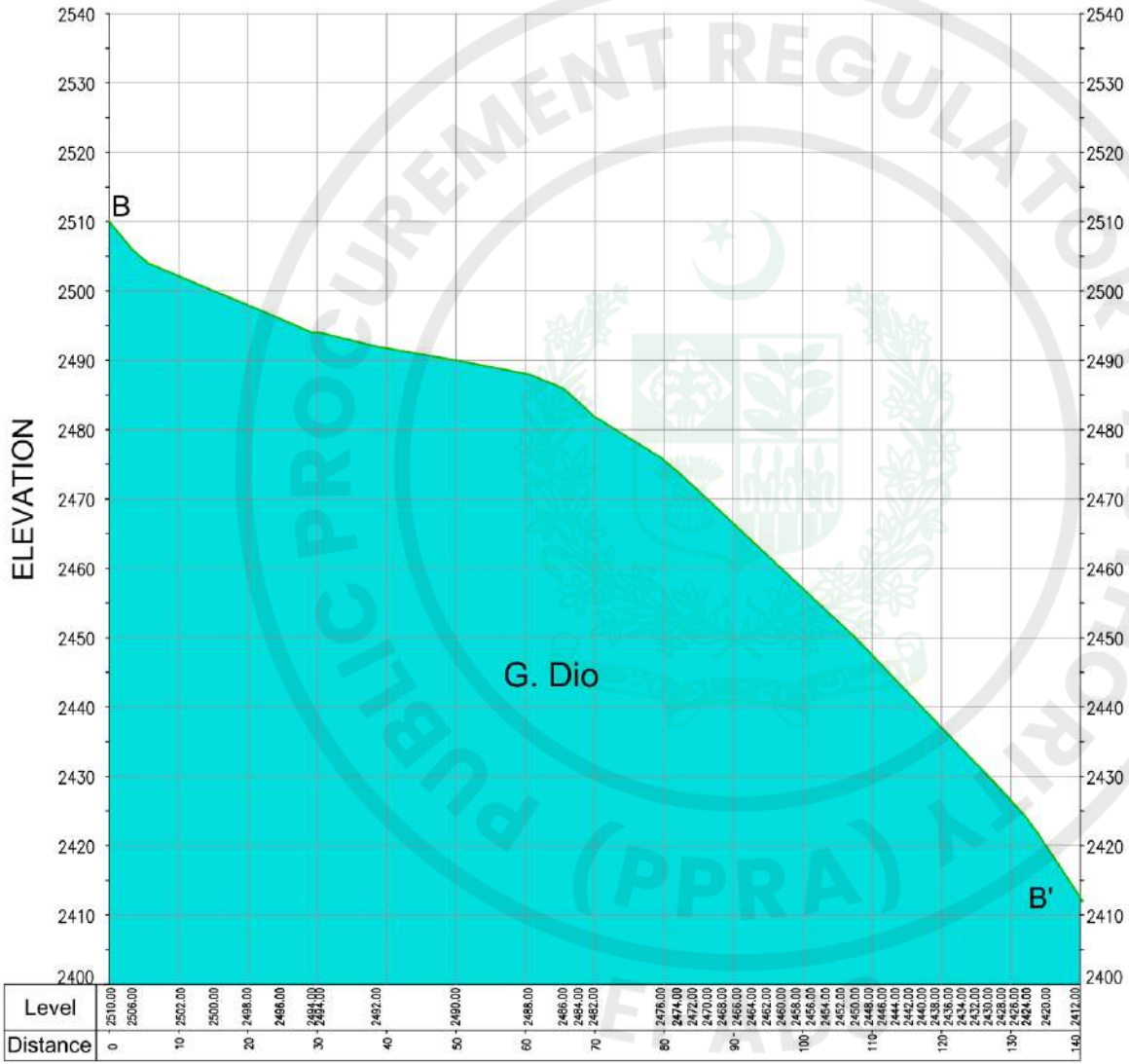


## LEGEND

**ROCK UNITS:**

G.Dio Granodiorite

## NOTE.

ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Nauman Naseer | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE | GEOLOGICAL X-SECTION BB' INTAKE AREA |
| CHECKED: Nasiruddin, Umar Tariq | | |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 750 |
| | DWG No: APS-GE-314 | REVISIONS |

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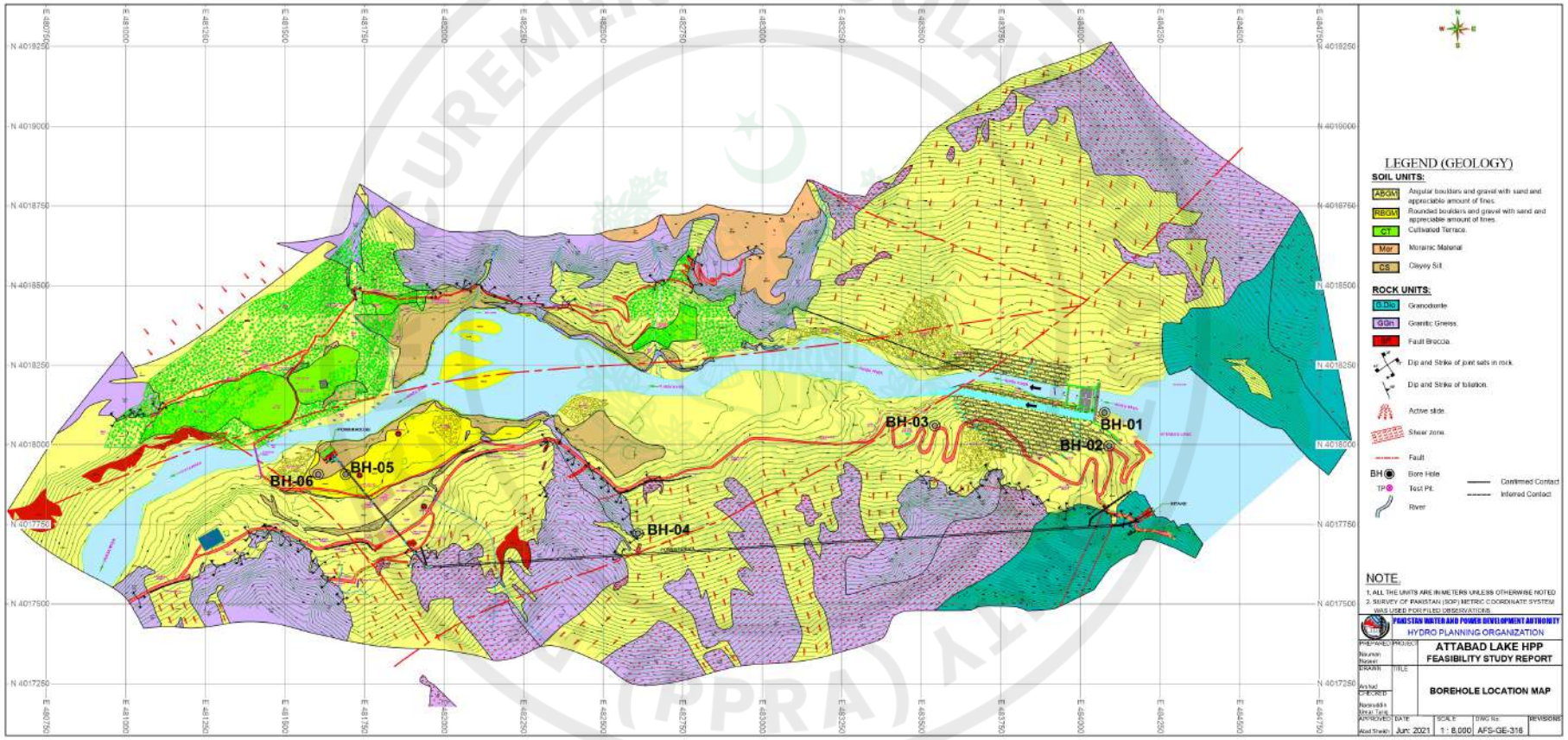


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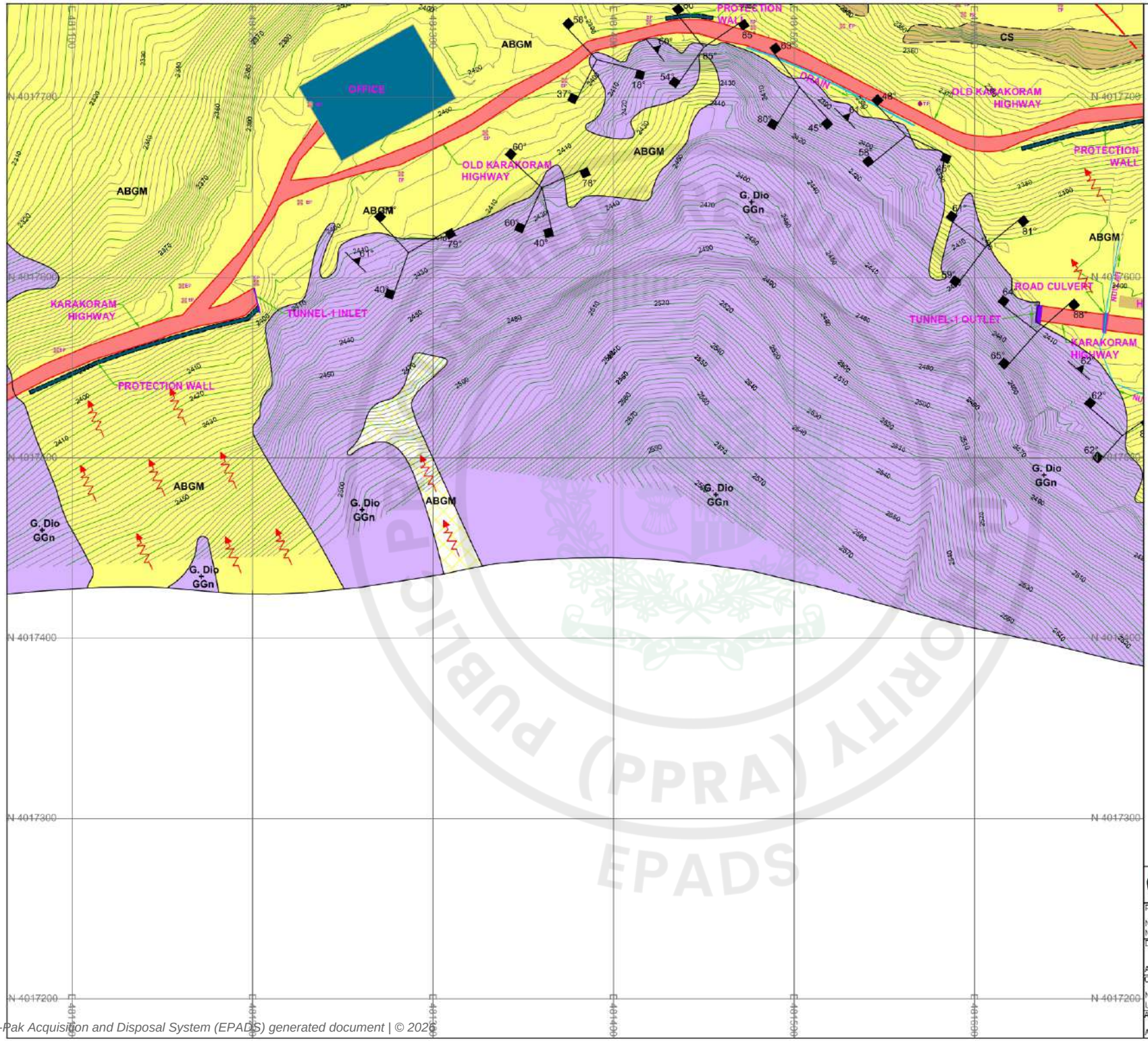


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**KEY PLAN:**

| | | | | | | |
|---|---|---|---|---|---|---|
| | 16 | 13 | 10 | 7 | 4 | 1 |
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## LEGEND (GEOLOGY)

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0 25 50 75 100 125 m

SCALE

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PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Nauman Naseer | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE | SURFACE GEOLOGICAL MAP |
| CHECKED: Nasiruddin, Umar Tariq | | Sheet 18 of 20 |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 2,000 / DWG No: APS-GE-310 / REVISIONS |

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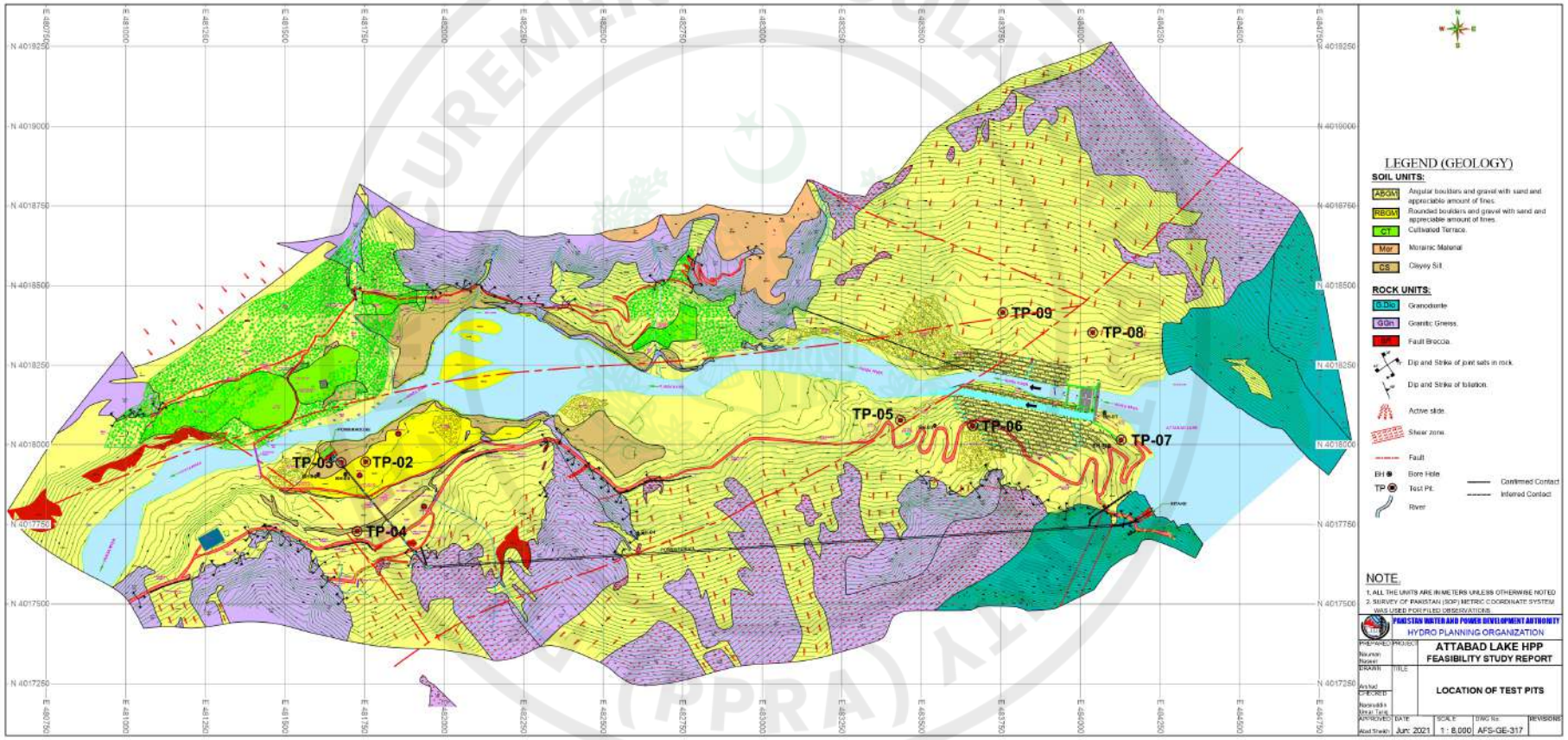


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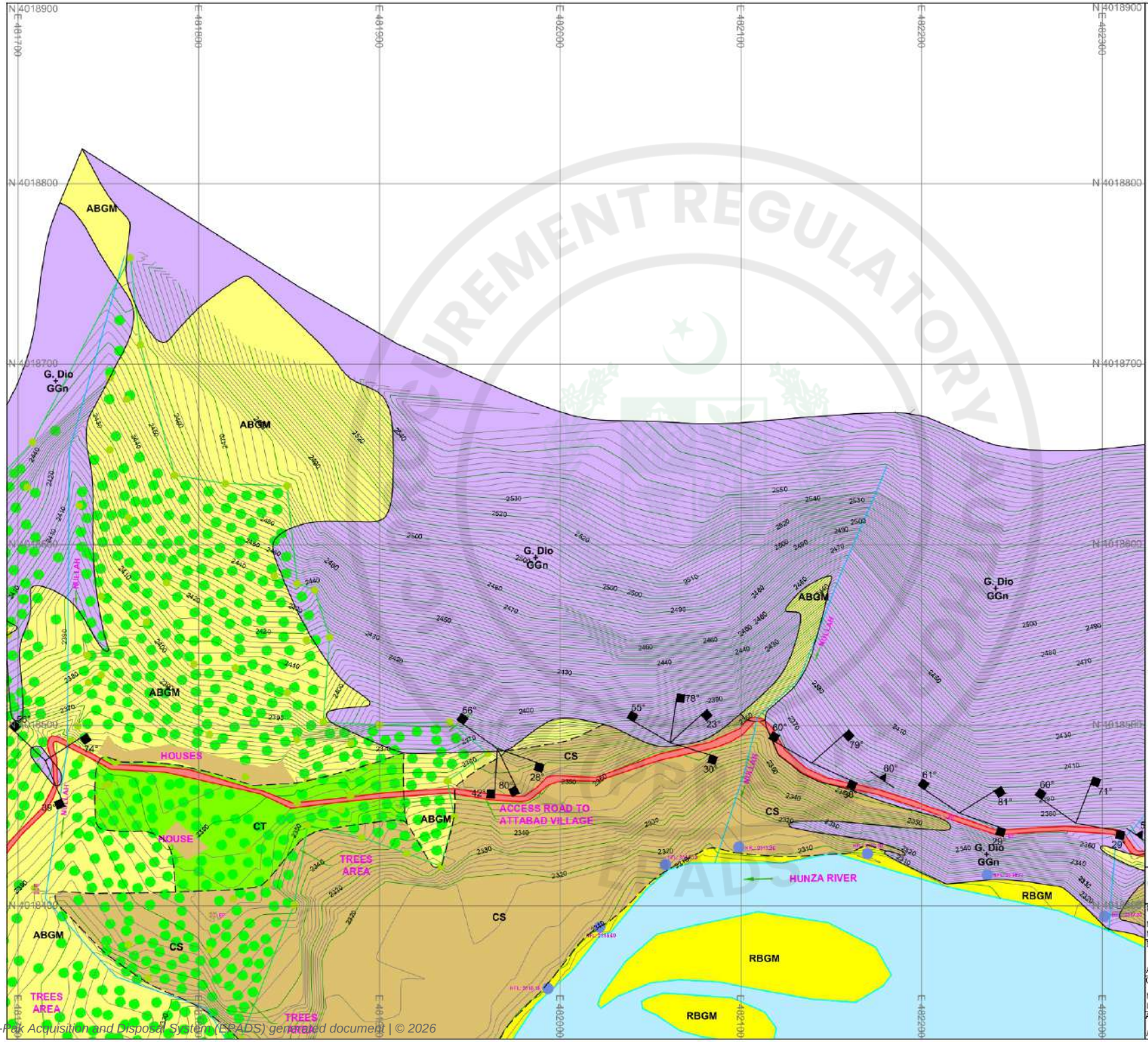


**KEY PLAN:**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | 4 | 1 | |
| | 16 | 13 | 10 | 7 | | 5 | 2 | |
| 19 | 17 | 14 | 11 | 8 | | 6 | 3 | |
| 20 | 18 | 15 | 12 | 9 | | | | |

## LEGEND (GEOLOGY)

**SOIL UNITS:**

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- G.Dio + GGn — Granodiorite + Granitic Gneiss.
- BR — Fault Breccia.
- Dip and Strike of joint sets in rock.
- Dip and Strike of foliation.
- Active slide.
- Shear zone.
- Fault
- BH — Bore Hole.
- TP — Test Pit.
- River
- Confirmed Contact
- Inferred Contact

0 25 50 75 100 125 m
SCALE

## NOTE.

1. ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED
2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FILED OBSERVATIONS.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Nauman Naseer | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE | SURFACE GEOLOGICAL MAP |
| CHECKED: Nasiruddin, Umar Tariq | | Sheet 13 of 20 |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 2,000 / DWG No: APS-GE-305 / REVISIONS |

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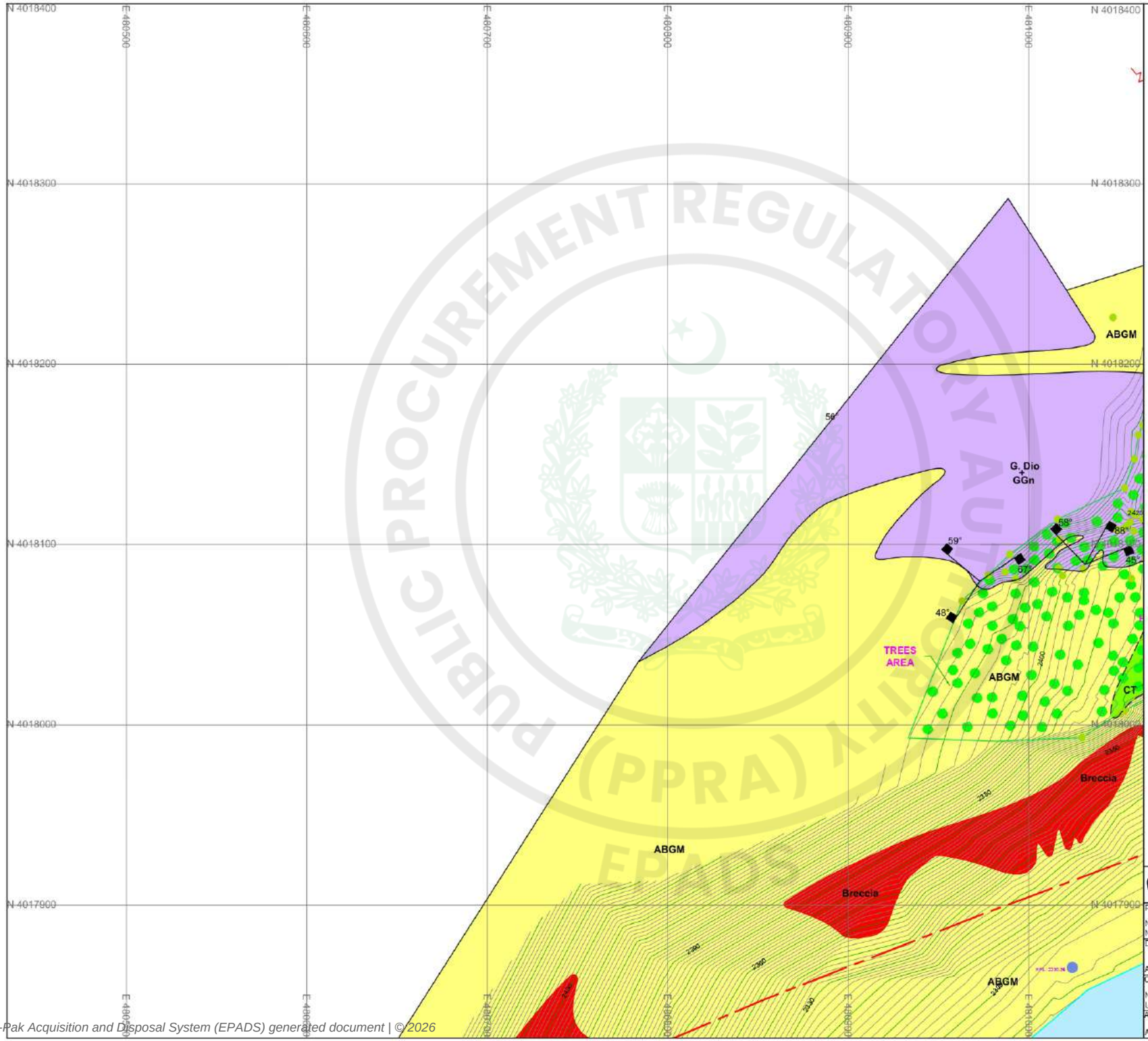



N

W E

S

**KEY PLAN:**

| | | | | | |
|---|---|---|---|---|---|
| | 16 | 13 | 10 | 7 | 4 1 |
| 19 | 17 | 14 | 11 | 8 | 5 2 |
| 20 | 18 | 15 | 12 | 9 | 6 3 |

## LEGEND (GEOLOGY)

**SOIL UNITS:**

- ABGM — Angular boulders and gravel with sand and appreciable amount of fines.
- RBGM — Rounded boulders and gravel with sand and appreciable amount of fines.
- CT — Cultivated Terrace.
- Mor — Morainic Material
- CS — Clayey Silt.

**ROCK UNITS:**

- G.Dio — Granodiorite
- G.Dio + GGn — Granodiorite + Granitic Gneiss.
- BR — Fault Breccia.
- Dip and Strike of joint sets in rock.
- Dip and Strike of foliation.
- Active slide.
- Shear zone.
- Fault
- BH — Bore Hole.
- TP — Test Pit.
- River
- Confirmed Contact
- Inferred Contact

0 25 50 75 100 125 m

SCALE

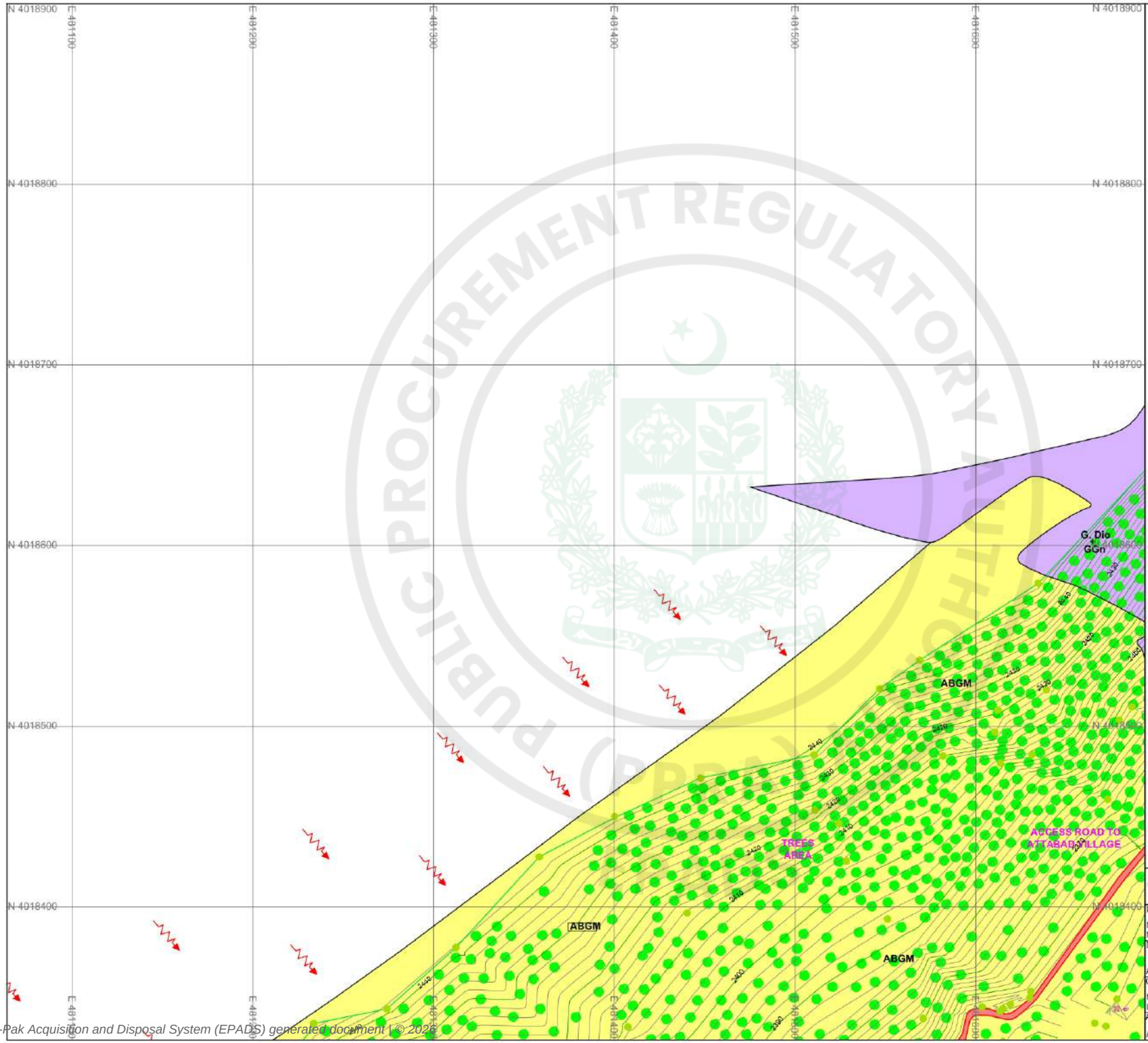
## NOTE.

1. ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED
2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FILED OBSERVATIONS.

**PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY**
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Nauman Naseer | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE | SURFACE GEOLOGICAL MAP |
| CHECKED: Nasiruddin, Umar Tariq | | Sheet 19 of 20 |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 2,000 / A1 |
| | DWG No.: APS-GE-311 | REVISIONS |

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS




N

W E

S

**KEY PLAN:**

| | | | | | | |
|---|---|---|---|---|---|---|
| | 16 | 13 | 10 | 7 | 4 | 1 |
| 19 | 17 | 14 | 11 | 8 | 5 | 2 |
| 20 | 18 | 15 | 12 | 9 | 6 | 3 |

## LEGEND (GEOLOGY)

**SOIL UNITS:**

- ABGM — Angular boulders and gravel with sand and appreciable amount of fines.
- RBGM — Rounded boulders and gravel with sand and appreciable amount of fines.
- CT — Cultivated Terrace.
- Mor — Morainic Material
- CS — Clayey Silt.

**ROCK UNITS:**

- G.Dio — Granodiorite
- G.Dio + GGn — Granodiorite + Granitic Gneiss.
- BR — Fault Breccia.
- Dip and Strike of joint sets in rock.
- Dip and Strike of foliation.
- Active slide.
- Shear zone.
- Fault
- BH — Bore Hole.
- TP — Test Pit.
- River
- Confirmed Contact
- Inferred Contact

0 25 50 75 100 125 m

SCALE

## NOTE.

1. ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED
2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FILED OBSERVATIONS.

**PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY**
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Nauman Naseer | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE | SURFACE GEOLOGICAL MAP |
| CHECKED: Nasiruddin, Umar Tang | | Sheet 16 of 20 |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 2,000 / DWG No: APS-GE-306 / REVISIONS |

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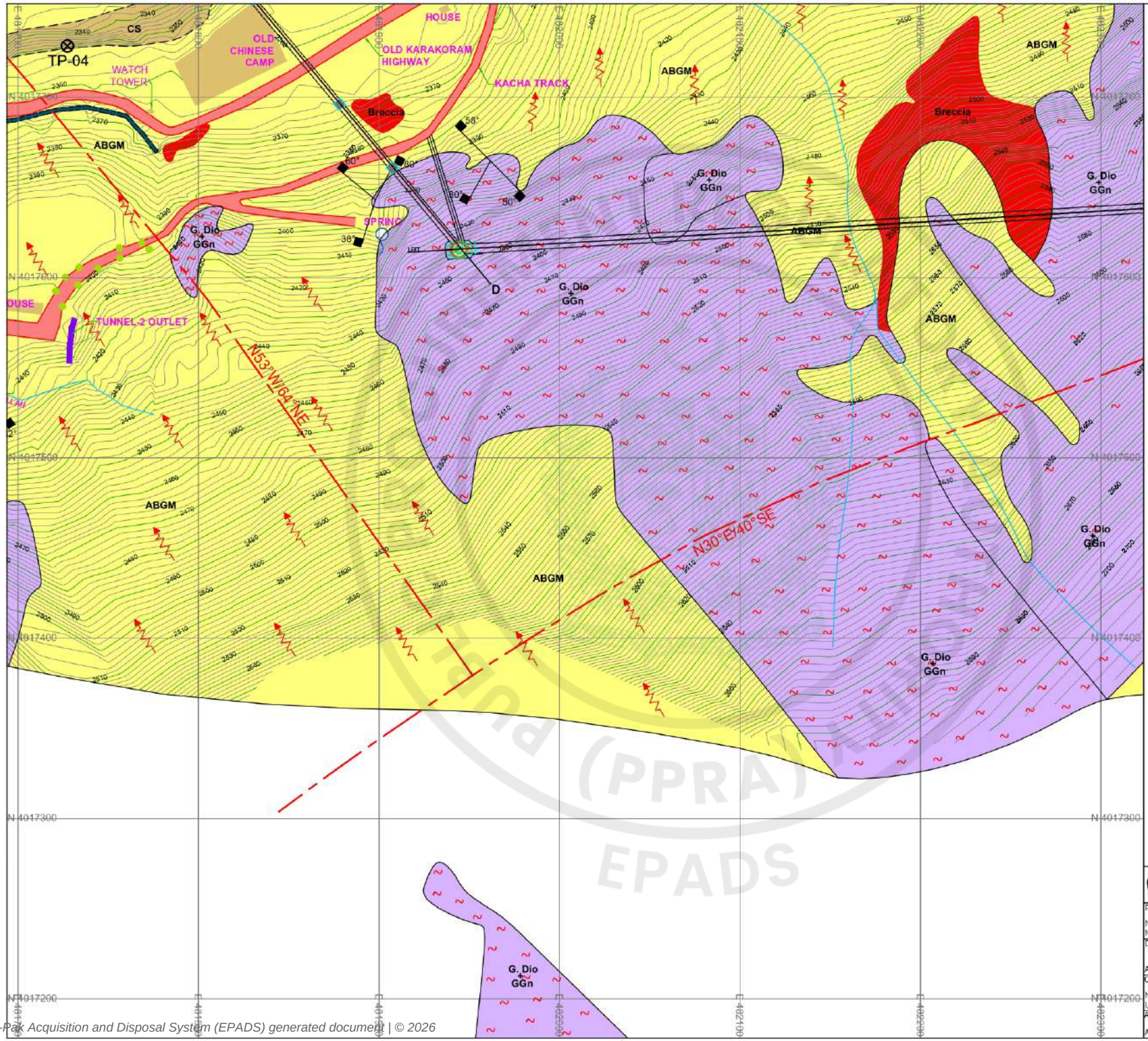


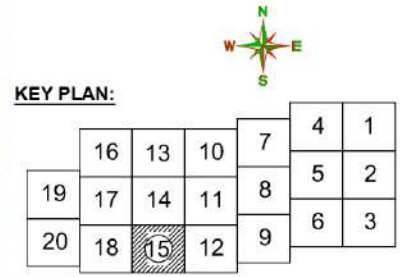


## LEGEND (GEOLOGY)

**SOIL UNITS:**

- ABGM — Angular boulders and gravel with sand and appreciable amount of fines.
- RBGM — Rounded boulders and gravel with sand and appreciable amount of fines.
- CT — Cultivated Terrace.
- Mor — Morainic Material
- CS — Clayey Silt.

**ROCK UNITS:**

- G.Dio — Granodiorite
- G.Dio + GGn — Granodiorite + Granitic Gneiss.
- BR — Fault Breccia.
- Dip and Strike of joint sets in rock.
- Dip and Strike of foliation.
- Active slide.
- Shear zone.
- Fault
- BH — Bore Hole.
- TP — Test Pit.
- River
- Confirmed Contact
- Inferred Contact

0 25 50 75 100 125 m
SCALE

NOTE.

1. ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED
2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FILED OBSERVATIONS.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| PREPARED | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
|---|---|---|
| Nauman Naseer | | |
| DRAWN | TITLE | SURFACE GEOLOGICAL MAP |
| Arshad | | |
| CHECKED | | Sheet 15 of 20 |
| Nasiruddin Umar Tariq | | |
| APPROVED | DATE | SCALE / DWG No. / REVISIONS |
| Abid Sheikh | Jun: 2021 | 1 : 2,000 / APS-GE-307 |

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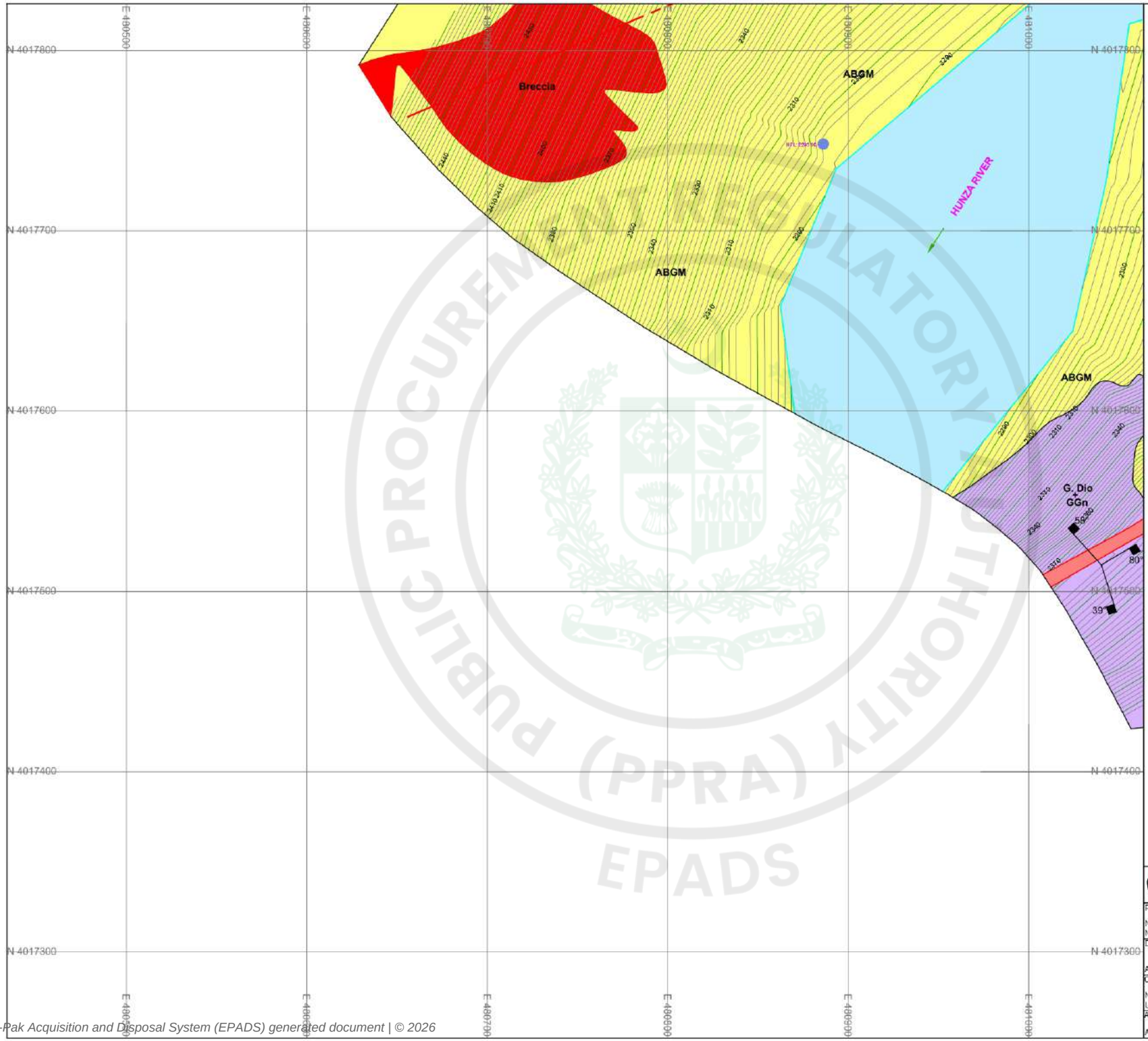


**KEY PLAN:**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | 4 | 1 | |
| | 16 | 13 | 10 | 7 | | 5 | 2 | |
| 19 | 17 | 14 | 11 | 8 | | 6 | 3 | |
| 20 | 18 | 15 | 12 | 9 | | | | |

## LEGEND (GEOLOGY)

**SOIL UNITS:**

- ABGM — Angular boulders and gravel with sand and appreciable amount of fines.
- RBGM — Rounded boulders and gravel with sand and appreciable amount of fines.
- CT — Cultivated Terrace.
- Mor — Morainic Material
- CS — Clayey Silt.

**ROCK UNITS:**

- G.Dio — Granodiorite
- G.Dio + GGn — Granodiorite + Granitic Gneiss.
- BR — Fault Breccia.
- Dip and Strike of joint sets in rock.
- Dip and Strike of foliation.
- Active slide.
- Shear zone.
- Fault
- BH — Bore Hole.
- TP — Test Pit.
- River
- Confirmed Contact
- Inferred Contact

0 25 50 75 100 125 m
SCALE

## NOTE.

1. ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED
2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FILED OBSERVATIONS.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Nauman Naseer | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE | SURFACE GEOLOGICAL MAP |
| CHECKED: Nasiruddin, Umar Tariq | | Sheet 20 of 20 |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 2,000 / DWG No: APS-GE-312 / REVISIONS |

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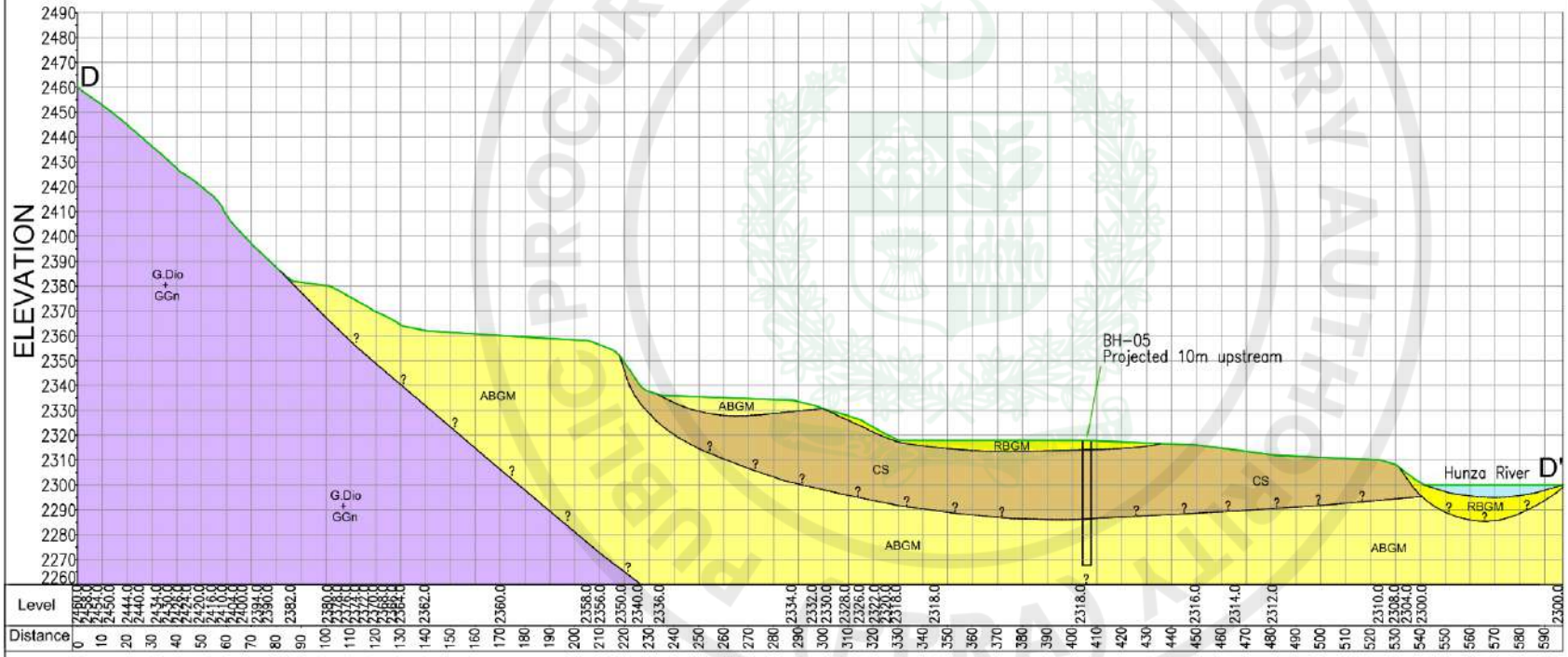


## LEGEND

**SOIL UNITS:**

- ABGM — Angular boulders and gravel with sand and appreciable amount of fines.
- RBGM — Rounded boulders and gravel with sand and appreciable amount of fines.
- CS — Clayey Silt

**ROCK UNITS:**

- G.Dio — Granodiorite + Granitic Gneiss
- BH — Bore Hole
- Hunza River

## NOTE.

ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED.

| | | | | |
|---|---|---|---|---|
| PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | | | | |
| PREPARED<br>Nauman Naseer | PROJECT | ATTABAD LAKE HPP<br>FEASIBILITY STUDY REPORT | | |
| DRAWN<br>Arshad | TITLE | GEOLOGICAL X-SECTION DD'<br>PENSTOCK & P/H AREA | | |
| CHECKED<br>Nasiruddin<br>Umar Tariq | | | | |
| APPROVED<br>Abid Sheikh | DATE<br>Jun: 2021 | SCALE<br>1 : 2000 | DWG No:<br>APS-GE-315 | REVISIONS |

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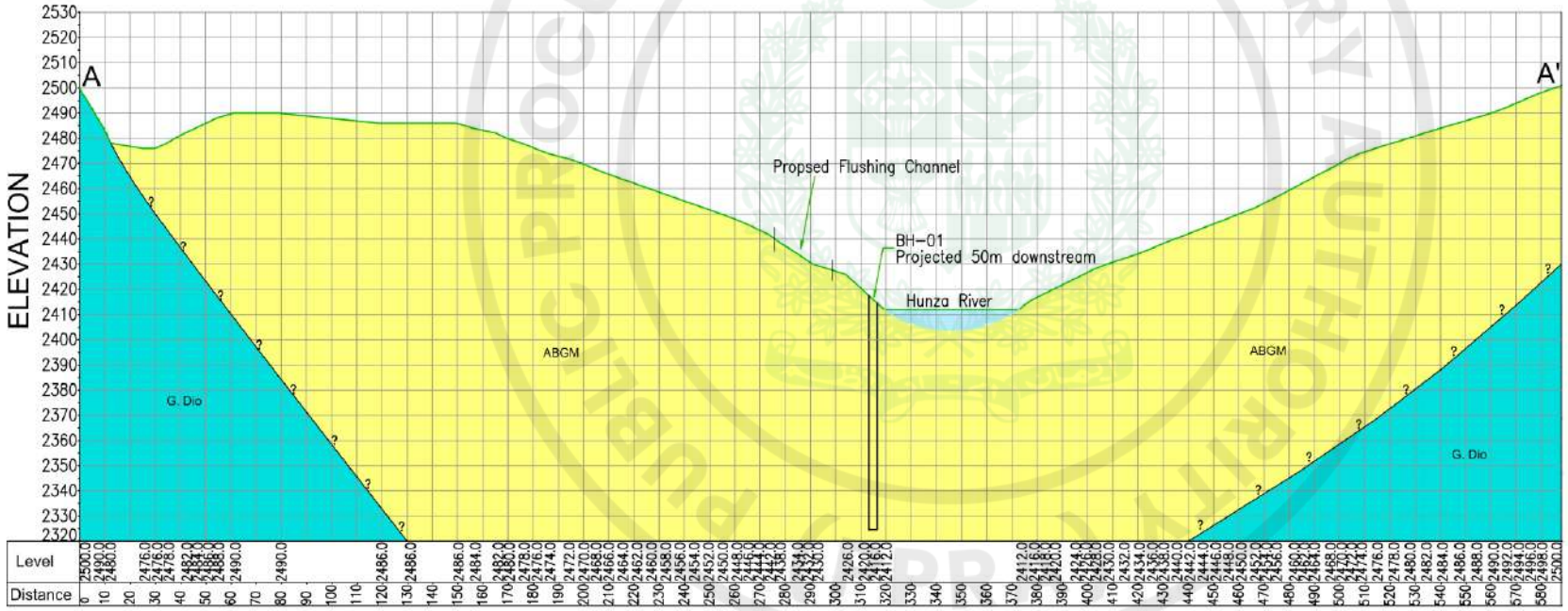


## LEGEND

**SOIL UNITS:**

ABGM — Angular boulders and gravel with sand and appreciable amount of fines.

**ROCK UNITS:**

G.Dio — Granodiorite

BH — Bore Hole

Hunza River

## NOTE.

ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED.

| | | | | |
|---|---|---|---|---|
| PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | | | | |
| PREPARED<br>Nauman Naseer | PROJECT | ATTABAD LAKE HPP<br>FEASIBILITY STUDY REPORT | | |
| DRAWN<br>Arshad | TITLE | GEOLOGICAL X-SECTION AA'<br>WEIR SITE | | |
| CHECKED<br>Nasiruddin Umar Tariq | | | | |
| APPROVED<br>Abid Sheikh | DATE<br>Jun: 2021 | SCALE<br>1 : 2000 | DWG No:<br>APS-GE-313 | REVISIONS |

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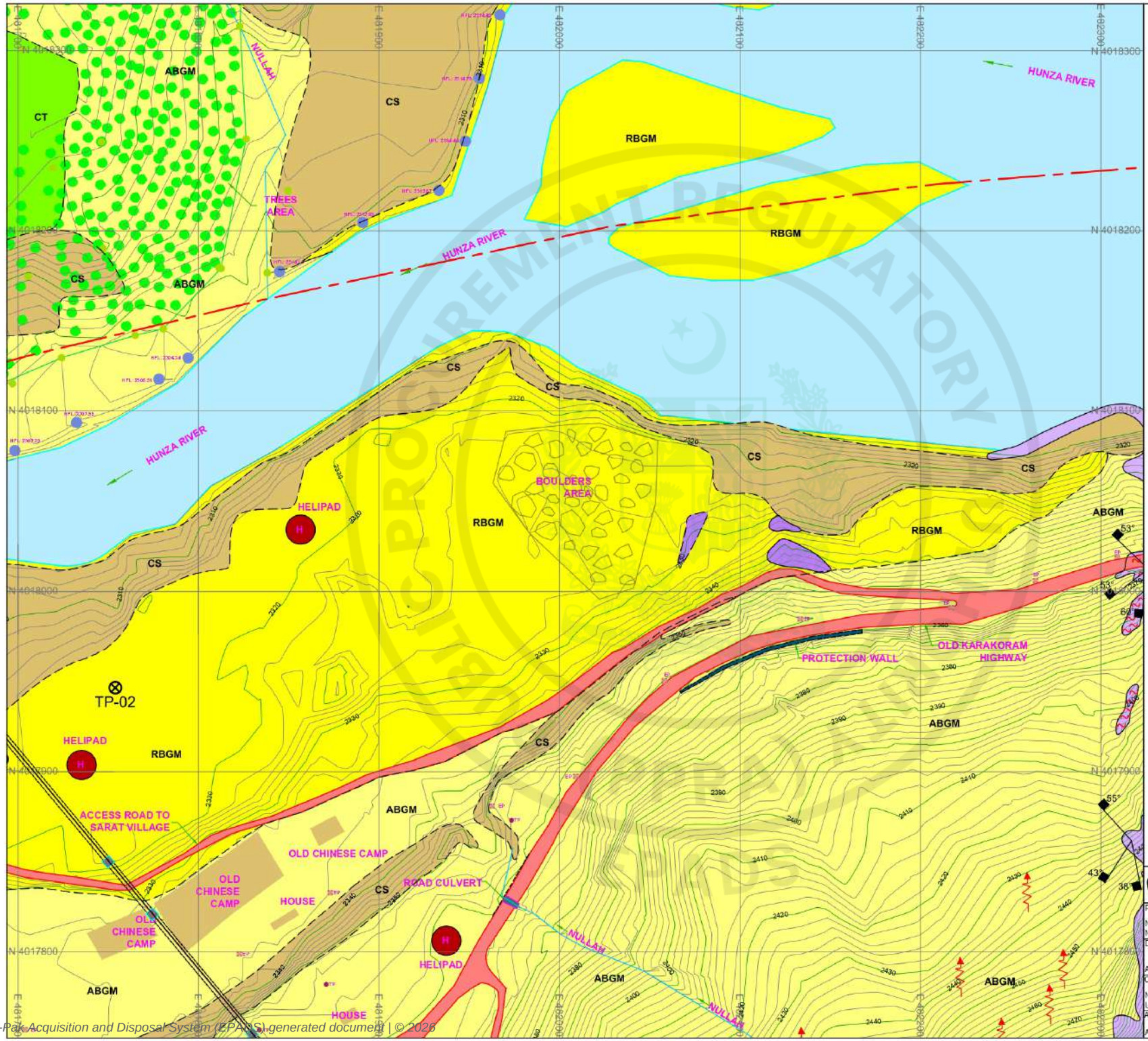


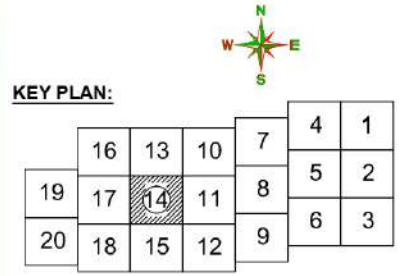


## LEGEND (GEOLOGY)

**SOIL UNITS:**

- ABGM — Angular boulders and gravel with sand and appreciable amount of fines.
- RBGM — Rounded boulders and gravel with sand and appreciable amount of fines.
- CT — Cultivated Terrace.
- Mor — Morainic Material
- CS — Clayey Silt.

**ROCK UNITS:**

- G.Dio — Granodiorite
- G.Dio + GGn — Granodiorite + Granitic Gneiss.
- BR — Fault Breccia.
- Dip and Strike of joint sets in rock.
- Dip and Strike of foliation.
- Active slide.
- Shear zone.
- Fault
- BH — Bore Hole.
- TP — Test Pit.
- River
- Confirmed Contact
- Inferred Contact

0 25 50 75 100 125 m
SCALE

## NOTE.

1. ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED
2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FILED OBSERVATIONS.

**PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY**
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Nauman Naseer | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE | SURFACE GEOLOGICAL MAP |
| CHECKED: Nasiruddin Umar Tang | | Sheet 14 of 20 |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 2,000 / DWG No: APS-GE-306 / REVISIONS |

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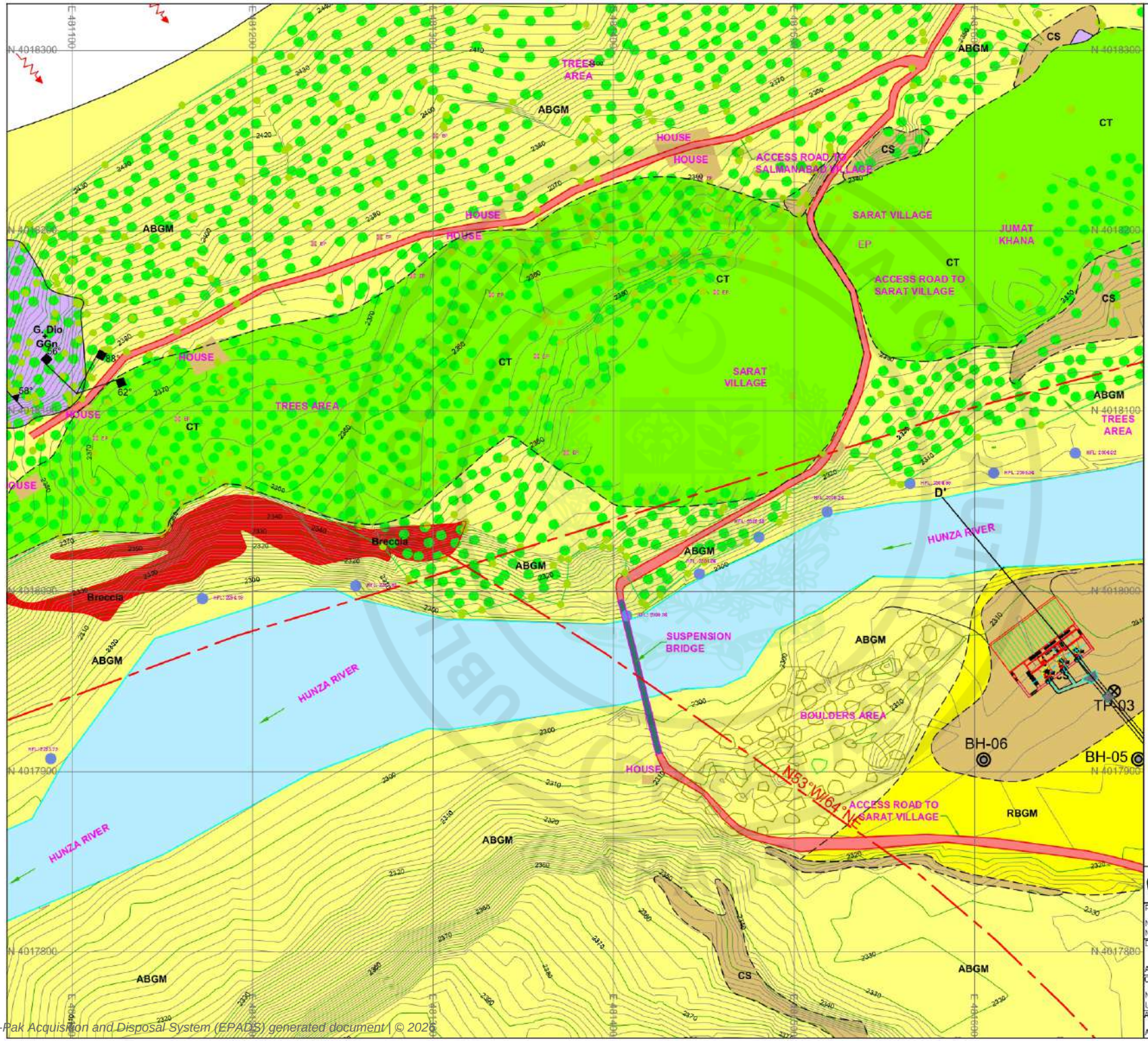


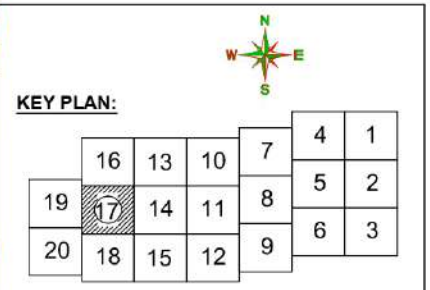


## LEGEND (GEOLOGY)

### SOIL UNITS:

| | |
|---|---|
| ABGM | Angular boulders and gravel with sand and appreciable amount of fines. |
| RBGM | Rounded boulders and gravel with sand and appreciable amount of fines. |
| CT | Cultivated Terrace. |
| Mor | Morainic Material |
| CS | Clayey Silt. |

### ROCK UNITS:

| | |
|---|---|
| G.Dio | Granodiorite |
| G.Dio + GGn | Granodiorite + Granitic Gneiss. |
| BR | Fault Breccia. |

Dip and Strike of joint sets in rock.

Dip and Strike of foliation.

Active slide.

Shear zone.

Fault

BH Bore Hole.

TP Test Pit.

River

Confirmed Contact

Inferred Contact

0 25 50 75 100 125 m

SCALE

## NOTE.

1. ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED
2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FILED OBSERVATIONS.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Nauman Naseer | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE | SURFACE GEOLOGICAL MAP |
| CHECKED: Nasiruddin, Umar Tariq | | Sheet 17 of 20 |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 2,000 |
| | DWG No: APS-GE-309 | REVISIONS |

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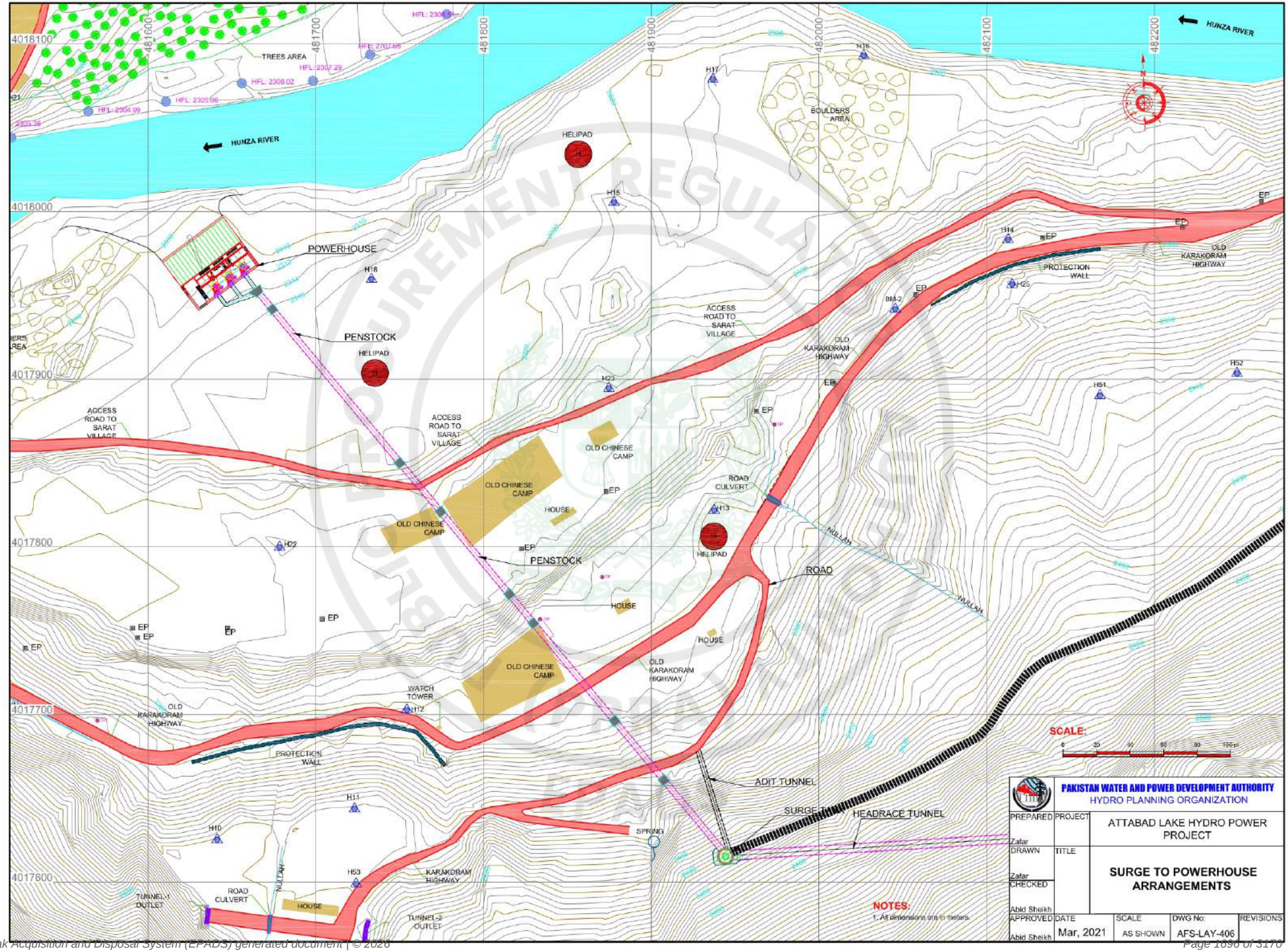


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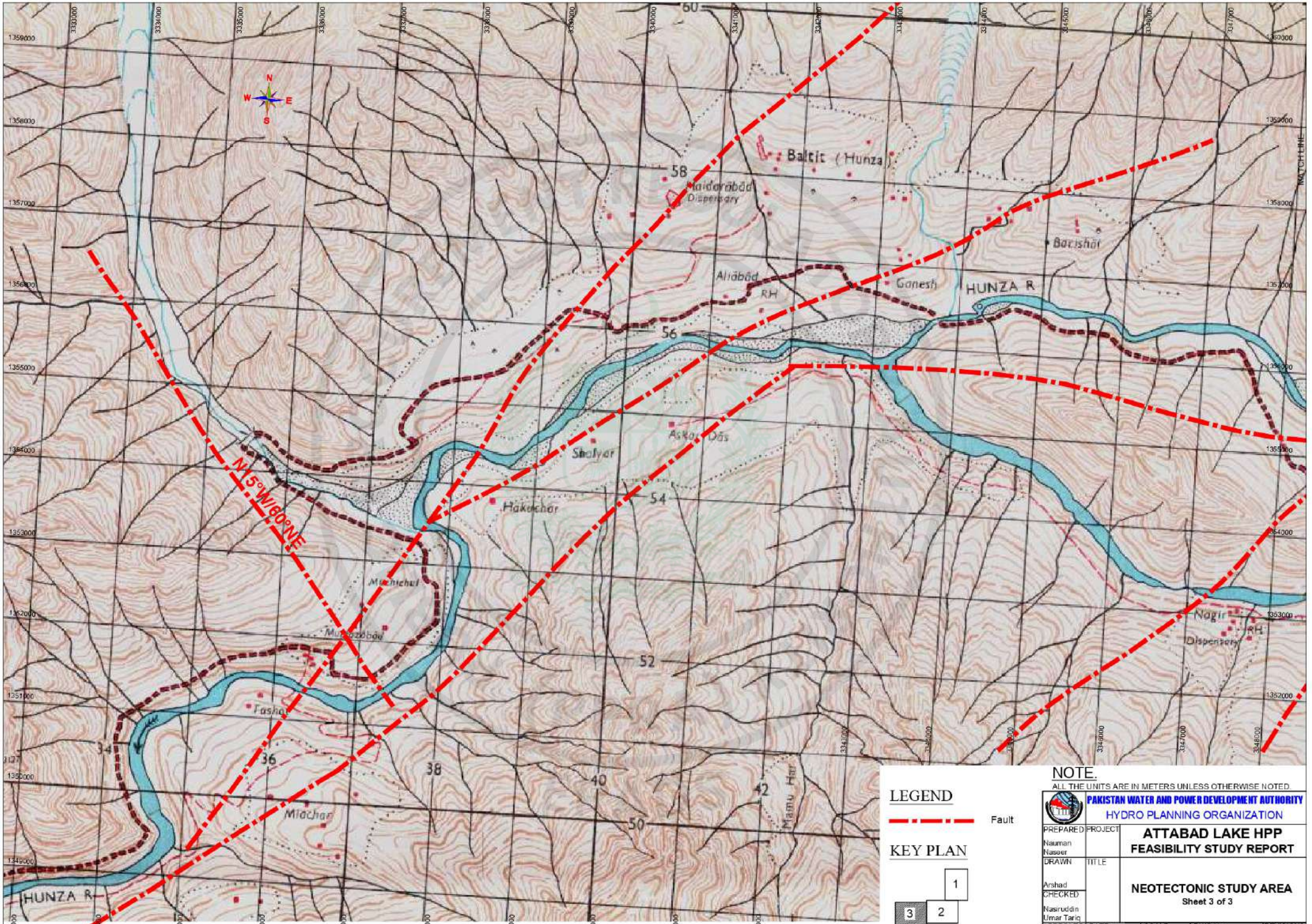


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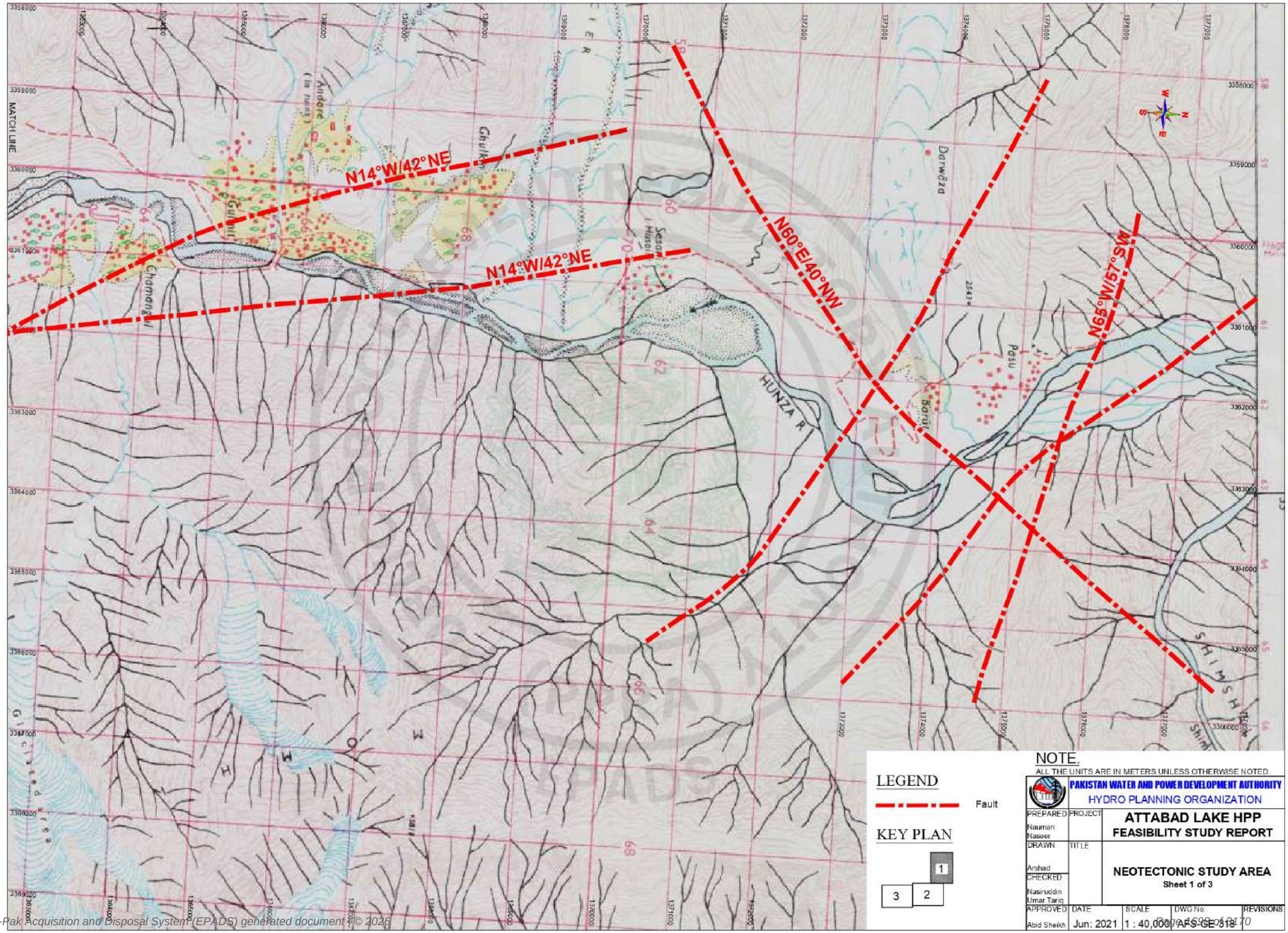


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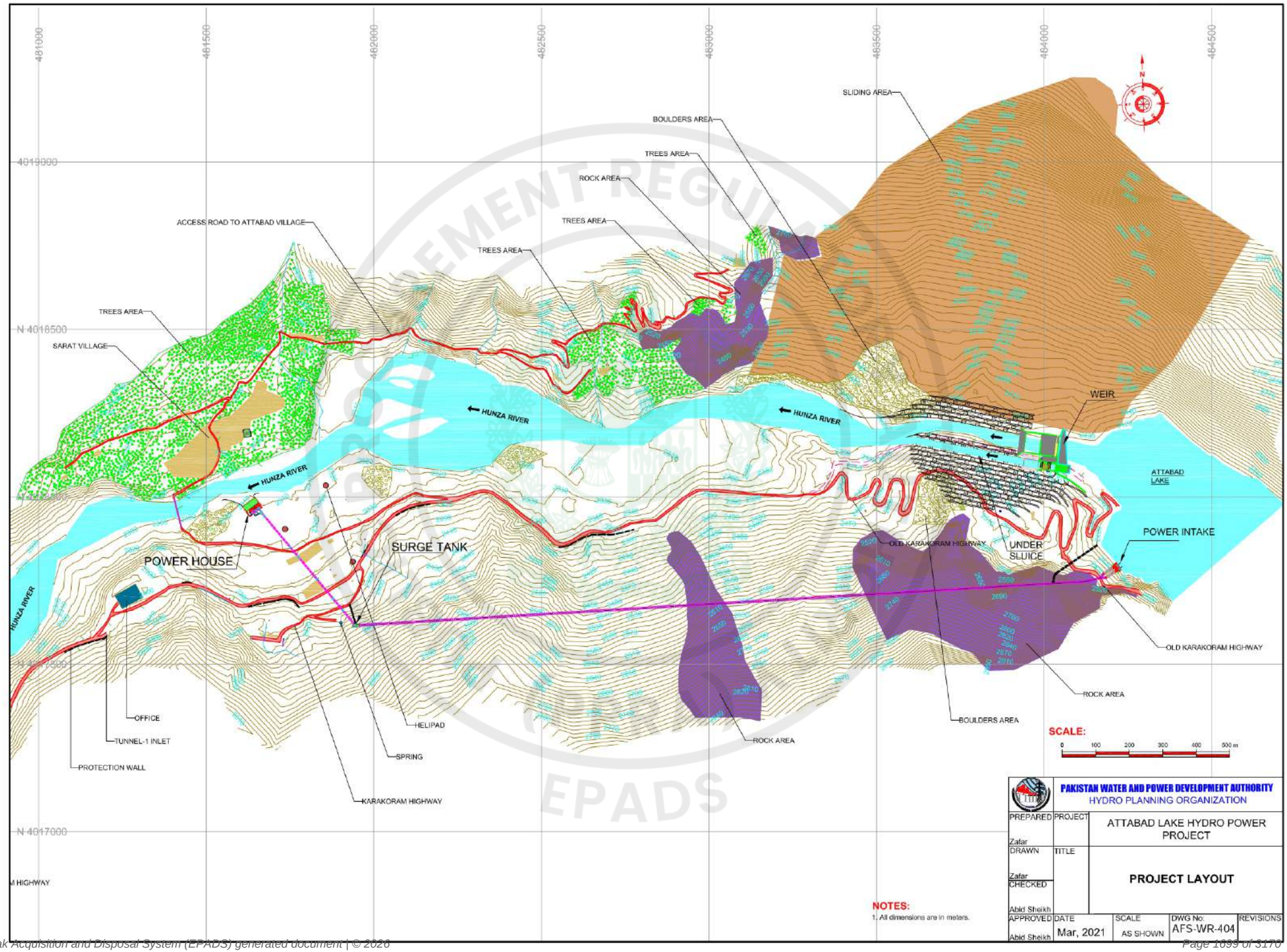


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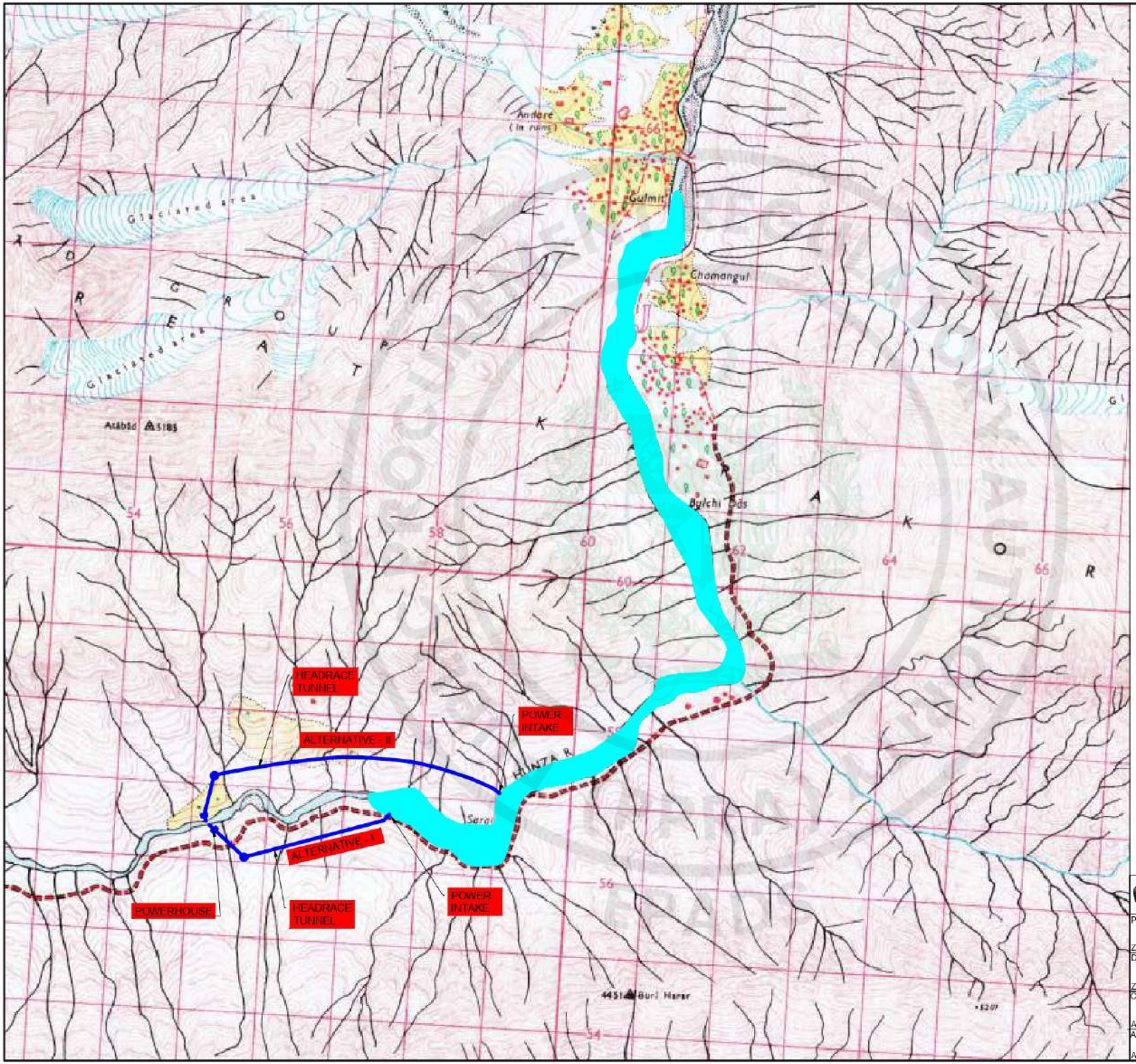


PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED Zafar | PROJECT | ATTABAD LAKE HYDRO POWER PROJECT |
| DRAWN Zafar | TITLE | PROJECT LAYOUT ON G.T SHEET |
| CHECKED Abid Sheikh | | |
| APPROVED Abid Sheikh | DATE Mar, 2021 | SCALE AS SHOWN |
| | DWG No: AFS-WR-403 | REVISIONS |

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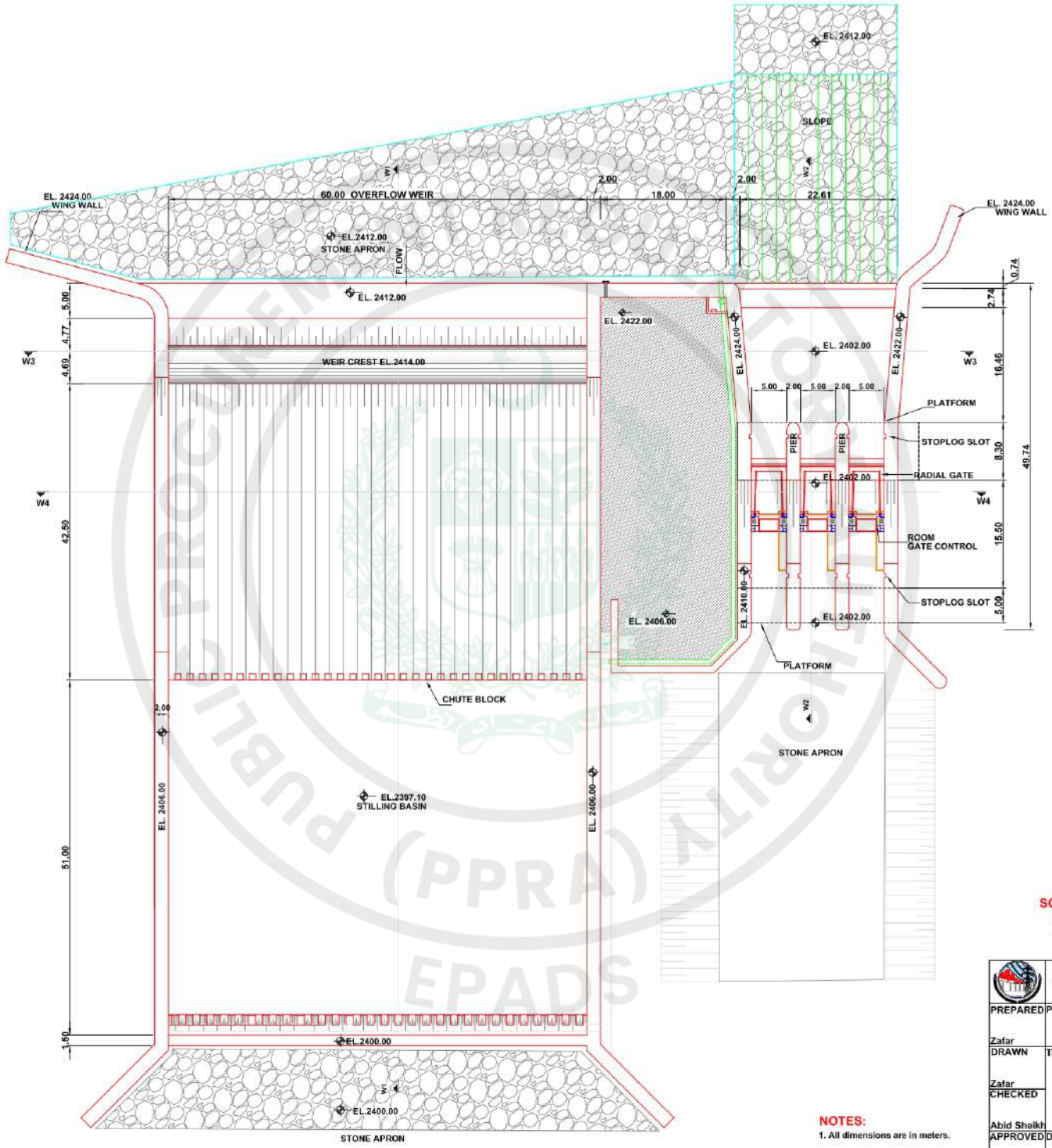


SCALE:

0 6 12 18 24 30 m

NOTES:

1. All dimensions are in meters.

| | | | | | |
|---|---|---|---|---|---|
| PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | | | | | |
| PREPARED<br>Zafar | PROJECT | ATTABAD LAKE HYDRO POWER PROJECT | | | |
| DRAWN<br>Zafar | TITLE | PLAN FOR WEIR | | | |
| CHECKED<br>Abid Sheikh | | | | | |
| APPROVED<br>Abid Sheikh | DATE<br>Mar, 2021 | SCALE<br>AS SHOWN | DWG No:<br>AFS-WR-409 | REVISIONS | |

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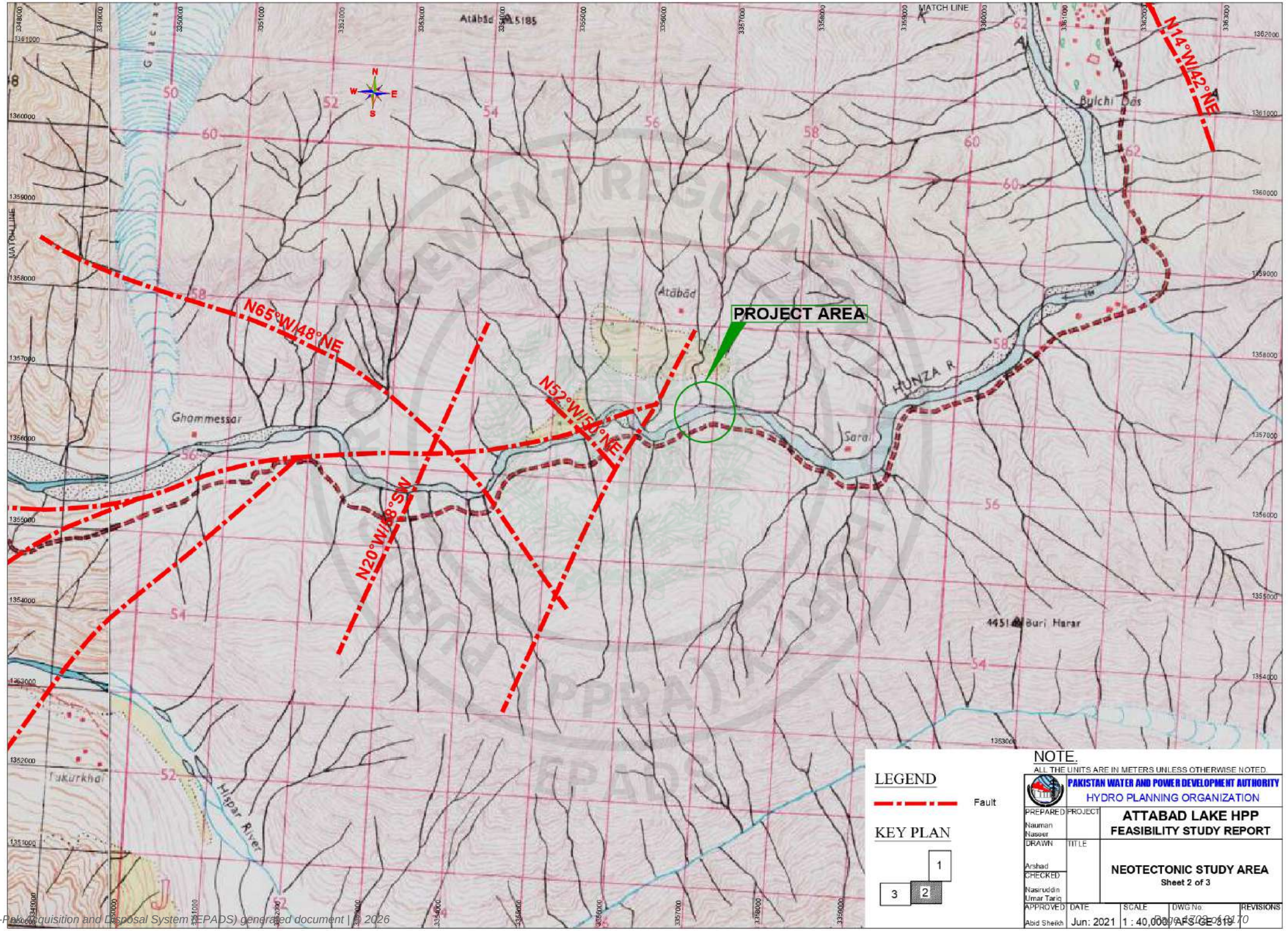


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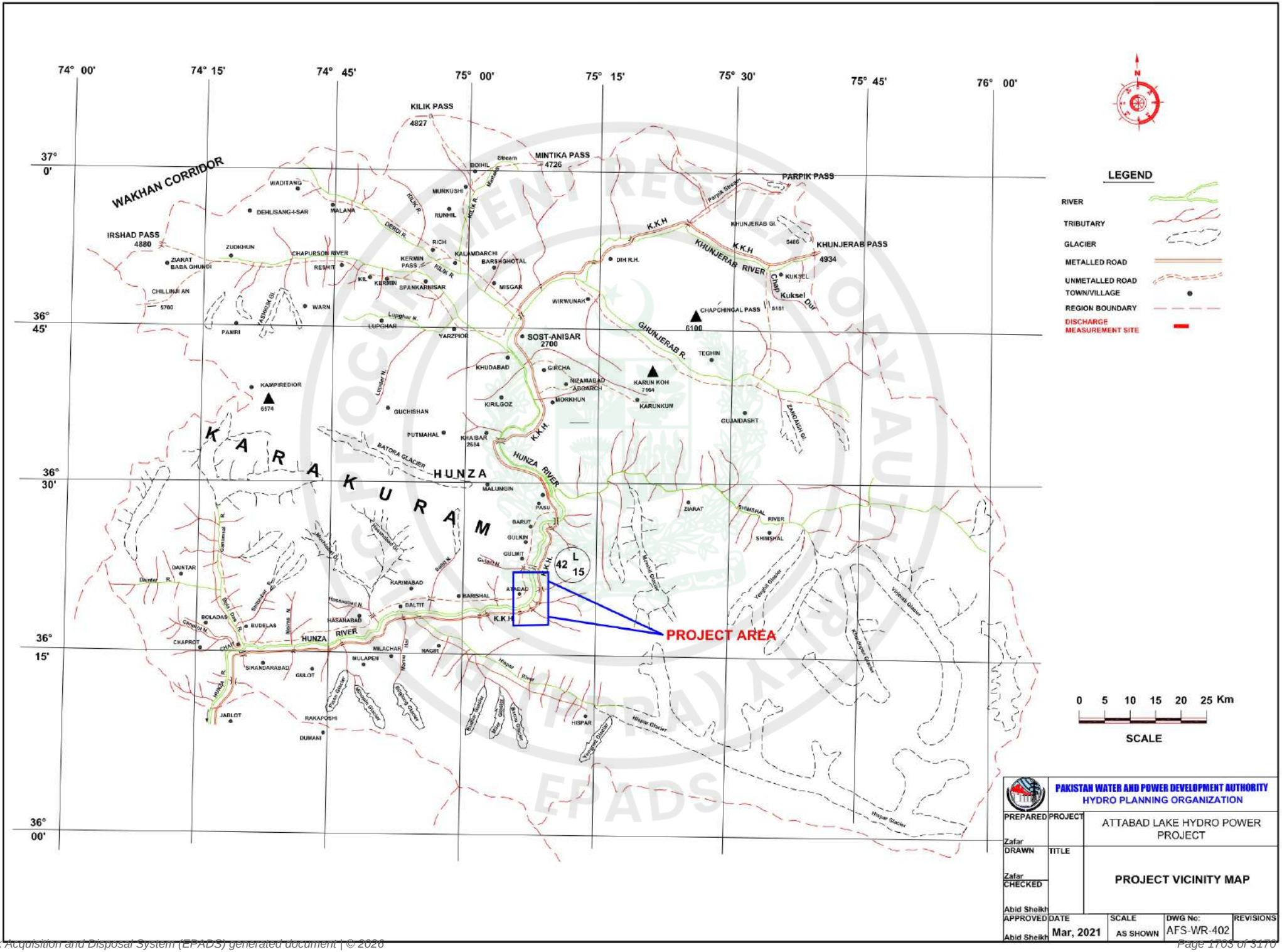


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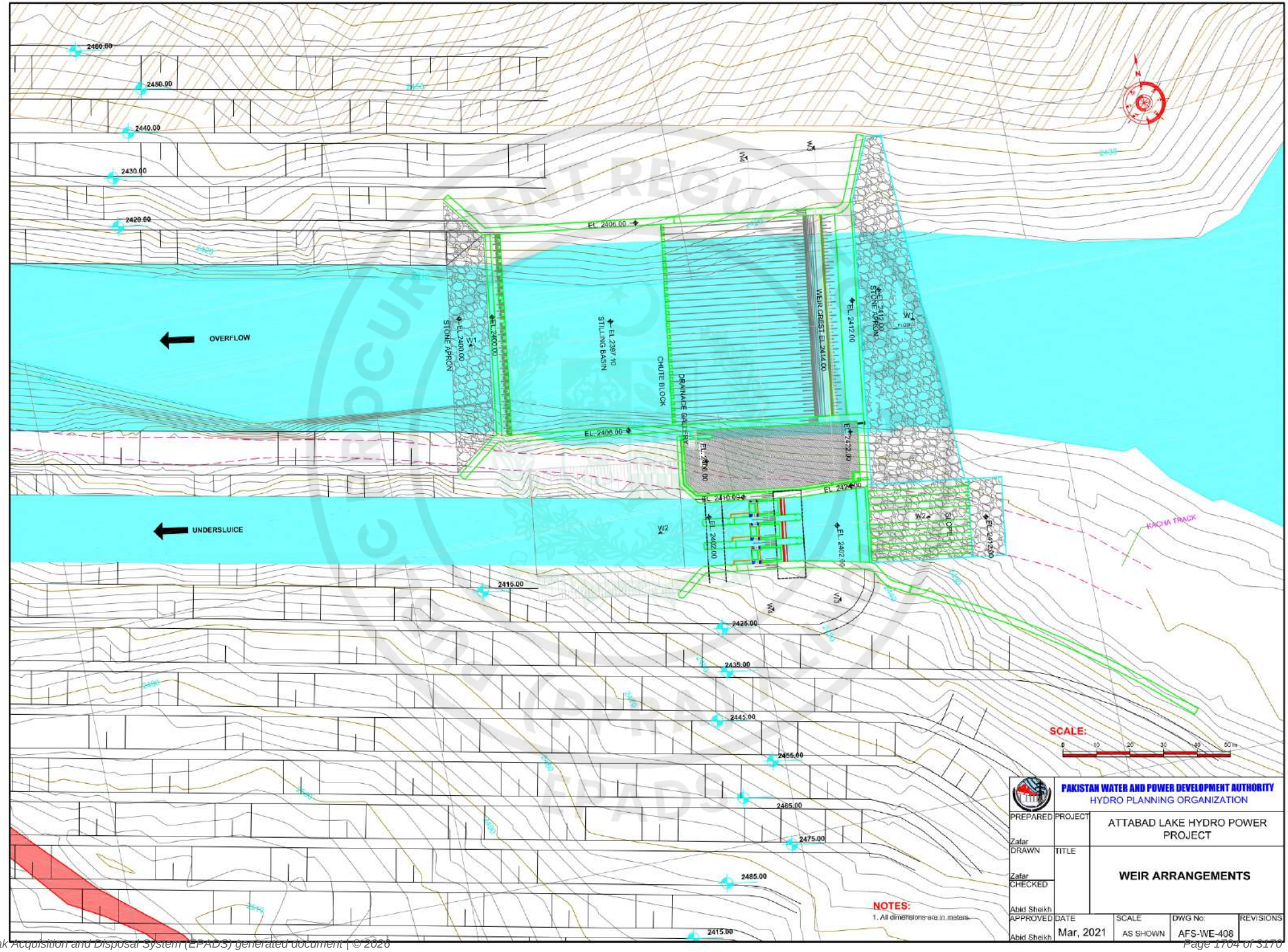


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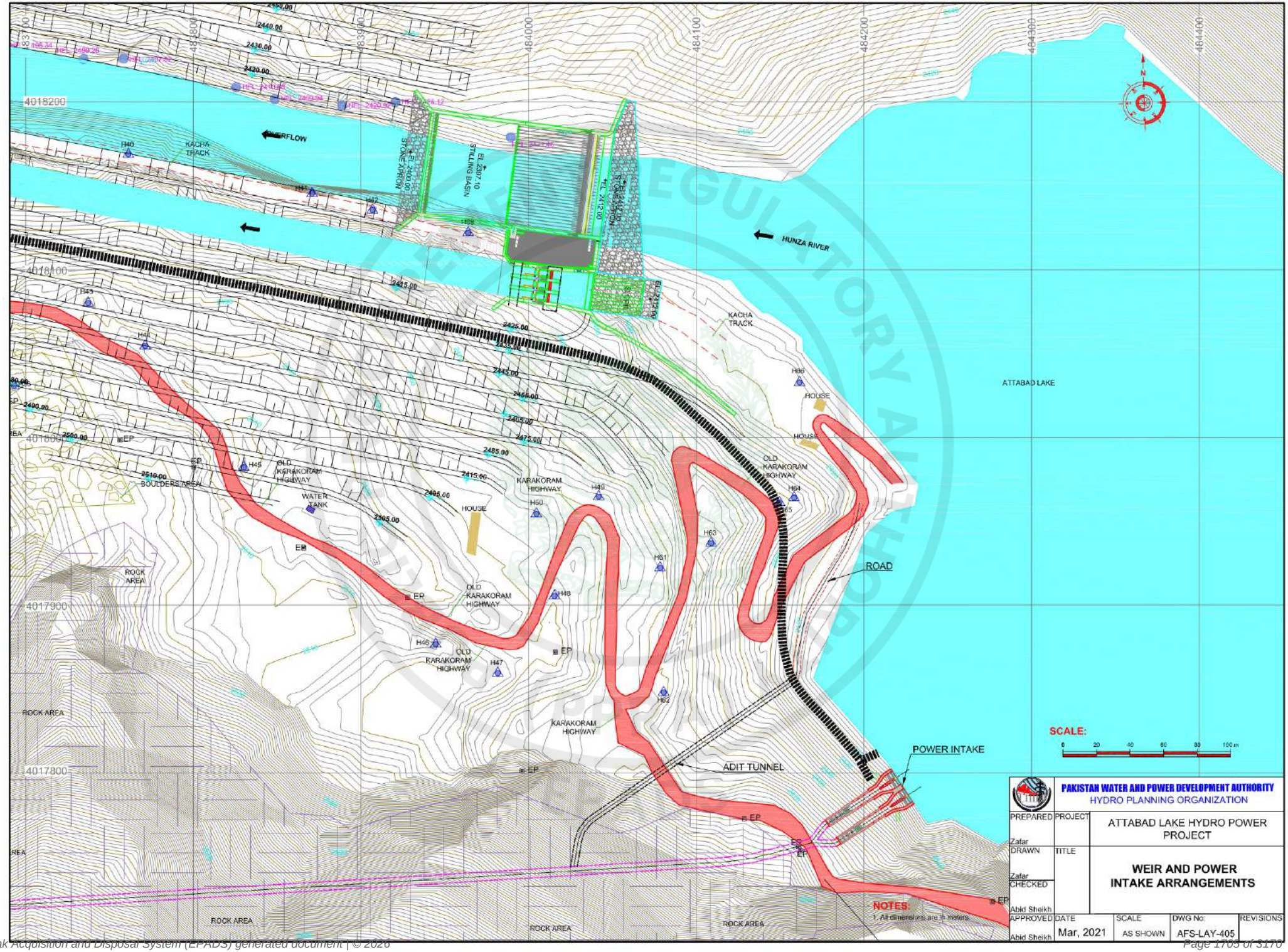


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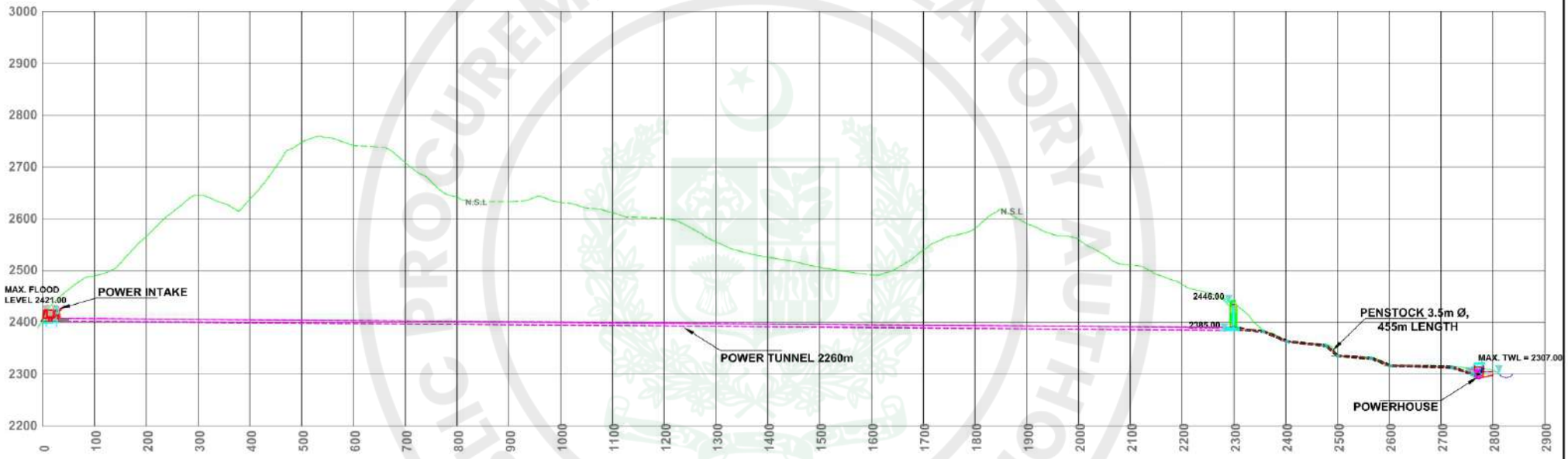


SCALE

0 10 32 48 64 80

NOTES:

1. All dimensions are in meters.

| | | | | | |
|---|---|---|---|---|---|
| PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | | | | | |
| PREPARED<br>Zafar | PROJECT | ATTABAD LAKE HYDRO POWER PROJECT | | | |
| DRAWN<br>Zafar | TITLE | PROJECT<br>LONGITUDINAL SECTION | | | |
| CHECKED<br>Abid Sheikh | | | | | |
| APPROVED<br>Abid Sheikh | DATE<br>Mar, 2021 | SCALE<br>AS SHOWN | DWG No:<br>AFS-LAY-407 | REVISIONS | |

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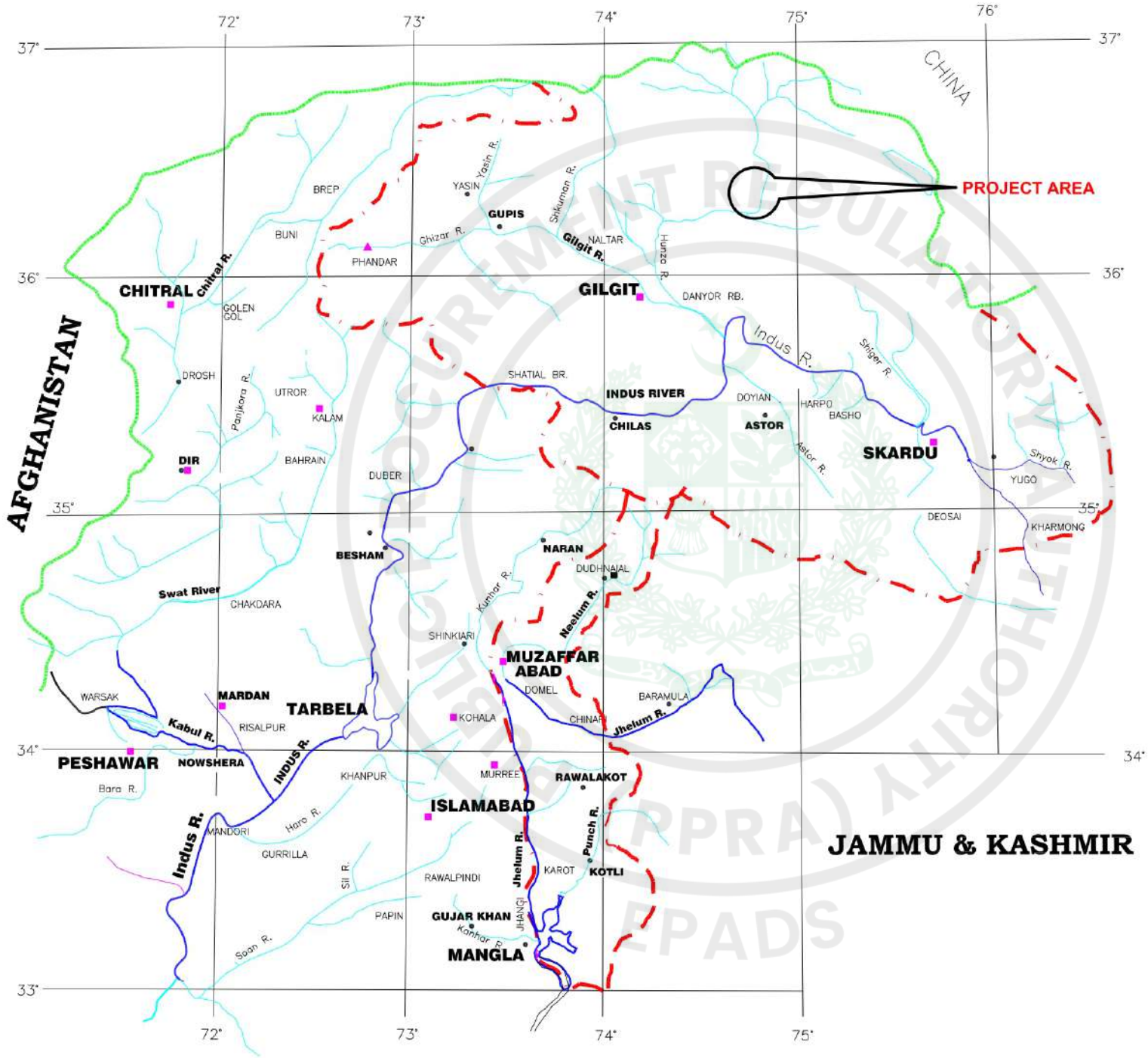


| | | | | |
|---|---|---|---|---|
| PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | | | | |
| PREPARED<br>Zafar | PROJECT | ATTABAD LAKE HYDRO POWER PROJECT | | |
| DRAWN<br>Zafar | TITLE | PROJECT LOCATION AREA | | |
| CHECKED<br>Abid Sheikh | | | | |
| APPROVED<br>Abid Sheikh | DATE<br>Mar, 2021 | SCALE<br>AS SHOWN | DWG No:<br>AFS-GEN-401 | REVISIONS |

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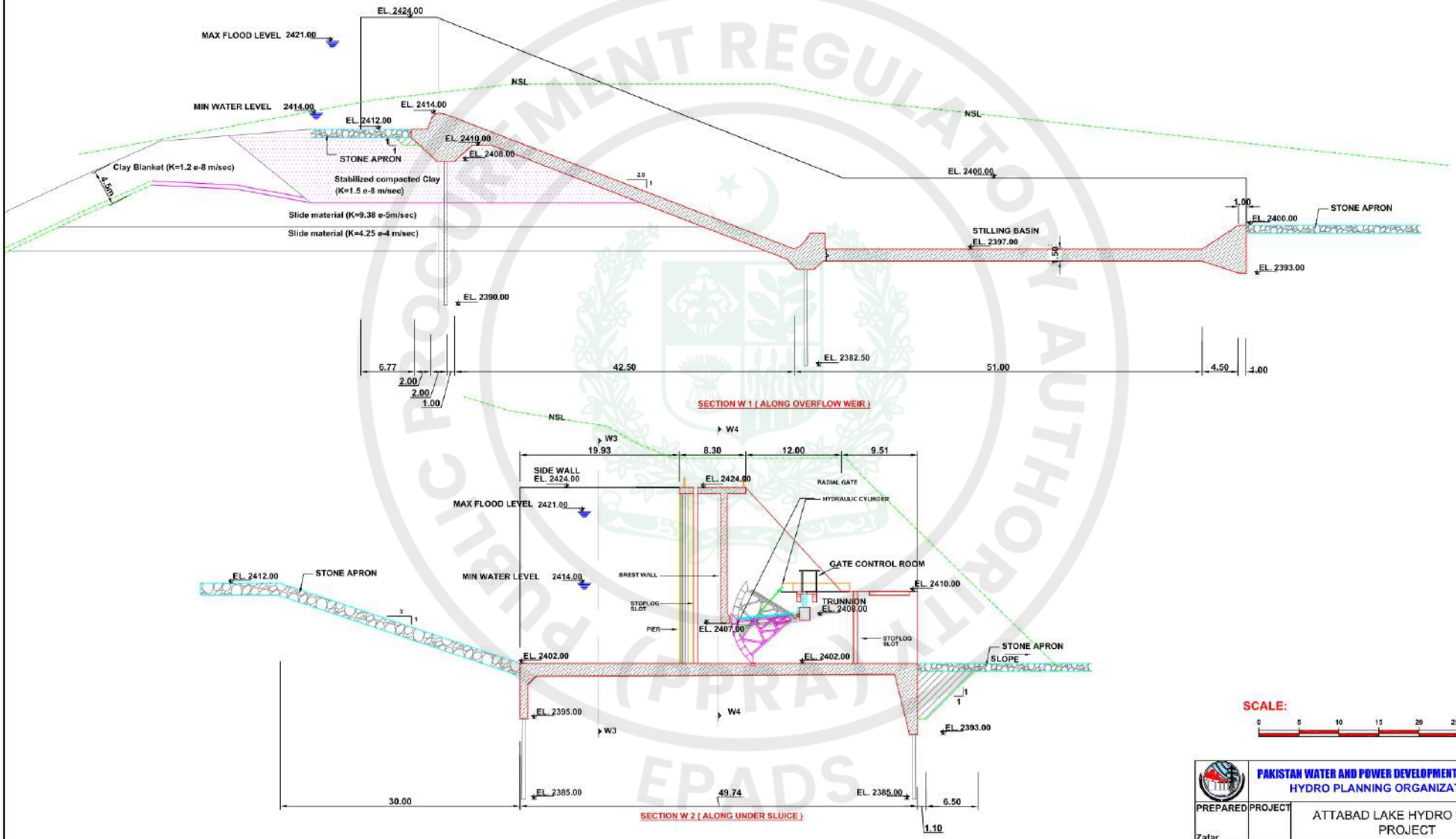


SCALE:

0 5 10 15 20 25 m

NOTES:

1. All dimensions are in meters.

| | | | | | |
|---|---|---|---|---|---|
| PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | | | | | |
| PREPARED<br>Zafar | PROJECT | ATTABAD LAKE HYDRO POWER PROJECT | | | |
| DRAWN<br>Zafar | TITLE | WEIR LONGITUDINAL SECTIONS | | | |
| CHECKED<br>Abid Sheikh | | | | | |
| APPROVED<br>Abid Sheikh | DATE<br>Mar, 2021 | SCALE<br>AS SHOWN | DWG No:<br>AFS-WR-410 | REVISIONS | |

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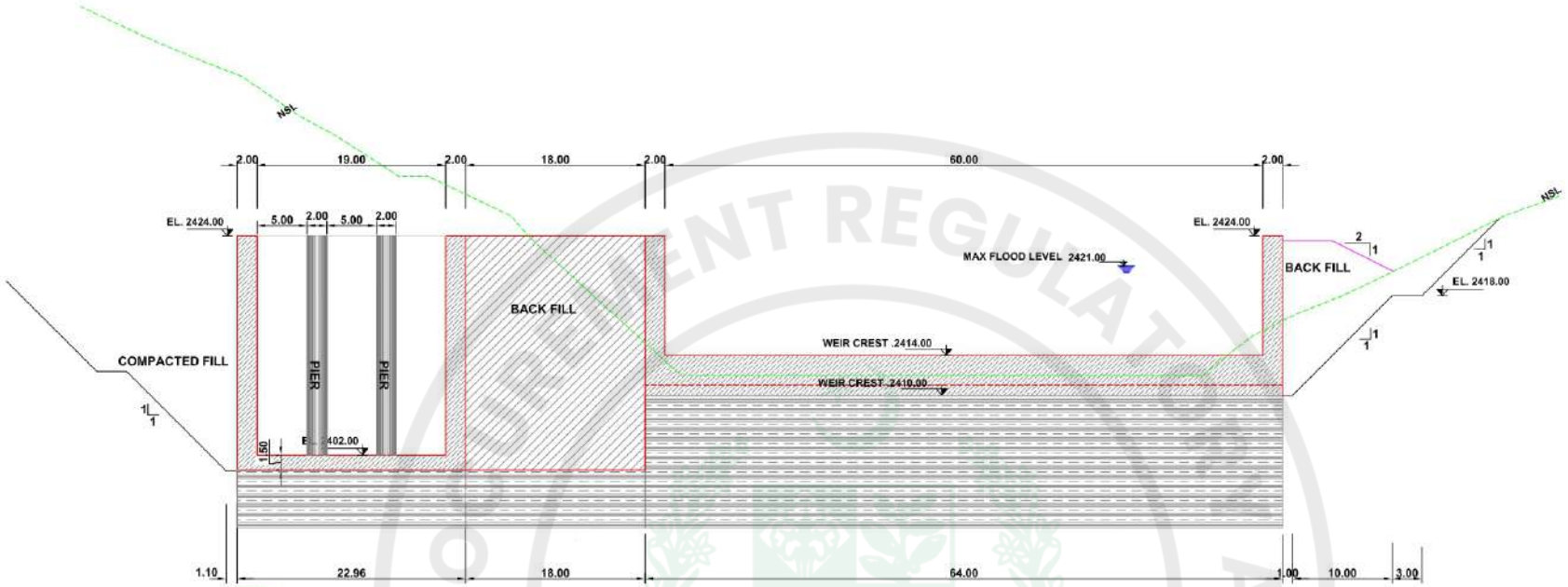
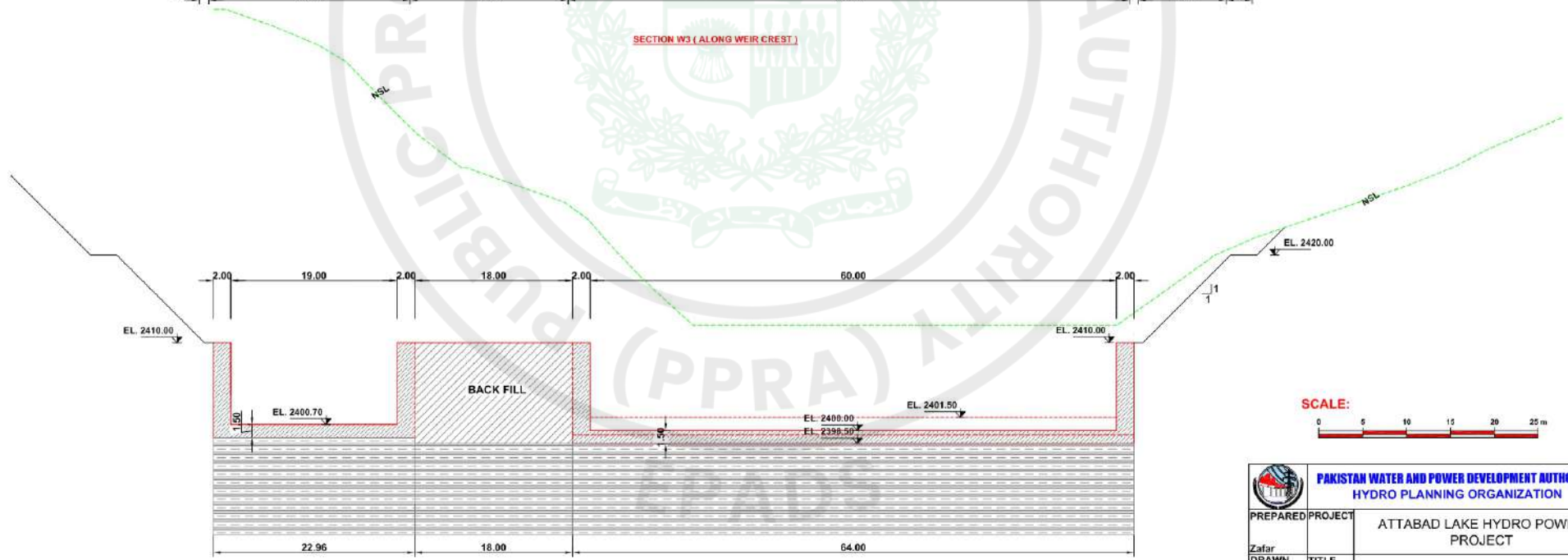



SECTION W3 ( ALONG WEIR CREST )




SECTION W4

SCALE:

0 5 10 15 20 25 m

NOTES:

1. All dimensions are in meters.

| | | | | | |
|---|---|---|---|---|---|
| PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | | | | | |
| PREPARED<br>Zafar | PROJECT | ATTABAD LAKE HYDRO POWER PROJECT | | | |
| DRAWN<br>Zafar | TITLE | WEIR CROSS SECTIONS | | | |
| CHECKED<br>Abid Sheikh | | | | | |
| APPROVED<br>Abid Sheikh | DATE<br>Mar, 2021 | SCALE<br>AS SHOWN | DWG No:<br>AFS-WR-411 | REVISIONS | |

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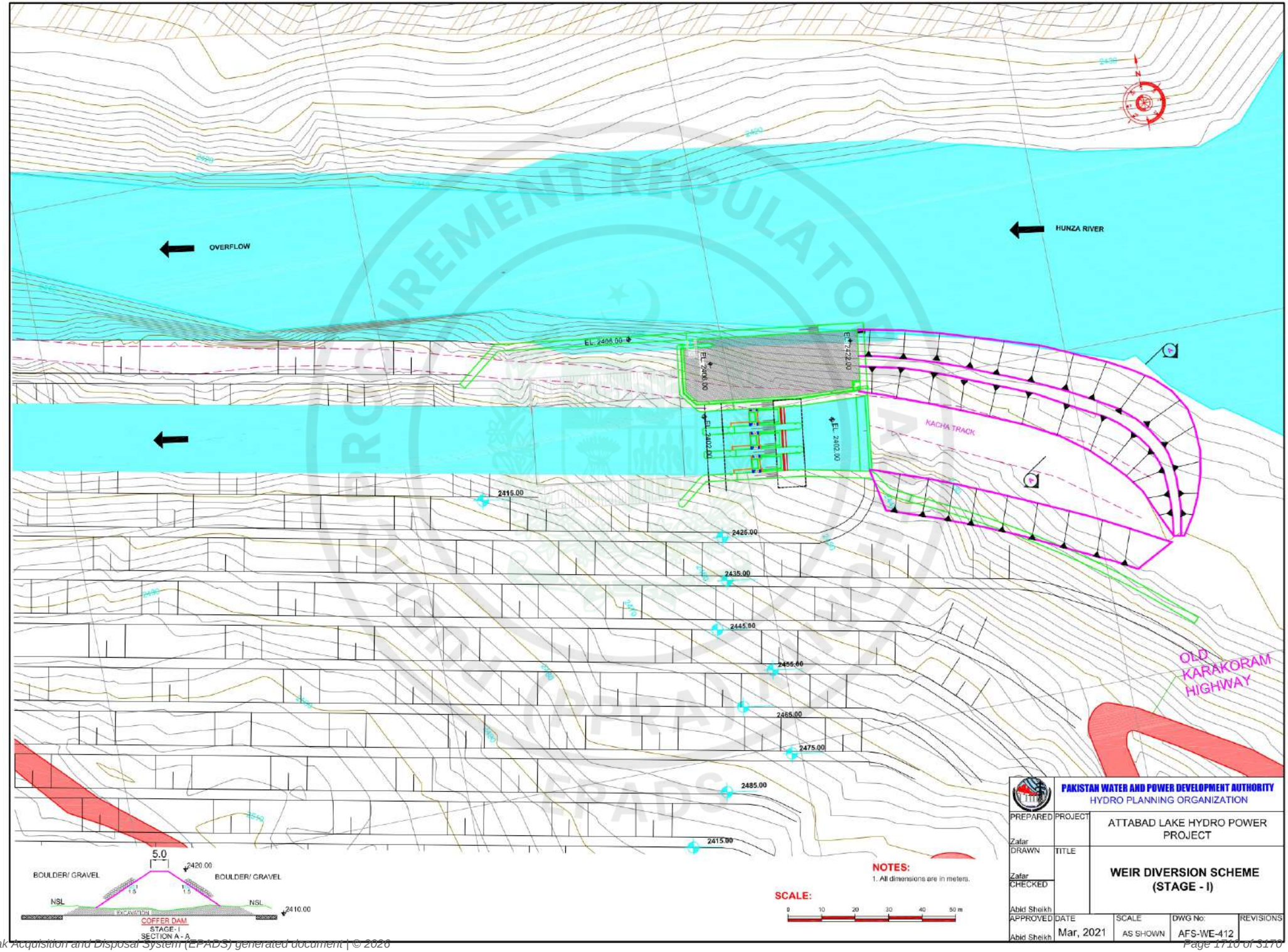


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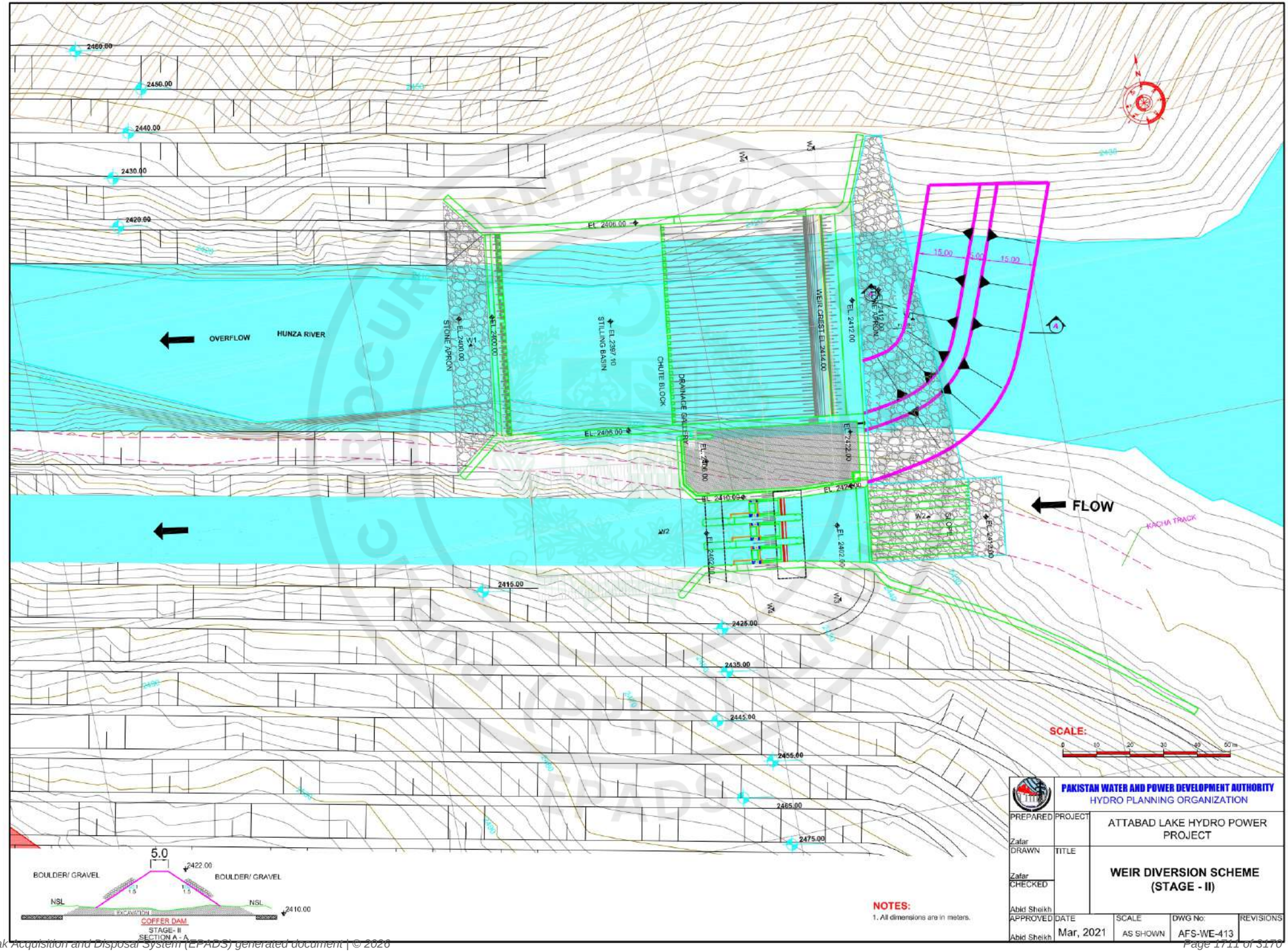
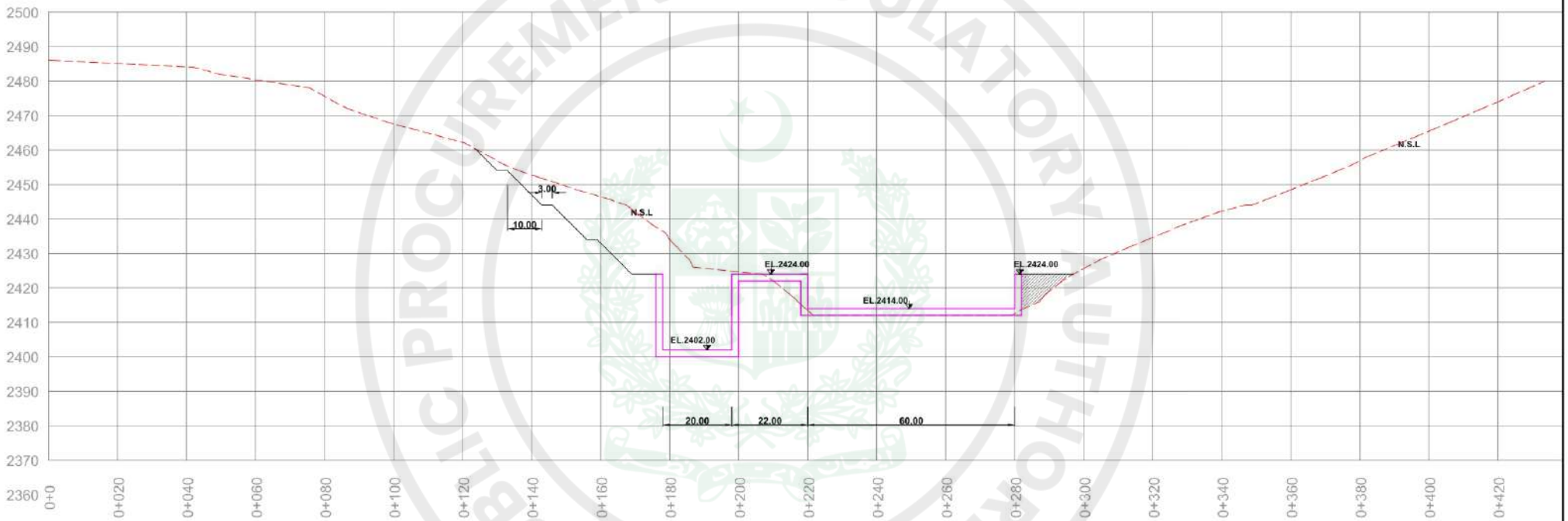



e-Pak Acquisition and Disposal System (EPADS) generated document | © 2026




CROSS SECTION AT RD. 0+0

SCALE

0 12 24 36 48 60 m

| | | | | | |
|---|---|---|---|---|---|
| PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | | | | | |
| PREPARED<br>Zafar | PROJECT | ATTABAD LAKE HYDRO POWER PROJECT | | | |
| DRAWN<br>Zafar | TITLE | CROSS SECTION AT RD. 0+0 FROM DOWNSTREAM OF WEIR SITE | | | |
| CHECKED<br>Abid Sheikh | | | | | |
| APPROVED<br>Abid Sheikh | DATE<br>Mar, 2021 | SCALE<br>AS SHOWN | DWG No:<br>AFS-WR- 414 | REVISIONS | |

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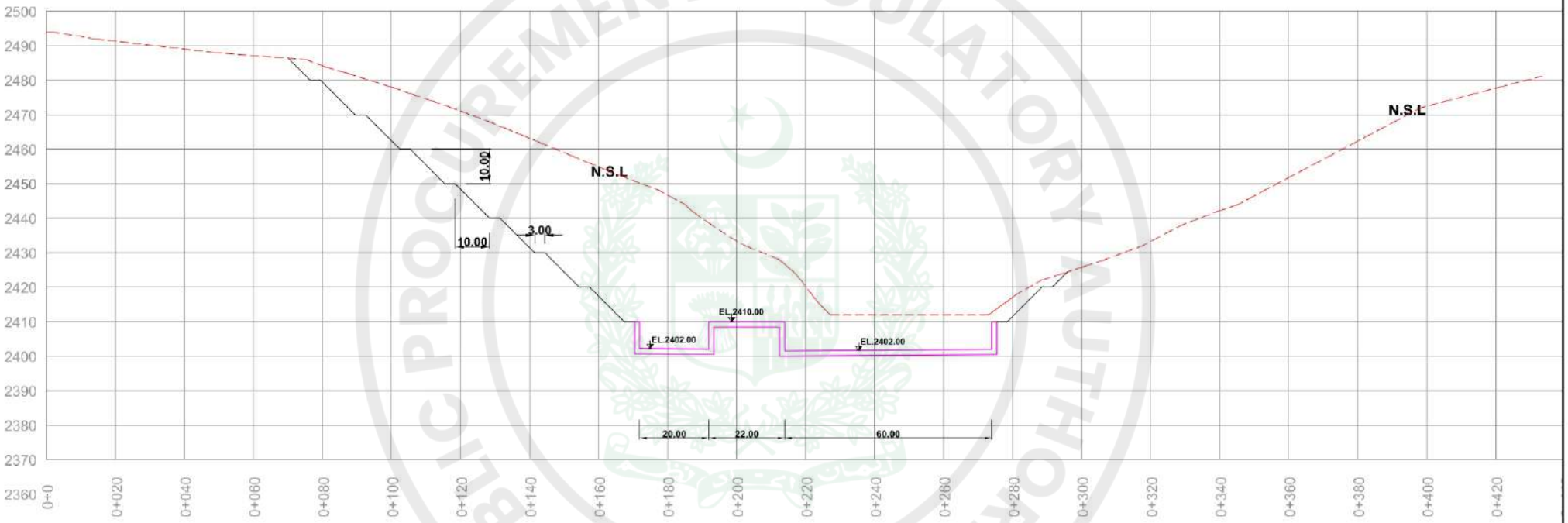


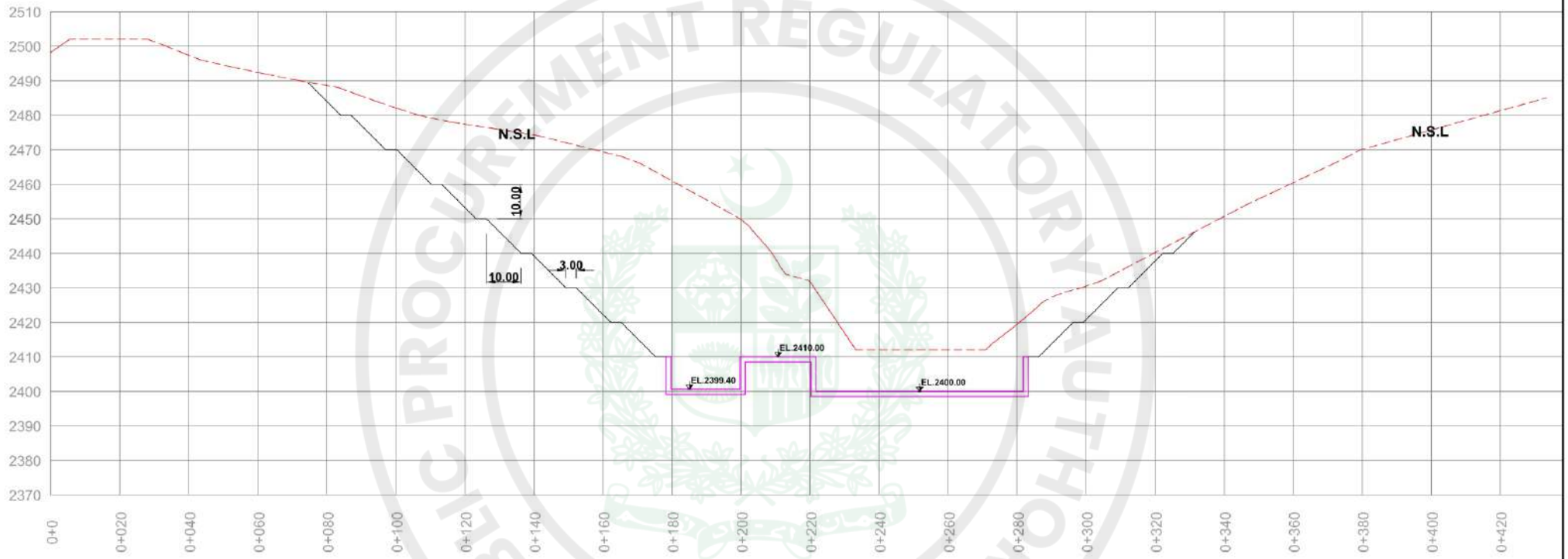

## CROSS SECTION AT RD. 0+50

SCALE

0 12 24 36 48 60 m

| | | | | | |
|---|---|---|---|---|---|
| PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | | | | | |
| PREPARED<br>Zafar | PROJECT | ATTABAD LAKE HYDRO POWER PROJECT | | | |
| DRAWN<br>Zafar | TITLE | CROSS SECTION AT RD. 0+50 FROM DOWNSTREAM OF WEIR SITE | | | |
| CHECKED<br>Abid Sheikh | | | | | |
| APPROVED<br>Abid Sheikh | DATE<br>Mar, 2021 | SCALE<br>AS SHOWN | DWG No:<br>AFS-WR- 415 | REVISIONS | |

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS




## CROSS SECTION AT RD. 0+100

SCALE

0 12 24 36 48 60 m

| | | | | | |
|---|---|---|---|---|---|
| PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | | | | | |
| PREPARED<br>Zafar | PROJECT | ATTABAD LAKE HYDRO POWER PROJECT | | | |
| DRAWN<br>Zafar | TITLE | CROSS SECTION AT RD. 0+100 FROM DOWNSTREAM OF WEIR SITE | | | |
| CHECKED<br>Abid Sheikh | | | | | |
| APPROVED<br>Abid Sheikh | DATE<br>Mar, 2021 | SCALE<br>AS SHOWN | DWG No:<br>AFS-WR- 416 | REVISIONS | |

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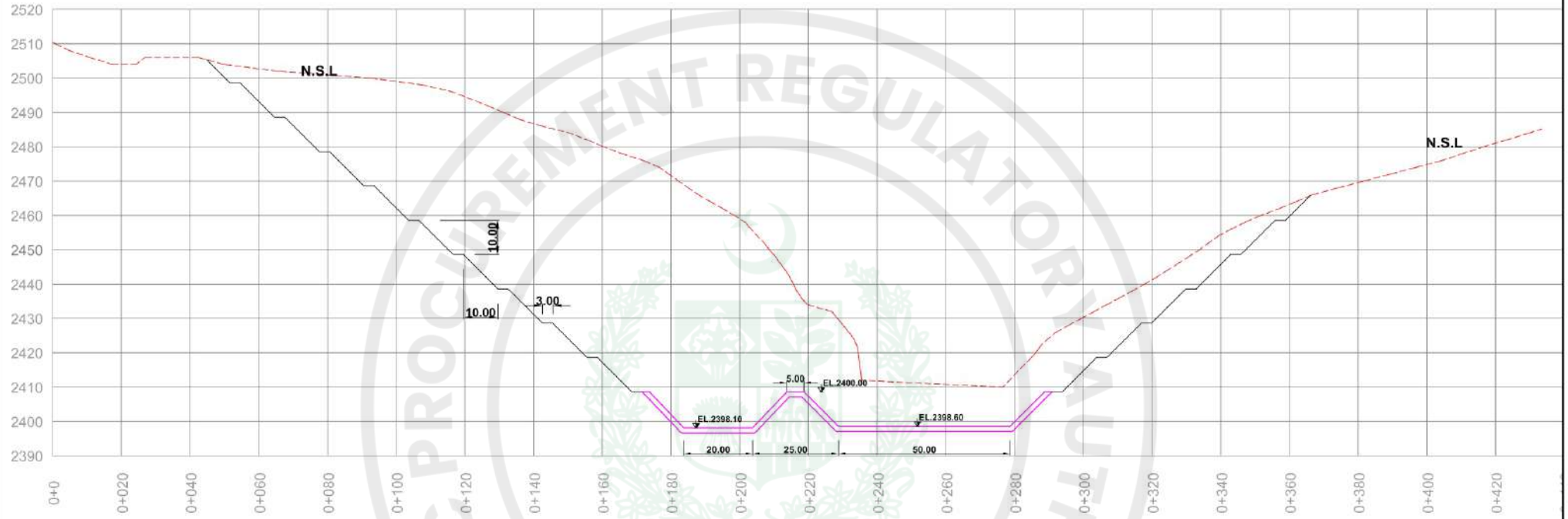


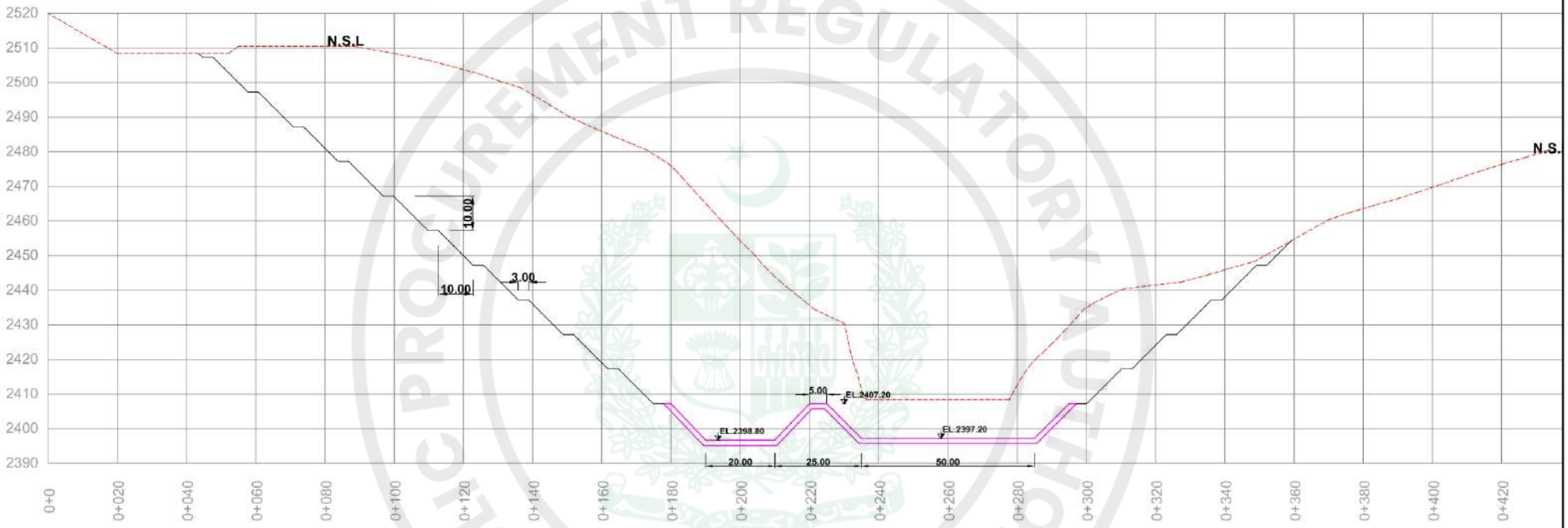

## CROSS SECTION AT RD. 0+150

SCALE

0 12 24 36 48 60 m

| | | | | | |
|---|---|---|---|---|---|
| PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | | | | | |
| PREPARED<br>Zafar | PROJECT | ATTABAD LAKE HYDRO POWER PROJECT | | | |
| DRAWN<br>Zafar | TITLE | CROSS SECTION AT RD. 0+150 FROM DOWNSTREAM OF WEIR SITE | | | |
| CHECKED<br>Abid Sheikh | | | | | |
| APPROVED<br>Abid Sheikh | DATE<br>Mar, 2021 | SCALE<br>AS SHOWN | DWG No:<br>AFS-WR- 417 | REVISIONS | |

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS



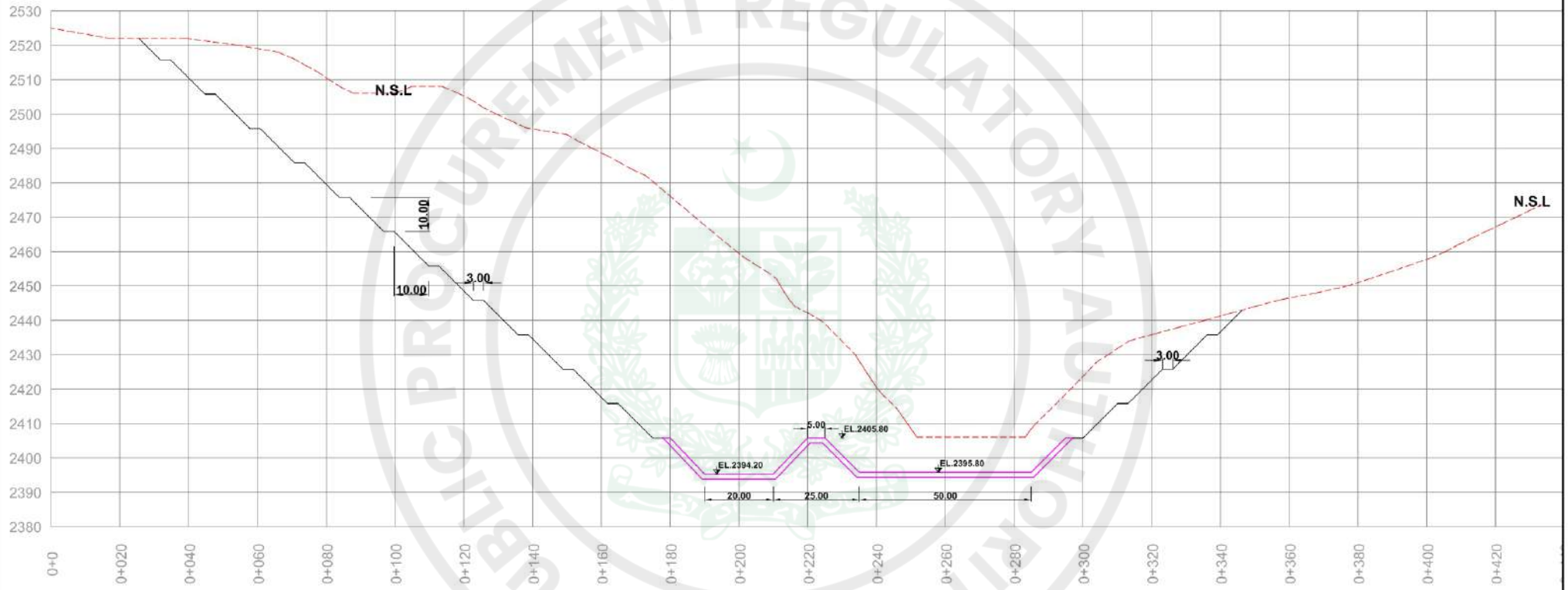

## CROSS SECTION AT RD. 0+200

SCALE

0 12 24 36 48 60 m

| | | | | | |
|---|---|---|---|---|---|
| PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | | | | | |
| PREPARED<br>Zafar | PROJECT | ATTABAD LAKE HYDRO POWER PROJECT | | | |
| DRAWN<br>Zafar | TITLE | CROSS SECTION AT RD. 0+200 FROM DOWNSTREAM OF WEIR SITE | | | |
| CHECKED<br>Abid Sheikh | | | | | |
| APPROVED<br>Abid Sheikh | DATE<br>Mar, 2021 | SCALE<br>AS SHOWN | DWG No:<br>AFS-WR- 418 | REVISIONS | |

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS



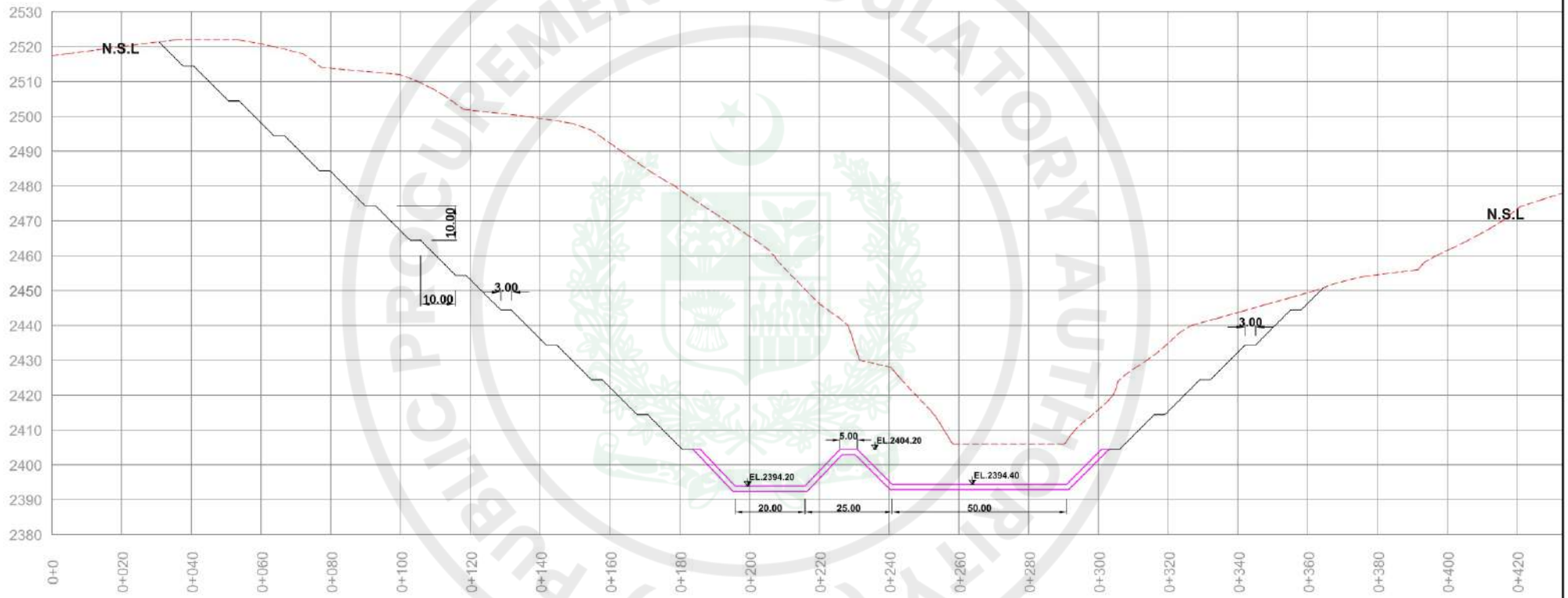

## CROSS SECTION AT RD. 0+250

SCALE

0 12 24 36 48 60 m

| | | | | | |
|---|---|---|---|---|---|
| PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | | | | | |
| PREPARED<br>Zafar | PROJECT | ATTABAD LAKE HYDRO POWER PROJECT | | | |
| DRAWN<br>Zafar | TITLE | CROSS SECTION AT RD. 0+250 FROM DOWNSTREAM OF WEIR SITE | | | |
| CHECKED<br>Abid Sheikh | | | | | |
| APPROVED<br>Abid Sheikh | DATE<br>Mar, 2021 | SCALE<br>AS SHOWN | DWG No:<br>AFS-WR- 419 | REVISIONS | |

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS



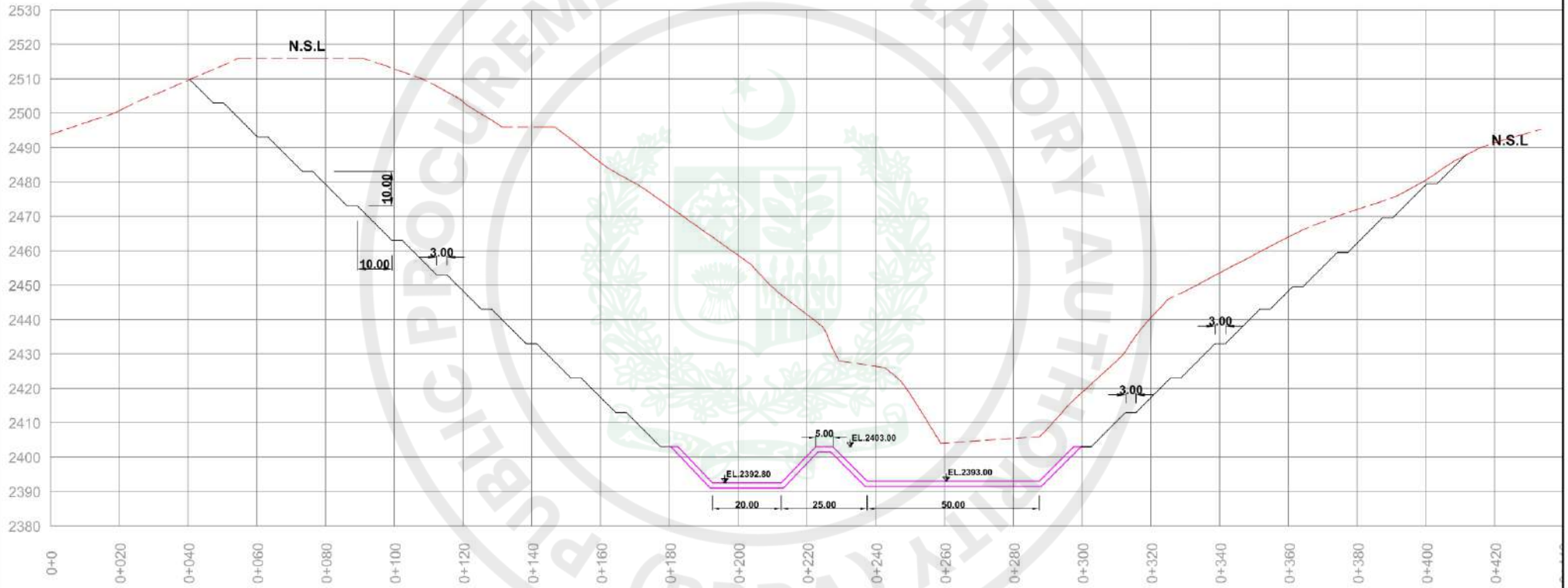

## CROSS SECTION AT RD. 0+300

SCALE

0 12 24 36 48 60 m

| | | | | | |
|---|---|---|---|---|---|
| PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | | | | | |
| PREPARED<br>Zafar | PROJECT | ATTABAD LAKE HYDRO POWER PROJECT | | | |
| DRAWN<br>Zafar | TITLE | CROSS SECTION AT RD. 0+300 FROM DOWNSTREAM OF WEIR SITE | | | |
| CHECKED<br>Abid Sheikh | | | | | |
| APPROVED<br>Abid Sheikh | DATE<br>Mar, 2021 | SCALE<br>AS SHOWN | DWG No:<br>AFS-WR- 420 | REVISIONS | |

PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS



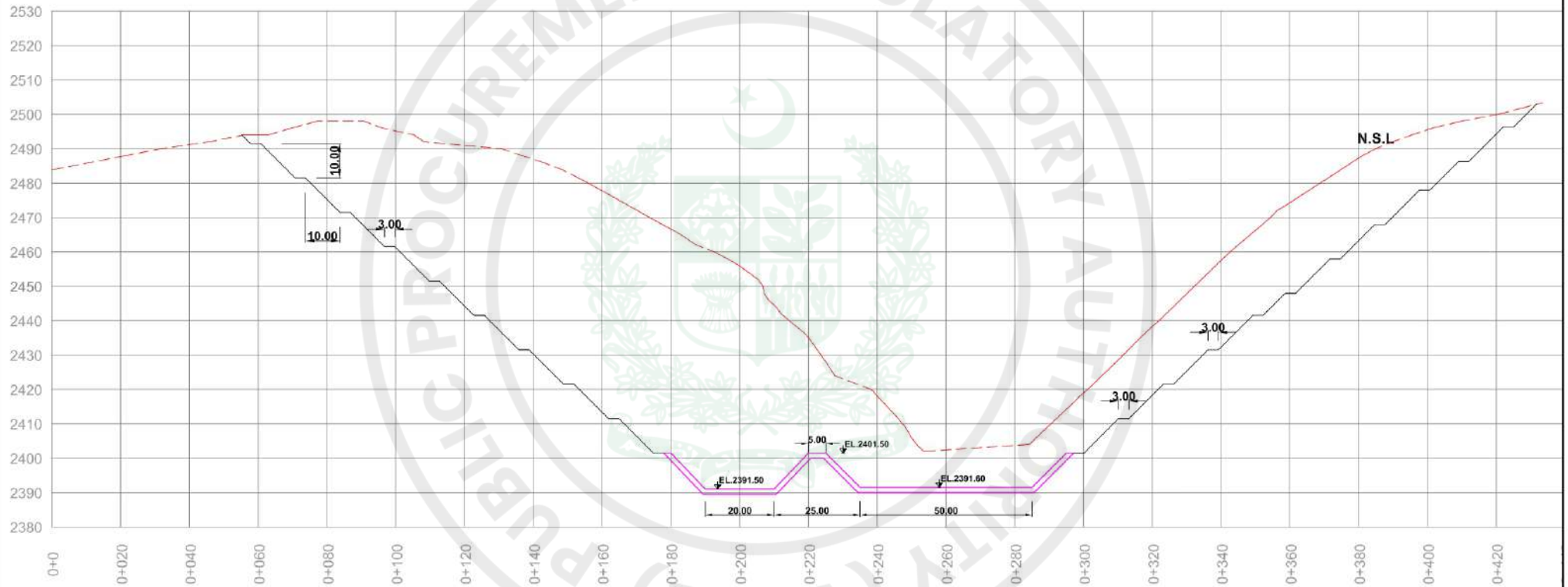

## CROSS SECTION AT RD. 0+350

SCALE

0 12 24 36 48 60 m

| | | | | | |
|---|---|---|---|---|---|
| PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | | | | | |
| PREPARED<br>Zafar | PROJECT | ATTABAD LAKE HYDRO POWER PROJECT | | | |
| DRAWN<br>Zafar | TITLE | CROSS SECTION AT RD. 0+350 FROM DOWNSTREAM OF WEIR SITE | | | |
| CHECKED<br>Abid Sheikh | | | | | |
| APPROVED<br>Abid Sheikh | DATE<br>Mar, 2021 | SCALE<br>AS SHOWN | DWG No:<br>AFS-WR- 421 | REVISIONS | |

PUBLIC PROCUREMENT REGULATORY AUTHORITY PPRA EPADS




## CROSS SECTION AT RD. 0+400

SCALE

0 12 24 36 48 60 m

| | | | | | |
|---|---|---|---|---|---|
| PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | | | | | |
| PREPARED<br>Zafar | PROJECT | ATTABAD LAKE HYDRO POWER PROJECT | | | |
| DRAWN<br>Zafar | TITLE | CROSS SECTION AT RD. 0+400 FROM DOWNSTREAM OF WEIR SITE | | | |
| CHECKED<br>Abid Sheikh | | | | | |
| APPROVED<br>Abid Sheikh | DATE<br>Mar, 2021 | SCALE<br>AS SHOWN | DWG No:<br>AFS-WR- 422 | REVISIONS | |

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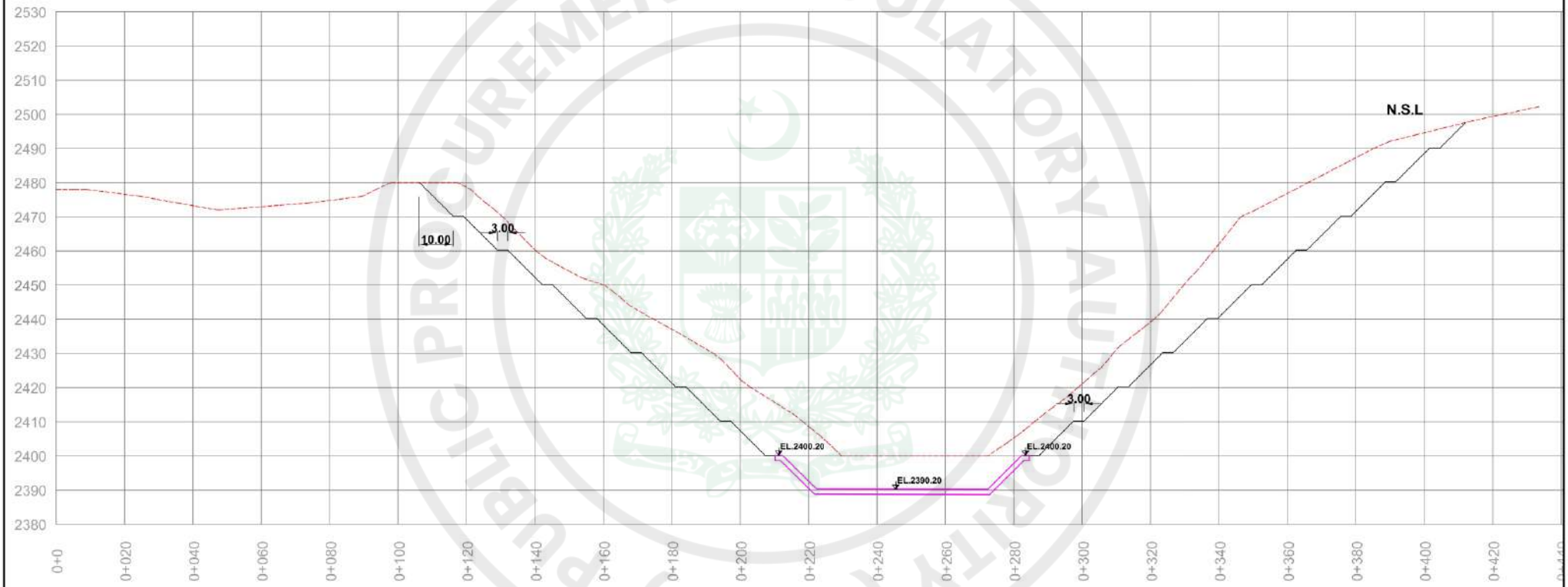


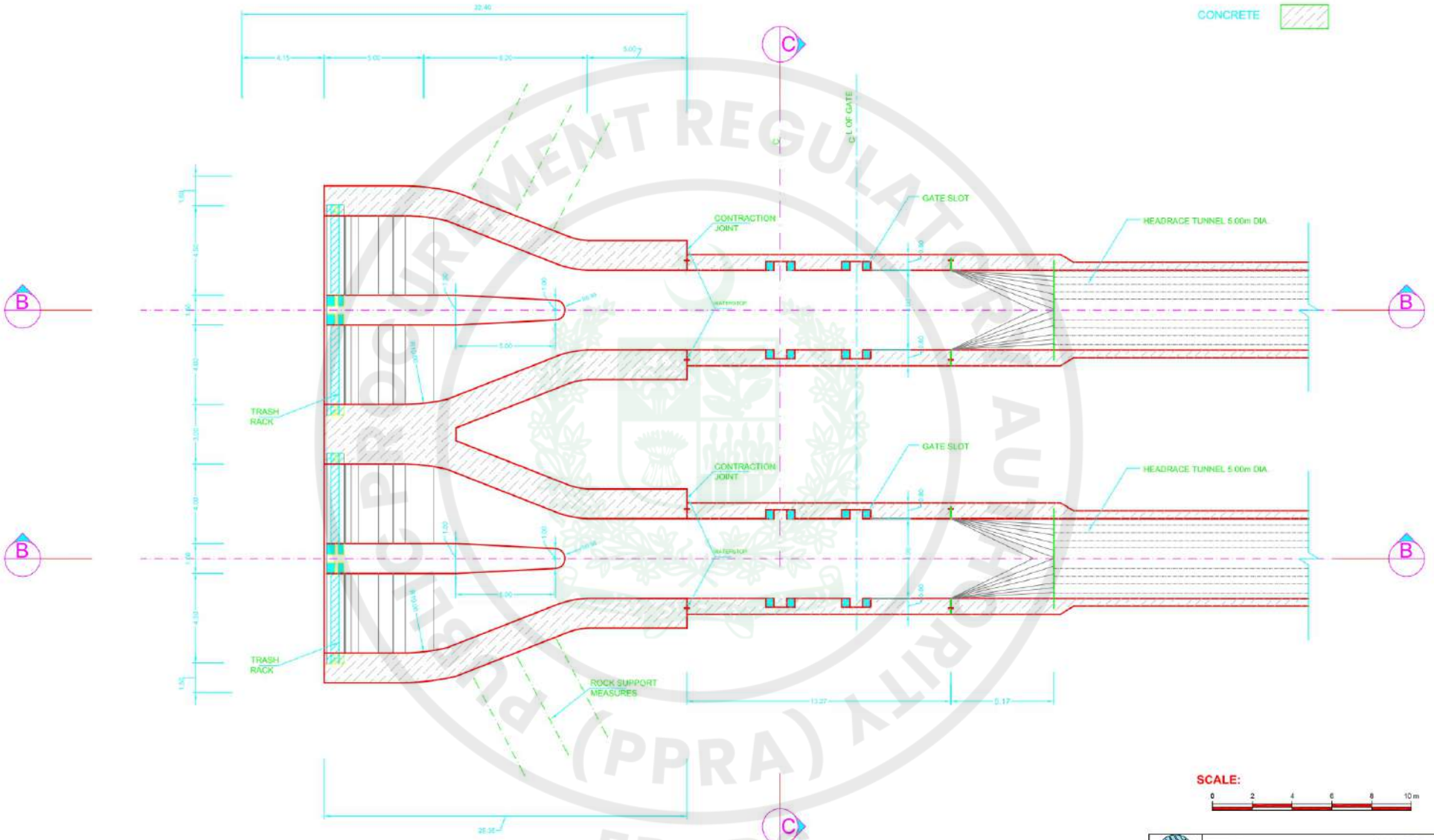

## CROSS SECTION AT RD. 0+450

SCALE

0 12 24 36 48 60 m

| | | | | | |
|---|---|---|---|---|---|
| PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | | | | | |
| PREPARED<br>Zafar | PROJECT | ATTABAD LAKE HYDRO POWER PROJECT | | | |
| DRAWN<br>Zafar | TITLE | CROSS SECTION AT RD. 0+450 FROM DOWNSTREAM OF WEIR SITE | | | |
| CHECKED<br>Abid Sheikh | | | | | |
| APPROVED<br>Abid Sheikh | DATE<br>Mar, 2021 | SCALE<br>AS SHOWN | DWG No:<br>AFS-WR- 423 | REVISIONS | |

PUBLIC PROCUREMENT REGULATORY AUTHORITY PPRA EPADS




PLAN

SECTION A - A

SCALE:

0 2 4 6 8 10 m

**NOTES:**

1. All dimensions are in meters.

| | | | | | |
|---|---|---|---|---|---|
| PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | | | | | |
| PREPARED<br>Zafar | PROJECT | ATTABAD LAKE HYDRO POWER PROJECT | | | |
| DRAWN<br>Zafar | TITLE | PLAN FOR POWER INTAKE | | | |
| CHECKED<br>Abid Sheikh | | | | | |
| APPROVED<br>Abid Sheikh | DATE<br>Mar, 2021 | SCALE<br>AS SHOWN | DWG No:<br>AFS-PI- 424 | REVISIONS | |

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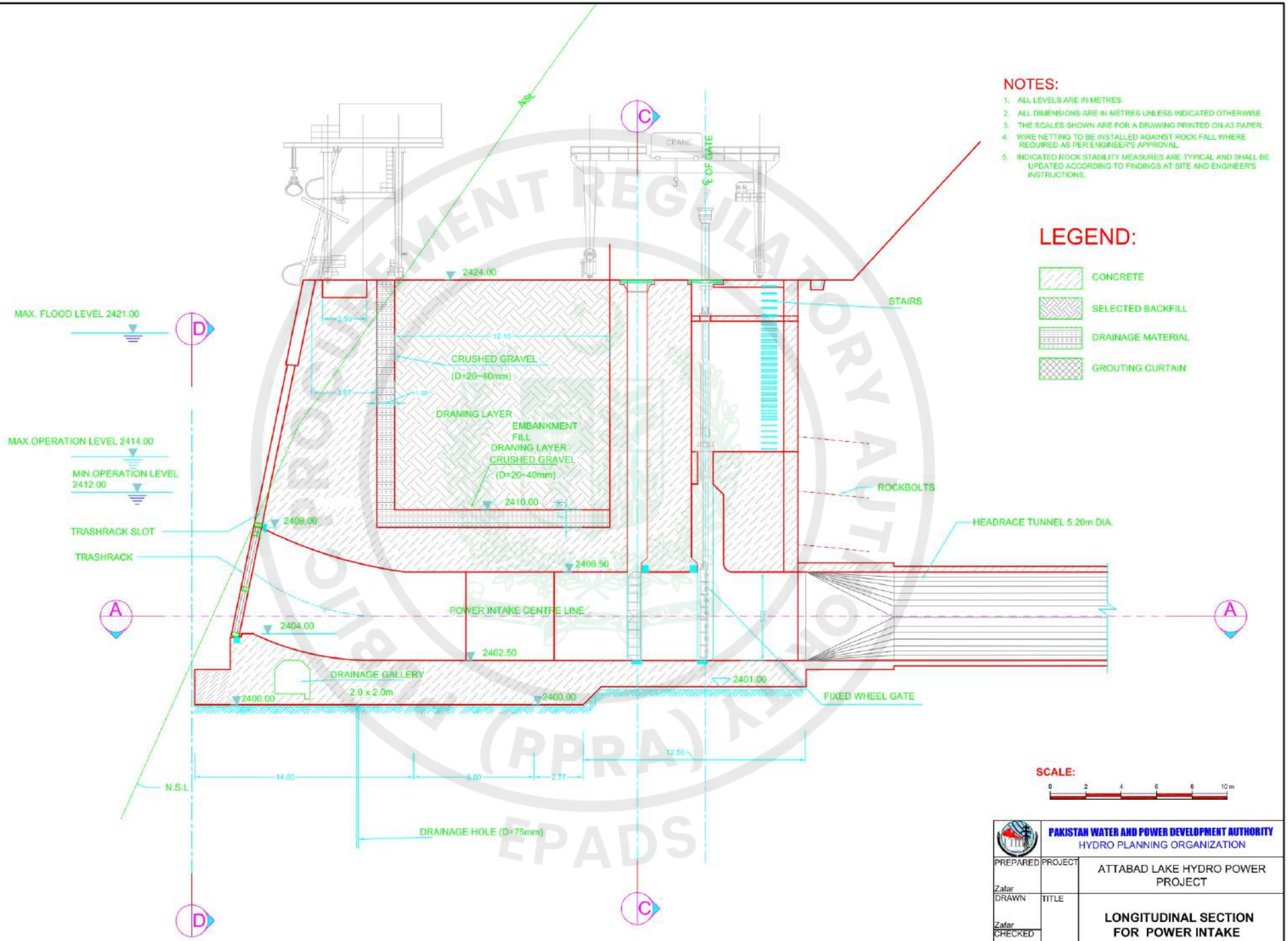


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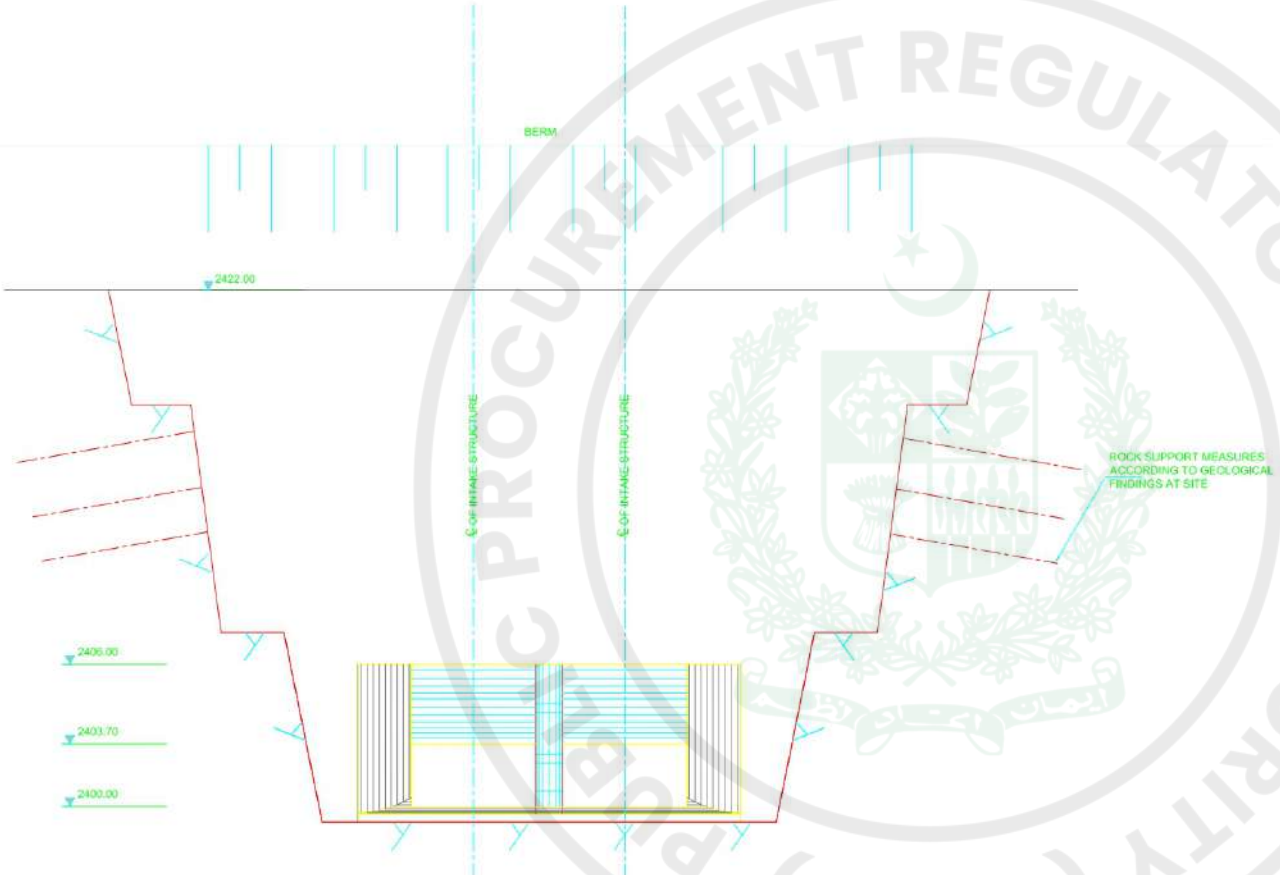
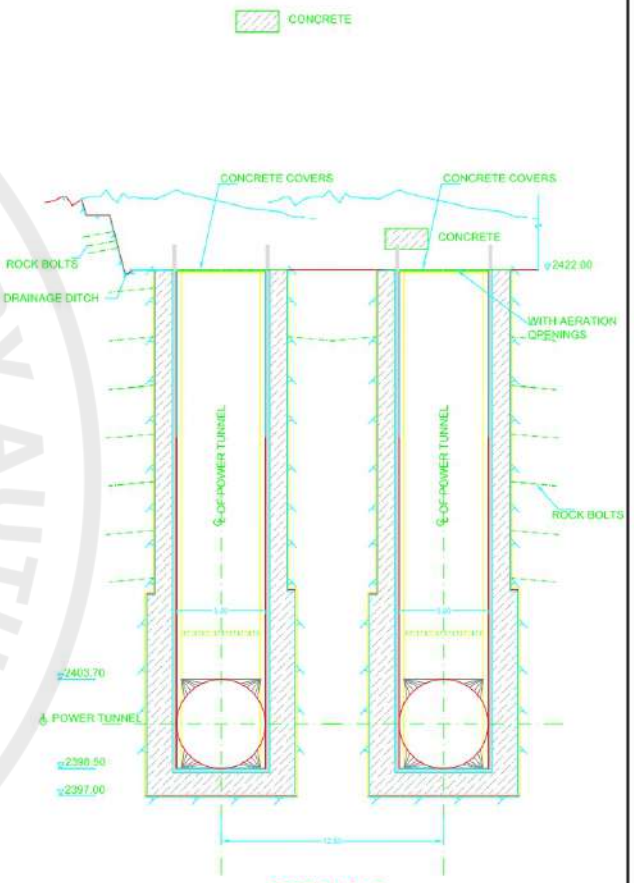



SECTION D - D




SECTION C - C

SCALE:

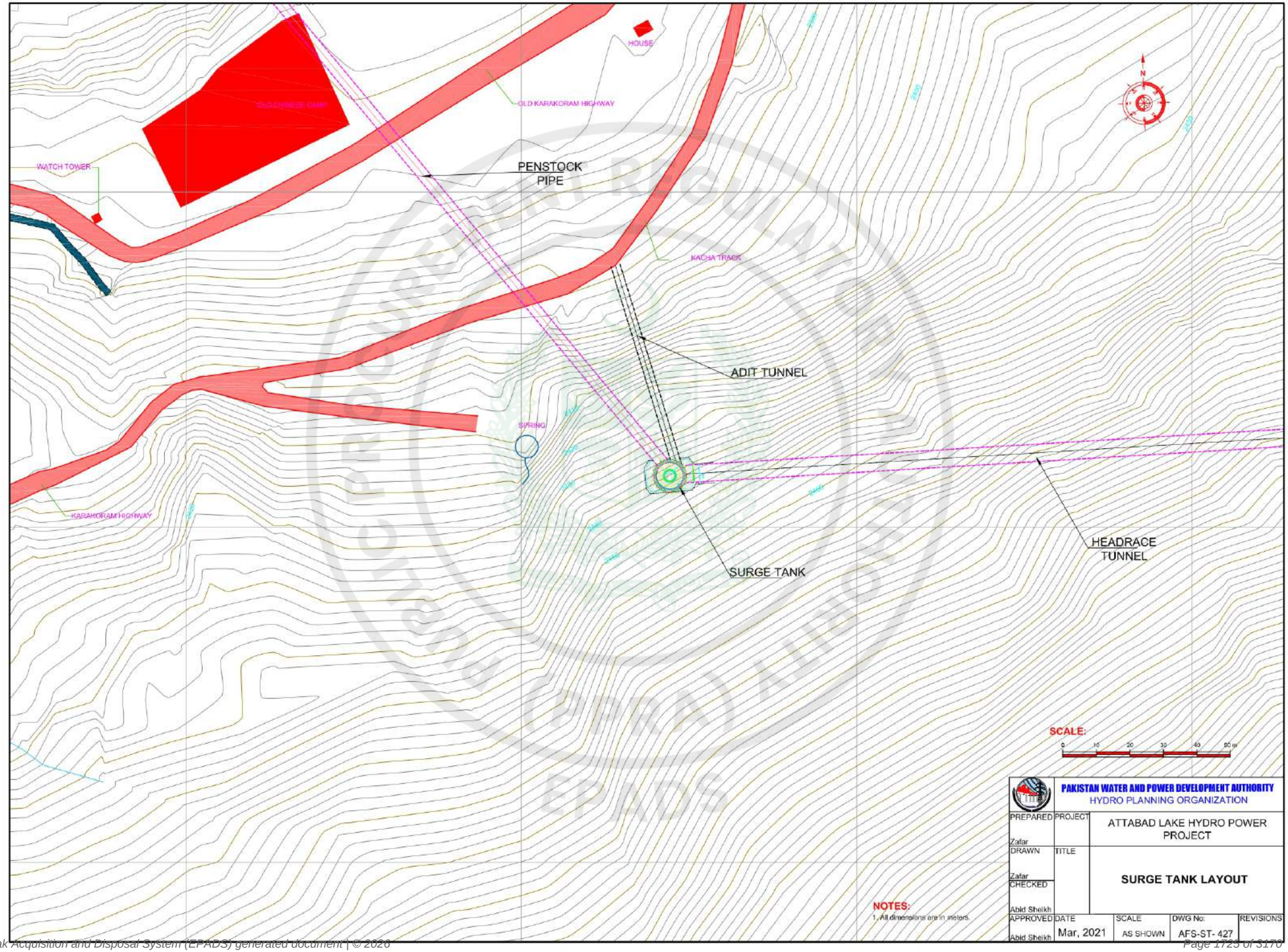
0 3 6 9 12 15 m

**NOTES:**

1. All dimensions are in meters.

| | | | | | |
|---|---|---|---|---|---|
| PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | | | | | |
| PREPARED<br>Zafar | PROJECT | ATTABAD LAKE HYDRO POWER PROJECT | | | |
| DRAWN<br>Zafar | TITLE | POWER INTAKE SECTIONS | | | |
| CHECKED<br>Abid Sheikh | | | | | |
| APPROVED<br>Abid Sheikh | DATE<br>Mar, 2021 | SCALE<br>AS SHOWN | DWG No:<br>AFS-PI- 426 | REVISIONS | |

PPRA PROCUREMENT REGULATORY AUTHORITY EPADS

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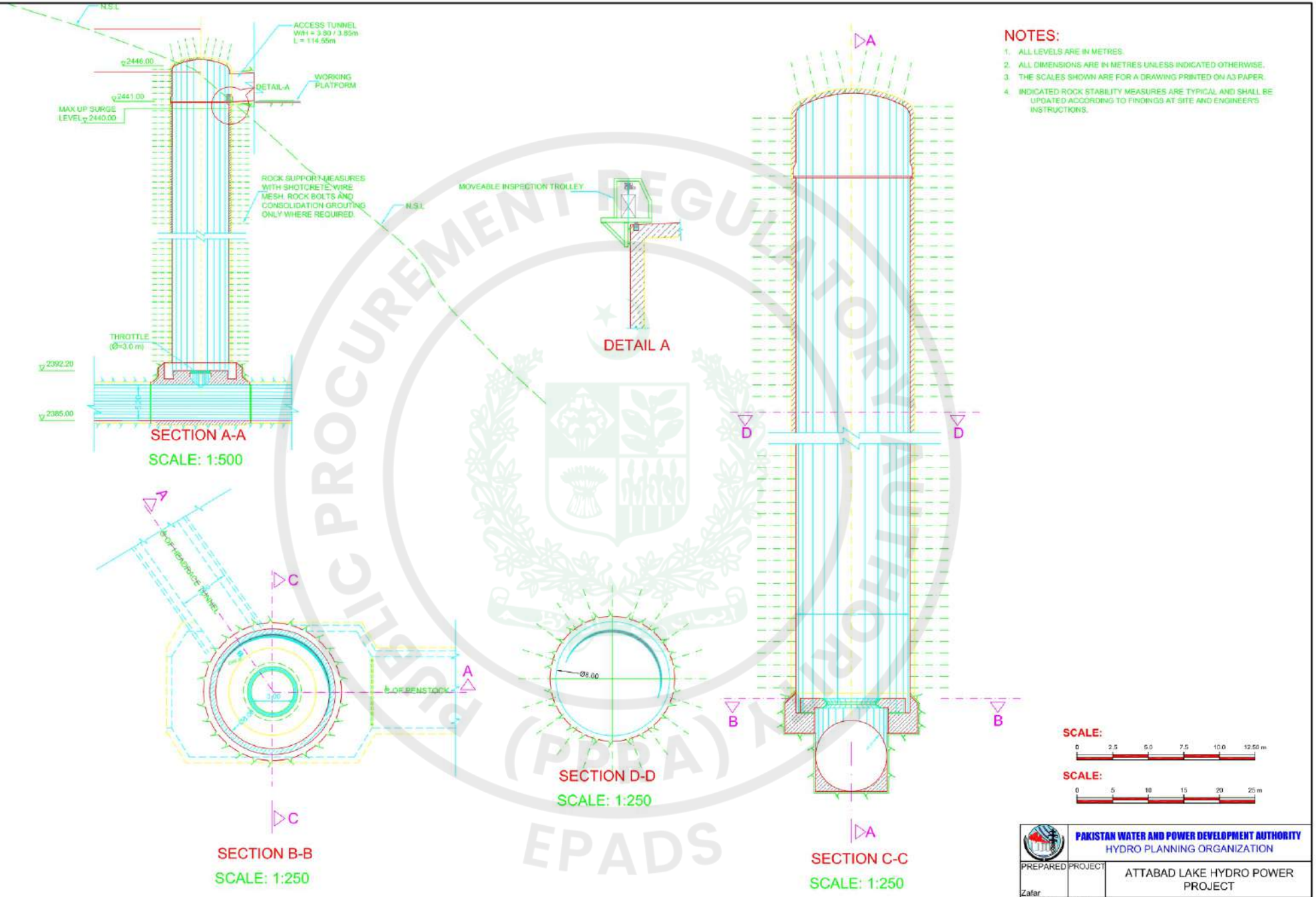


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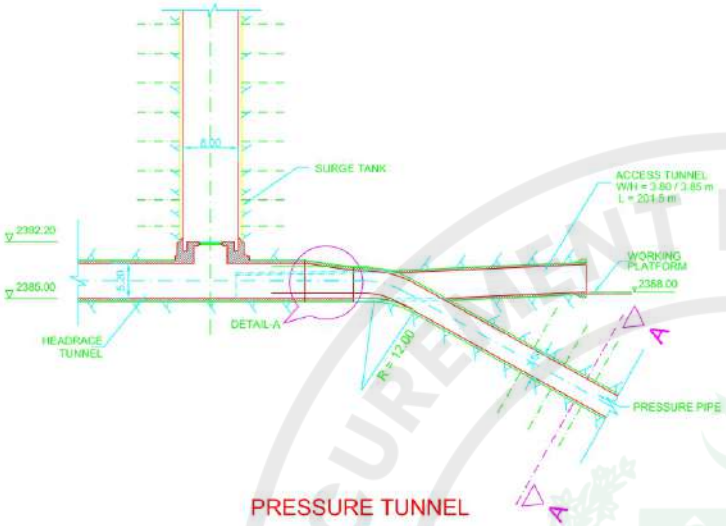
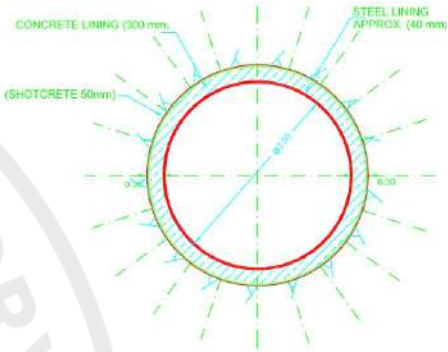
NOTES:

1. ALL LEVELS ARE IN METRES.
2. ALL DIMENSIONS ARE IN METRES UNLESS INDICATED OTHERWISE.
3. THE SCALES SHOWN ARE FOR A DRAWING PRINTED ON A3 PAPER.
4. INDICATED ROCK STABILITY MEASURES ARE TYPICAL AND SHALL BE UPDATED ACCORDING TO FINDINGS AT SITE AND ENGINEER'S INSTRUCTIONS.




PRESSURE TUNNEL

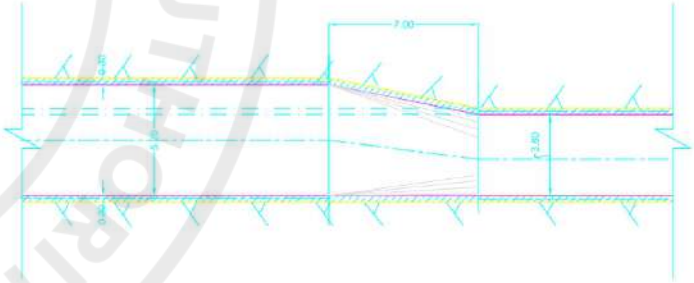
SCALE: 1:750




SECTION A-A

SCALE: 1:100

X -SECTION FOR PENSTOCK



DETAIL A

SCALE: 1:250

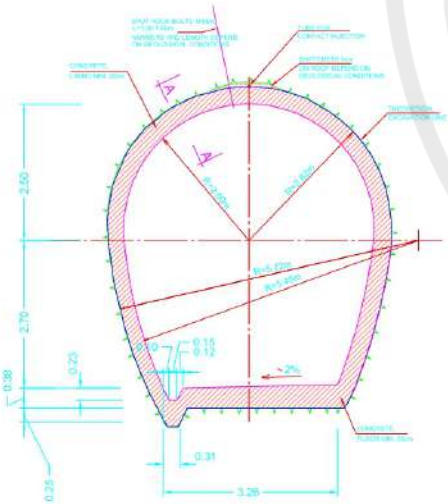
SCALE 1:100

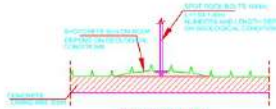
0 1 2 3 4 5

SCALE 1:250

0 2.5 5 7.5 10 12.5

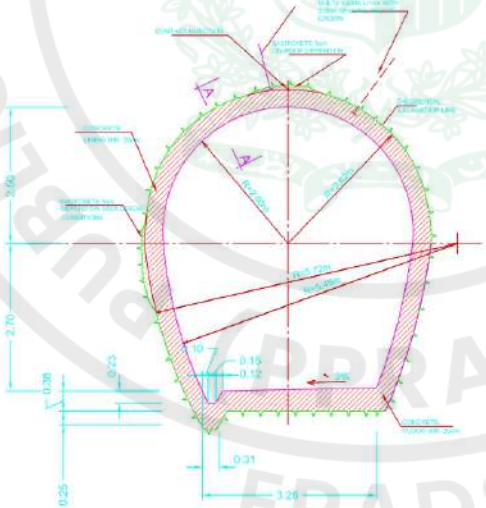
CONVENTIONAL HEADING
ROCK CLASS-I
VERY GOOD ROCK
(ACCORDING TO RMR)

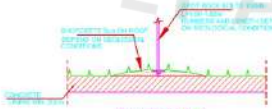


SECTION A-A

CONVENTIONAL HEADING
ROCK CLASS-II
VERY GOOD ROCK
(ACCORDING TO RMR)



SECTION A-A

CROSS SECTION
HEADRACE

SCALE: 1:100

NOTES:

1. All dimensions are in meters.

| | | | | | |
|---|---|---|---|---|---|
| PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | | | | | |
| PREPARED<br>Zafar | PROJECT | ATTABAD LAKE HYDRO POWER PROJECT | | | |
| DRAWN<br>Zafar | TITLE | SURGE TANK SECTIONS | | | |
| CHECKED<br>Abid Sheikh | | | | | |
| APPROVED<br>Abid Sheikh | DATE<br>Mar, 2021 | SCALE<br>AS SHOWN | DWG No:<br>AFS-ST- 429 | REVISIONS | |

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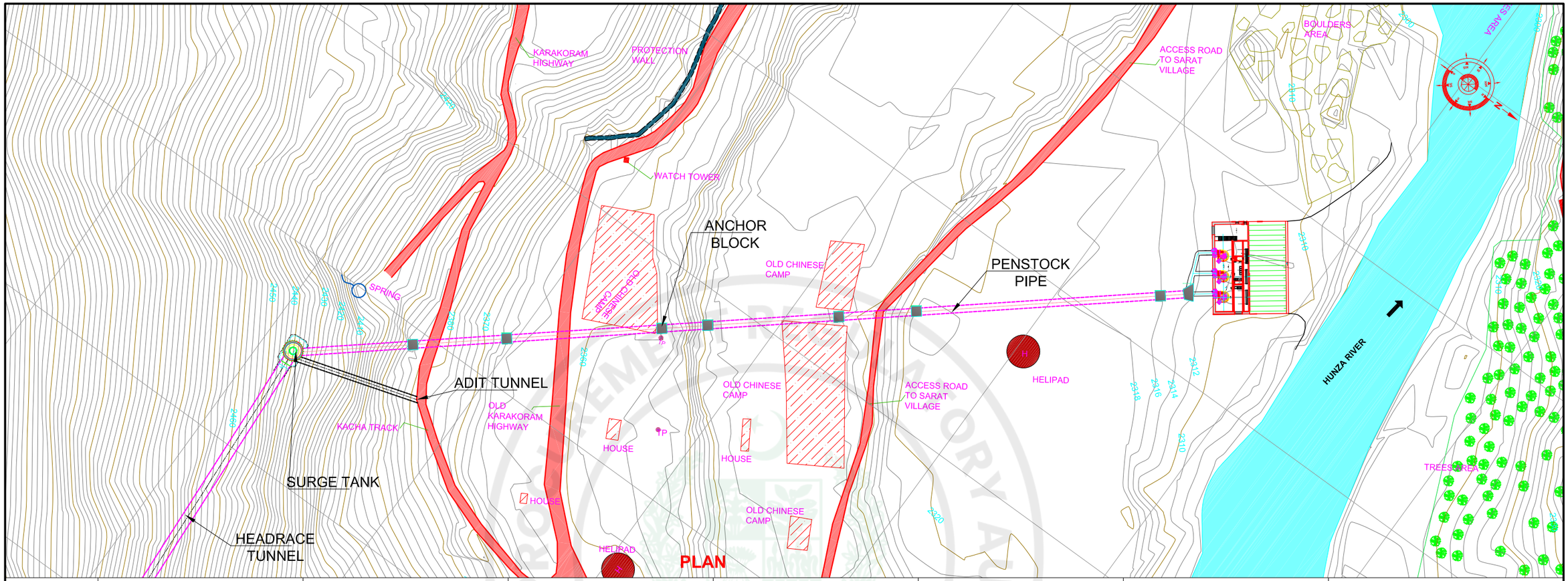


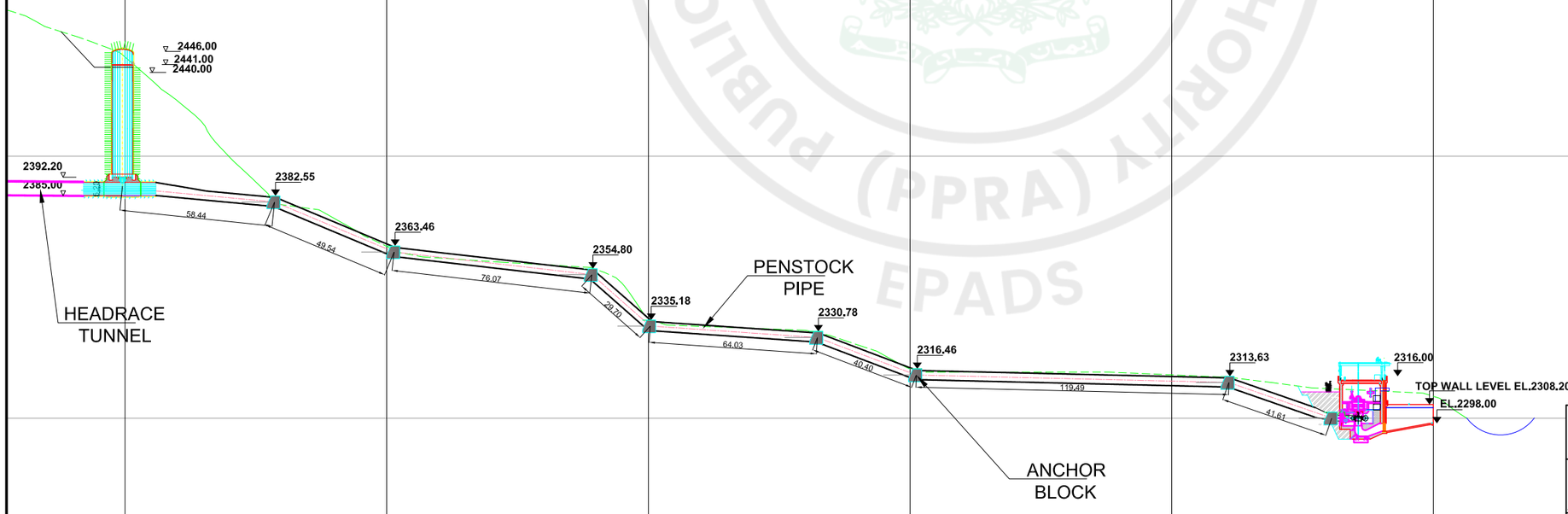


SCALE:

0 20 40 60 80 100 m

**NOTES:**

1. All dimensions are in meters.

**PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY**
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Zafar | PROJECT | ATTABAD LAKE HYDRO POWER PROJECT |
| DRAWN: Zafar | TITLE | **PENSTOCK PLAN AND LONGITUDINAL PROFILE** |
| CHECKED: Abid Sheikh | | |
| APPROVED: Abid Sheikh | DATE: Mar, 2021 | SCALE: AS SHOWN / DWG No: AFS-ST- 430 / REVISIONS |

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4018100

4018000

4017900

481600

481700

481800

HUNZA RIVER

POWERHOUSE

HELIPAD

H

HELIPAD

H

PENSTOCK
PIPE

BOULDERS AREA

BOULDERS AREA

ACCESS ROAD TO
SARAT VILLAGE

ACCESS ROAD TO
SARAT VILLAGE

2300
2302
2304
2306
2308
2310
2312
2314
2316
2318
2320
2322
2324
2326
2328
2330
2332
2334
2336
2338
2340
2342
2344

N

**NOTES:**

1. All dimensions are in meters.

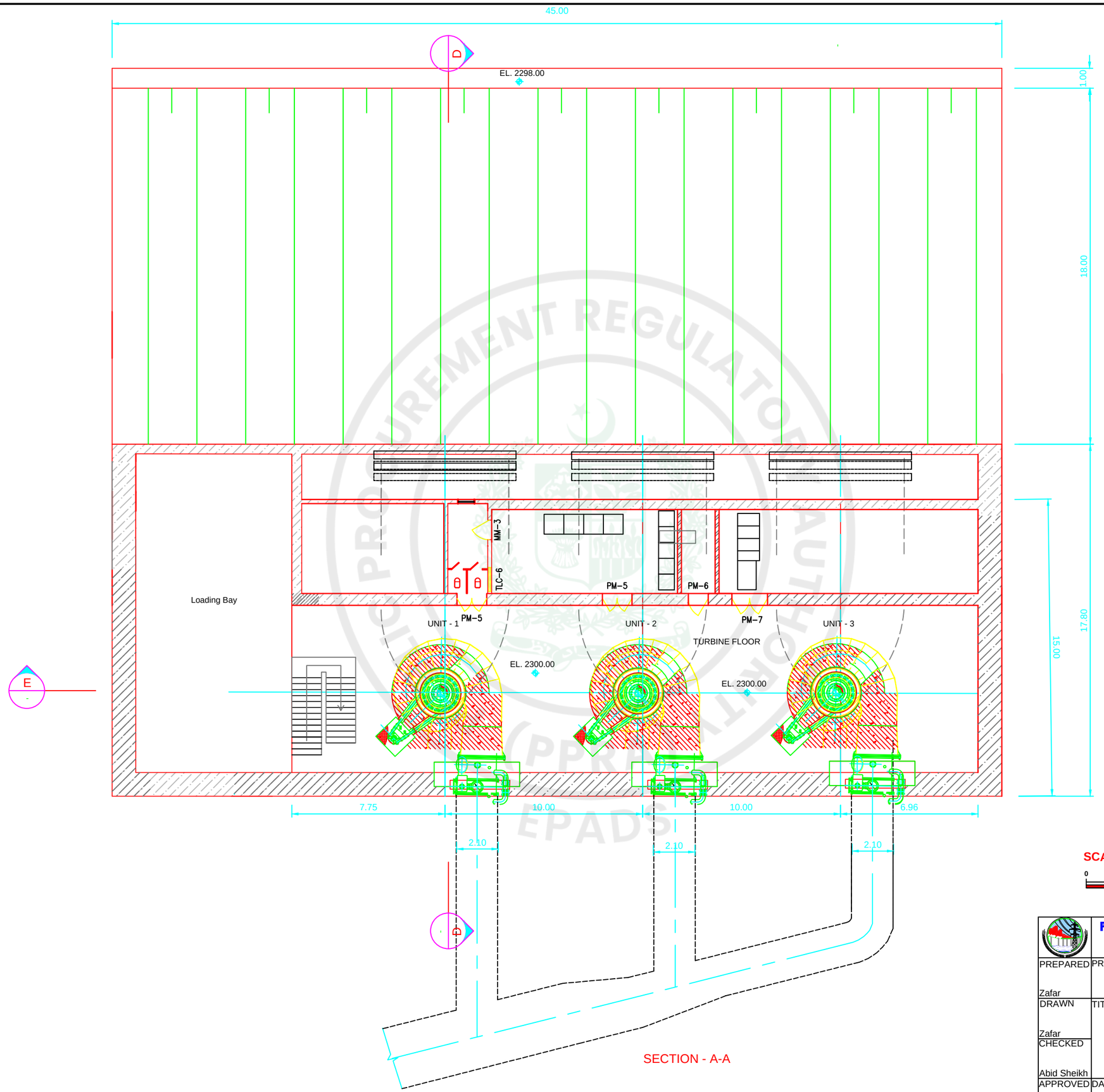
**SCALE:**

0 10 20 30 40 50 m

**PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY**
HYDRO PLANNING ORGANIZATION

| | | | | | |
|---|---|---|---|---|---|
| PREPARED<br>Zafar | PROJECT | ATTABAD LAKE HYDRO POWER PROJECT | | | |
| DRAWN<br>Zafar | TITLE | **POWERHOUSE LAYOUT** | | | |
| CHECKED<br>Abid Sheikh | | | | | |
| APPROVED<br>Abid Sheikh | DATE<br>Mar, 2021 | SCALE<br>AS SHOWN | DWG No:<br>AFS-PH - 431 | REVISIONS | |

PROCUREMENT REGULATORY AUTHORITY PUBLIC (PPRA) EPADS




SECTION - A-A

**NOTES:**

1. All dimensions are in meters.

SCALE

0 2 4 6 8 10 m

**PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY**

GENERAL MANAGER (HYDRO) PLANNING

| | | |
|---|---|---|
| PREPARED: Zafar | PROJECT | **ATTABAD LAKE HPP** FEASIBILITY STUDY REPORT |
| DRAWN: Zafar | TITLE | **PLAN FOR POWERHOUSE** |
| CHECKED: Abid Sheikh | | |
| APPROVED: Abid Sheikh | DATE: Jun, 2021 | SCALE: AS SHOWN |
| | DWG No: AFS-PH-432 | REVISIONS |

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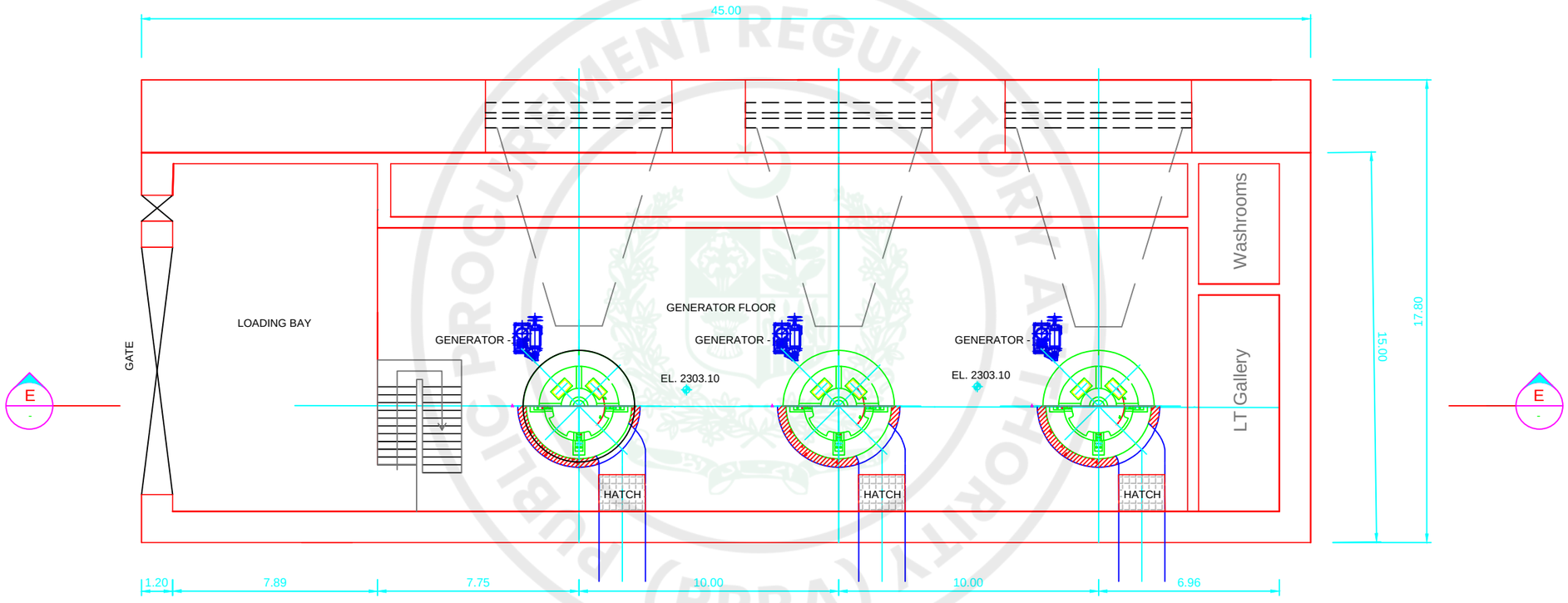
**NOTES:**

1. All dimensions are in meters.




SECTION - B-B

**SCALE**

0 2 4 6 8 10 m

| | | | | |
|---|---|---|---|---|
| **PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY** | | | | |
| GENERAL MANAGER (HYDRO) PLANNING | | | | |
| PREPARED Zafar | PROJECT | **ATTABAD LAKE HPP** FEASIBILITY STUDY REPORT | | |
| DRAWN Zafar | TITLE | **GENERATOR FLOOR PLAN** | | |
| CHECKED Abid Sheikh | | | | |
| APPROVED Abid Sheikh | DATE Jun, 2021 | SCALE AS SHOWN | DWG No: AFS-PH-433 | REVISIONS |

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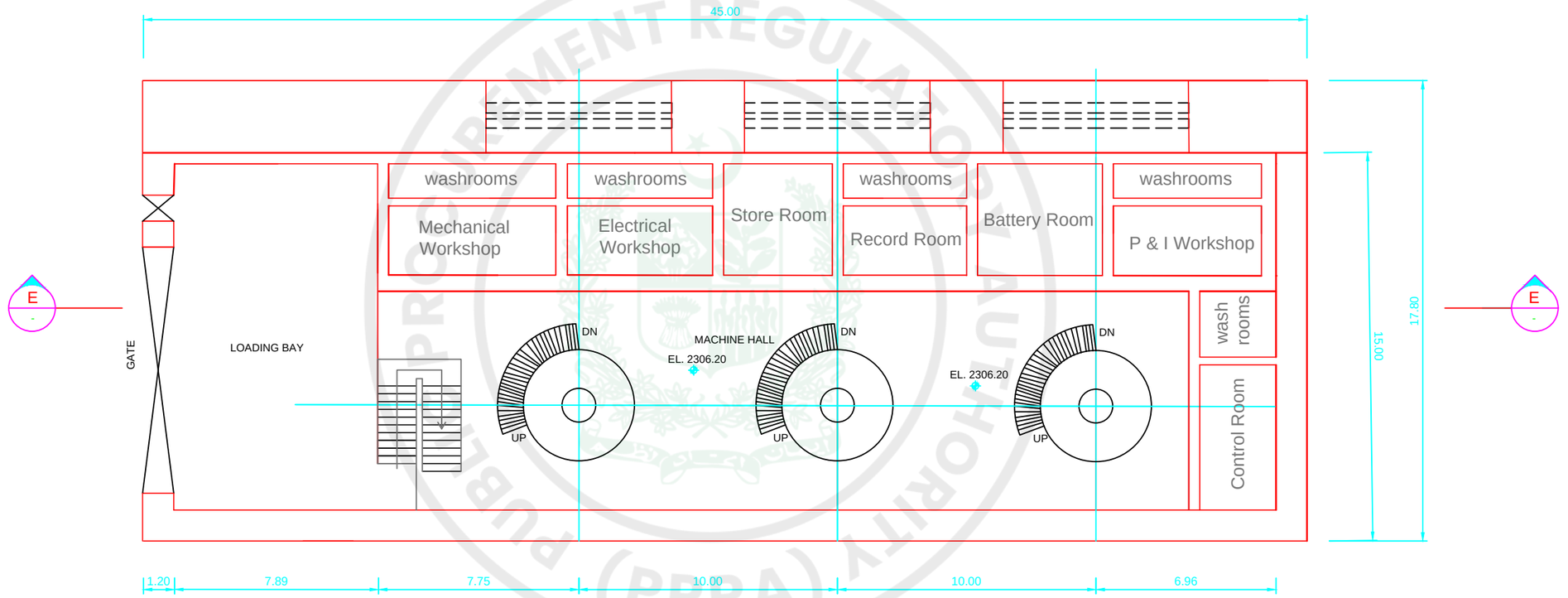
**NOTES:**
1. All dimensions are in meters.




SECTION - C-C

SCALE

0 2 4 6 8 10 m

| | | | | | |
|---|---|---|---|---|---|
| PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>GENERAL MANAGER (HYDRO) PLANNING | | | | | |
| PREPARED<br>Zafar | PROJECT | ATTABAD LAKE HPP<br>FEASIBILITY STUDY REPORT | | | |
| DRAWN<br>Zafar | TITLE | MACHINE HALL PLAN | | | |
| CHECKED<br>Abid Sheikh | | | | | |
| APPROVED<br>Abid Sheikh | DATE<br>Jun, 2021 | SCALE<br>AS SHOWN | DWG No:<br>AFS-PH-434 | REVISIONS | |

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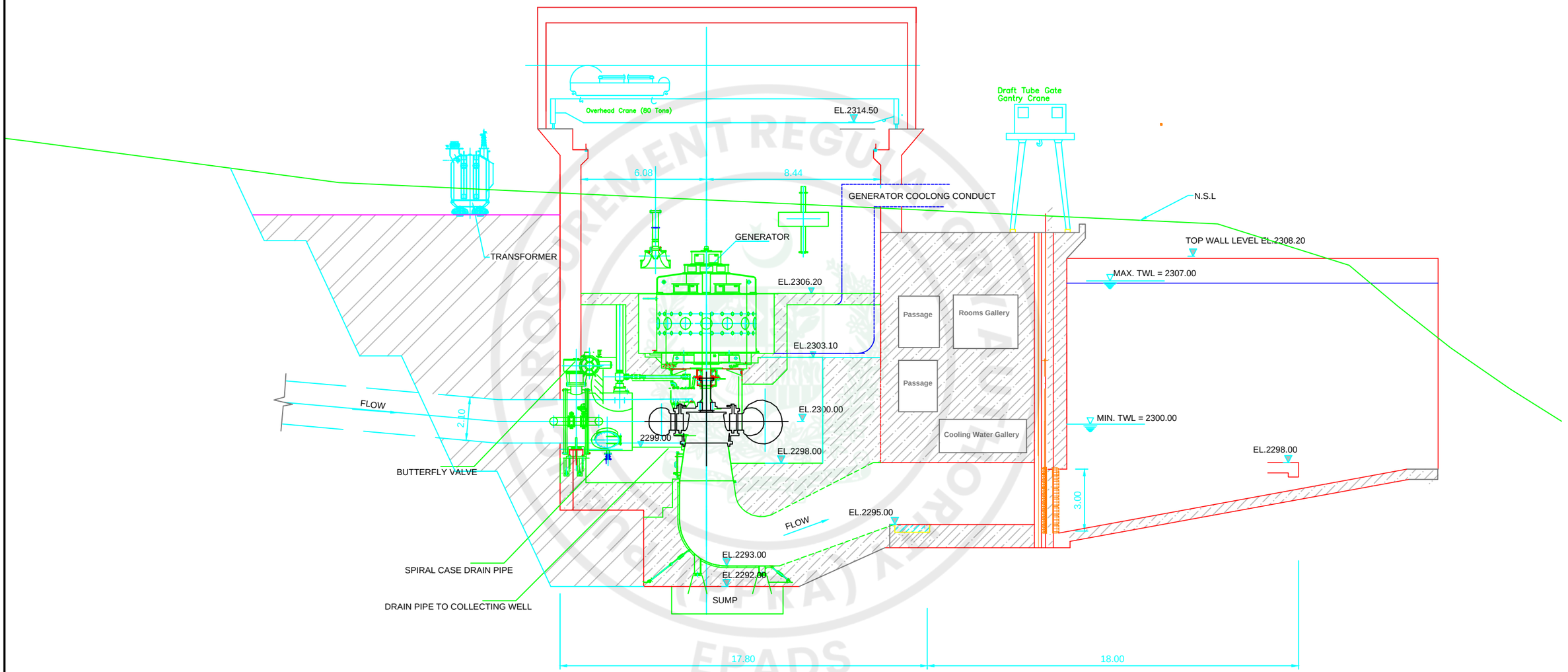
**NOTES:**

1. All dimensions are in meters.




SECTION D - D

**SCALE**

0 2 4 6 8 10 m

| | | | | | |
|---|---|---|---|---|---|
| **PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY**<br>GENERAL MANAGER (HYDRO) PLANNING | | | | | |
| PREPARED<br>Zafar | PROJECT | **ATTABAD LAKE HPP**<br>FEASIBILITY STUDY REPORT | | | |
| DRAWN<br>Zafar | TITLE | **CROSS SECTION FOR POWERHOUSE** | | | |
| CHECKED<br>Abid Sheikh | | | | | |
| APPROVED<br>Abid Sheikh | DATE<br>Jun, 2021 | SCALE<br>AS SHOWN | DWG No:<br>AFS-PH-435 | REVISIONS | |

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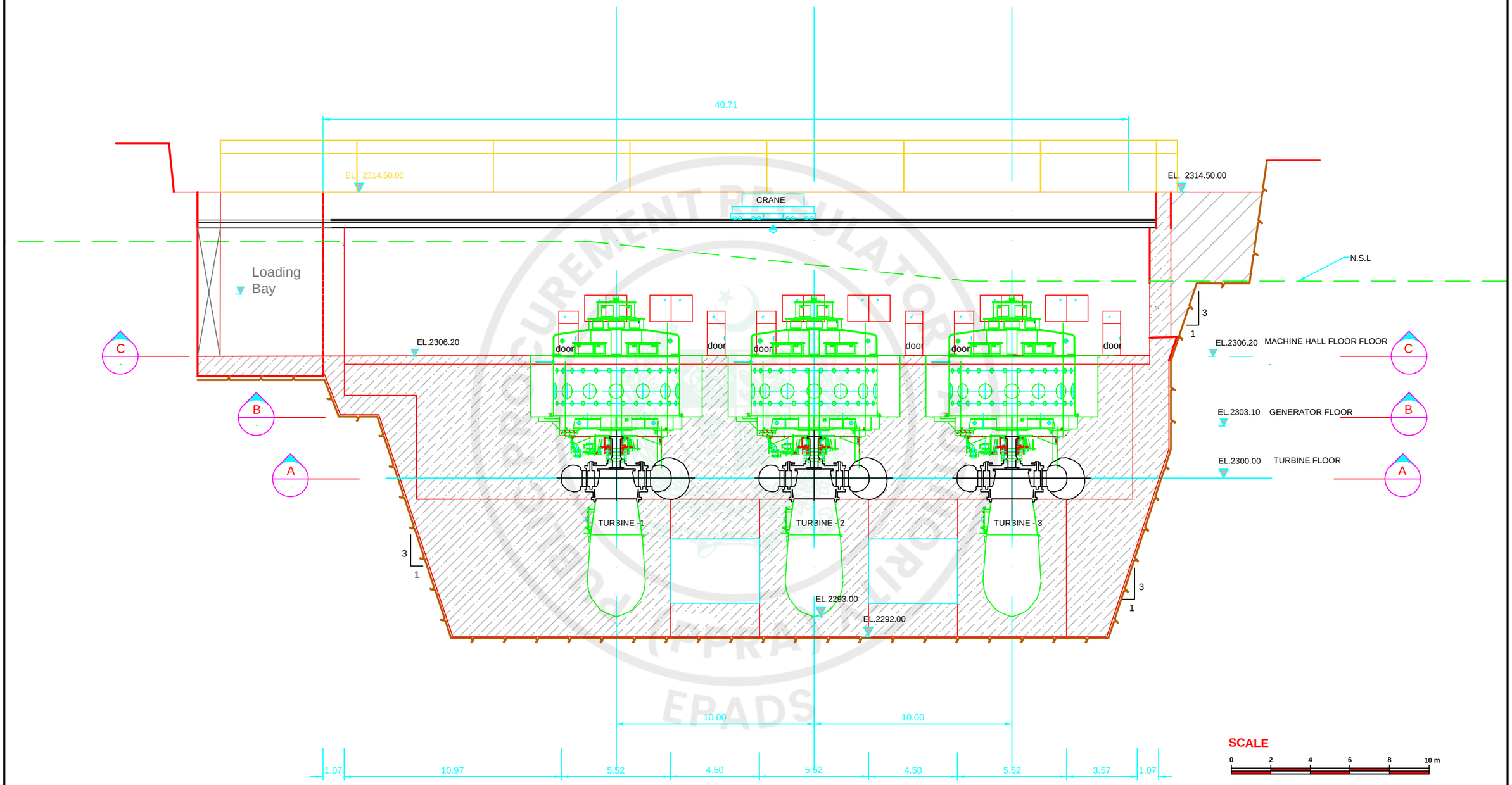
**NOTES:**

1. All dimensions are in meters.




SECTION E - E

| | | | | | |
|---|---|---|---|---|---|
| PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>GENERAL MANAGER (HYDRO) PLANNING | | | | | |
| PREPARED<br>Zafar | PROJECT | ATTABAD LAKE HPP<br>FEASIBILITY STUDY REPORT | | | |
| DRAWN<br>Zafar | TITLE | LONGITUDINAL SECTION FOR POWERHOUSE | | | |
| CHECKED<br>Abid Sheikh | | | | | |
| APPROVED<br>Abid Sheikh | DATE<br>Jun, 2021 | SCALE<br>AS SHOWN | DWG No:<br>AFS-PH-436 | REVISIONS | |

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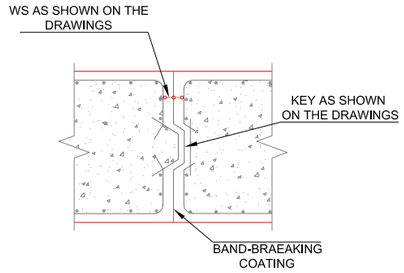
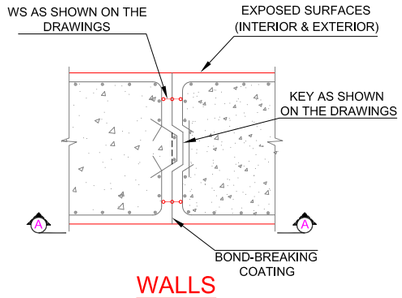


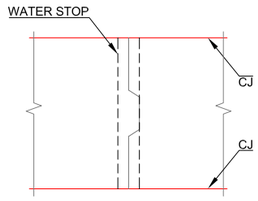

## CONTRACTION JOINT (FLOOR)

(UNLESS OTHERWISE SHOWN)
REINFORCEMENT STOPS AT CONTRACTION JOINT

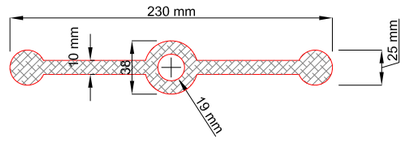



## WALLS CONTRACTION JOINT

(UNLESS OTHERWISE SHOWN)




## ELEVATION A-A

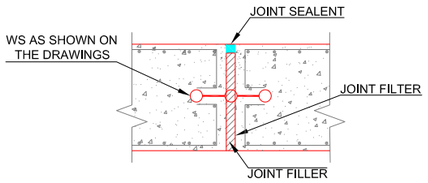



## WATER STOP TYPE-A

(THREE-BULB PVC)

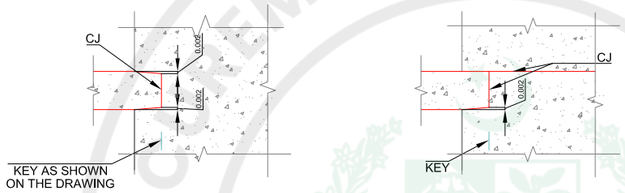
## GENRAL NOTES FOR CONCRETE

1. CONCRETE ELEVATION AND DIMENSIONS ARE IN METER, UNLESS OTHERWISE NOTED.
2. PROVID TOOLED EDGES FOR ALL CONSTRUCTION, CONTRACTION AND EXPANSION JOINTS ON SURFACE WHERE WOOD FLOAT OR STEEL TROWEL FINISH IS REQUIRED.
3. CONCRETE SURFACES EXPOSED TO THE FLOW OF WATER MUST BE SMOOTH AND FREE FROM SPALLS, HONEYCOMBS AND OR POCKETS.
4. ALL CONSTRUCTION JOINTS, BOTH HORIZONTAL AND VERTICAL, SHALL BE TREATED BEFORE PLACEMENT OF FRESH CONCRETE.
5. WATER STOPS TO BE CONTINUOUS, JOINTS AT SPLICES AND CORNERS SHALL BE RECOMMENDED BY THE MANUFACTURER.
6. PROVIDED CONSTRUCTION JOINT TREATMENT TO ALL CONCRETE SURFACES RECEIVING ABONDED CONCRETE FINISH.
7. LIFT HEIGHT AND TIME BETWEEN PLACEMENT SHALL BE IN ACCORDANCE WITH THE REQUIREMENTS OF THE SPECIFICATIONS.
8. ALL WATER STOPS SHALL BE TYPE A UNLESS NOTED OTHERWISE ON THE DRAWINGS




## EXPANSION JOINT

(UNLESS OTHERWISE SHOWN)

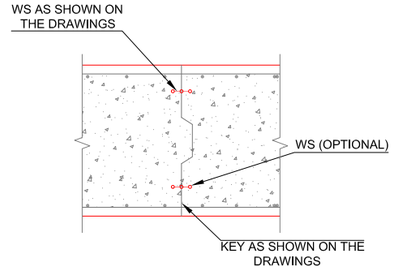



## TYPICAL KEY DETAILS

| A | B | C | D | E |
|---|---|---|---|---|
| 0.75 TO 1.0 | 0.35 | 0.20 TO 0.35 | 0.05 | 0.10 |
| 1.0 TO 1.5 | 0.50 | 0.25 TO 0.50 | 0.05 | 0.10 |
| 1.5 TO 2.3 | 0.8 | 0.35 TO 0.75 | 0.075 | 0.15 |
| 2.3 TO 3.0 | 1.3 | 0.5 TO 0.85 | 0.15 | 0.30 |

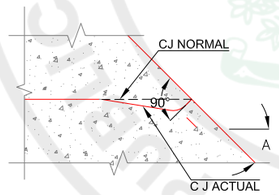
## HORIZONTAL LIFT KEYS

(UNLESS OTHERWISE NOTED)

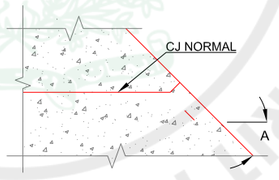



## TYPICAL CONSTRUCTION JOINT

(REINFORCEMENT CONTINUOUS THROUGH JOINT)



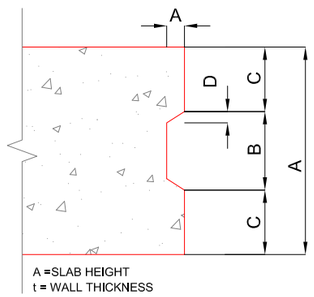

## MASS CONCRETE




## WALL

## SPECIAL TREATMENT AT CONSTRUCTION JOINT

(TYPICAL FIELD DETAIL AT SLOPING SURFACE WHEN 'A' IS EQUAL TO OR LESS THAN 60°. OMIT SPECIAL TREATMENT WHEN 'A' IS MORE THAN 60°.)




## KEY DIMENSIONS

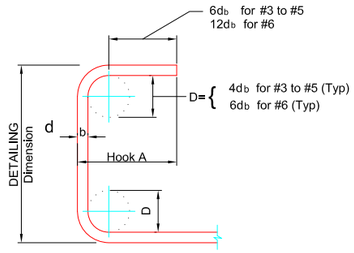
| CLASS | STRENGTH | NOMINAL PROPORTION |
|---|---|---|
| CLASS A (P.C) | 28 MPa | 1 : 1 1/2 : 3 |
| CLASS B (R.C.) | 21 MPa | 1 : 2 : 4 |
| CLASS C (P.C.C.) | 15 MPa | 1 : 4 : 8 |
| CLASS D (P.C.C.) | 10 MPa | 1 : 6 : 12 |

## CONCRETE CLASSES

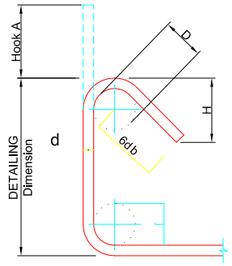
**PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY**
HYDRO PLANNING ORGANIZATION

| | | | | |
|---|---|---|---|---|
| PREPARED: Zafar | PROJECT | ATTABAD LAKE HYDRO POWER PROJECT | | |
| DRAWN: Zafar | TITLE | **TYPICAL DETAILS OF CONCRETE JOINTS** | | |
| CHECKED: Abid Sheikh | | | | |
| APPROVED: Abid Sheikh | DATE: Mar, 2021 | SCALE: AS SHOWN | DWG No: AFS- MIS - 437 | REVISIONS |

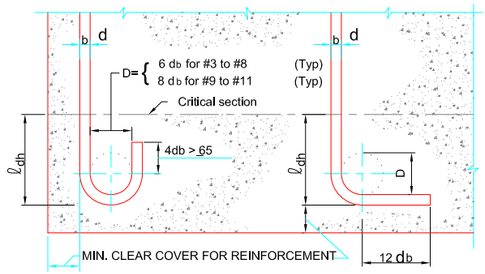
PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS



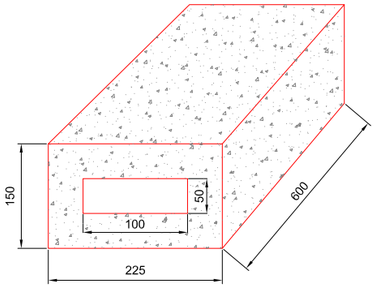

STIRRUP 90° HOOK



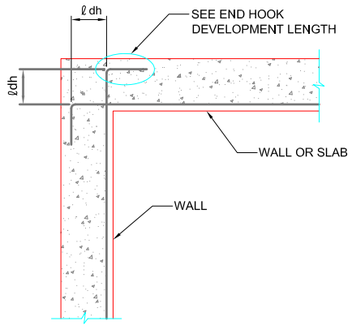

STIRRUP 135° HOOK



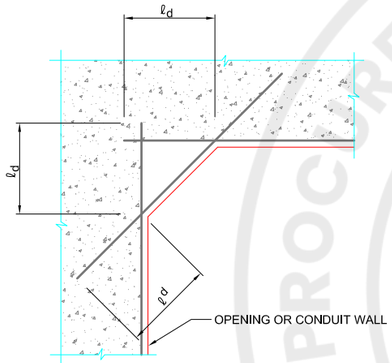

END HOOK DEVELOPMENT LENGTH



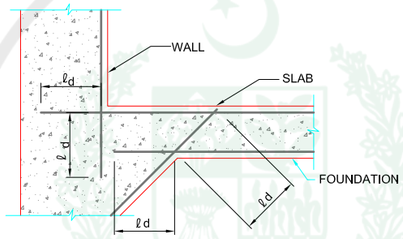

HOLLOW BLOCKS (PCC)
POWERHOUSE




CASE 1

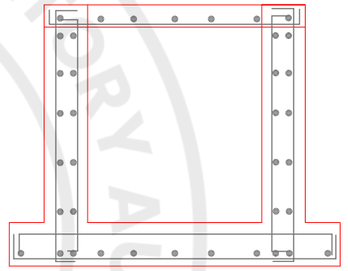



CASE 2

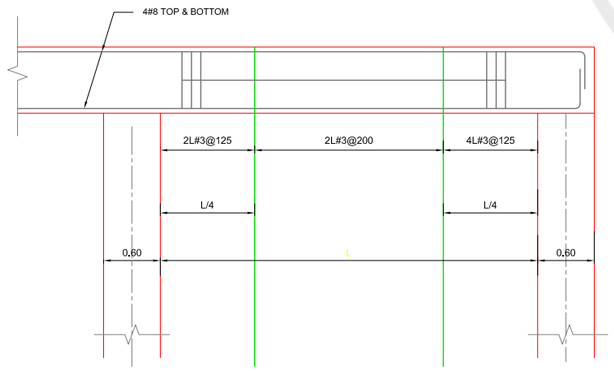


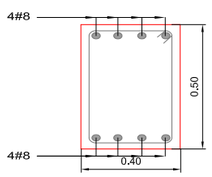

CASE 3

BAR DEVELOPMENT LENGTH, TYPICAL CASES

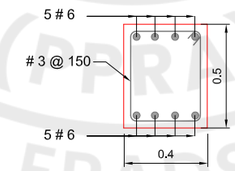


TAILRACE CHANNEL REINFORCEMENT DETAILS

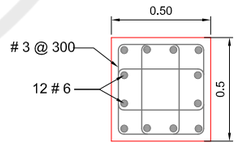


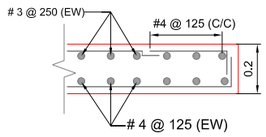

TOP BEAM, LINTEL BEAM, MID BEAM
POWERHOUSE



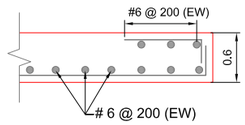

BEAM




COLUMN




TOP SLAB




FLOOR

CONTROL ROOM REINFORCEMENT DETAILS

## NOTES:

1. ALL DIMENSIONS AND LEVELS ARE IN METERS OR AS SPECIFIED ON DRAWING
2. REINFORCEMENT SHALL BE GRADE 40, DEFORMED BILLET STEEL IN ACCORDANCE WITH ASTM DESIGNATION : A 615
3. LAP LENGTH, SPLICING, ANCHORAGE AND OTHER DETAILS SHALL BE AS SHOWN ON DRAWINGS, JNG-MIS-001 TO JNG-MIS-003.
4. CONCRETE COVER TO REINFORCEMENT SHALL BE AS FOLLOWS:
   a)CAST AGAINST EARTH ROCK 75mm.
   b)EXPOSED TO WATER OR WEATHER 50mm.
   c)NOT EXPOSED TO WATER OR WEATHER 40mm.
5. PROVIDE TOOLED EDGES FOR ALL CONSTRUCTION, CONTRACTION AND EXPANSION JOINTS ON SURFACE WHERE WOODEN FLOAT OR STEEL TROWEL FINISH IS REQUIRED.
6. CONCRETE SURFACES EXPOSED TO THE FLOW OF WATER MUST BE SMOOTH AND FREE FROM SPALLS, HONEYCOMBS AND OR POCKETS.
7. WATER STOPS AT JOINTS IS TO BE CONTINUOUS.WATER STOP JOINTS SHALL BE AS RECOMMENDED BY THE MANUFACTURER.
8. ALL WATER STOPS SHALL BE TYPE A UNLESS OTHERWISE NOTED ON THE DRAWINGS.
9. LIFT HEIGHTS AND TIME BETWEEN PLACEMENT SHALL BE IN ACCORDANCE WITH THE RELEVANT TECHNICAL PROVISIONS OR AS DIRECTED BY THE ENGINEER.
10. BAR NOTATION:
    a)# 4 @ 200,INDICATES BAR No.4 PLACED AT 200mm CENTRE TO CENTRE.
    b)5 # 4, INDICATES 5, No. 4 BARS.
11. ALL EXPOSED EDGES OF THE CONCRETE ARE TO BE CHAMFERED 25mm x 25mm UNLESS OTHERWISE INDICATED ON THE DRAWING.

## LEGENDS:

EF EACH FACE
T&B TOP AND BOTTOM.

## CONCRETE CLASSES

| CLASS | STRENGTH | NOMINAL PROPORTION |
|---|---|---|
| CLASS A (P.C.C.) | 28 MPa | 1 : 1 1/2 : 3 |
| CLASS B (R.C.) | 21 MPa | 1 : 2 : 4 |
| CLASS C (P.C.C.) | 15 MPa | 1 : 4 : 8 |
| CLASS D (P.C.C.) | 10 MPa | 1 : 4 : 8 |

**PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY**
HYDRO PLANNING ORGANIZATION

| | | | | |
|---|---|---|---|---|
| PREPARED Zafar | PROJECT | ATTABAD LAKE HYDRO POWER PROJECT | | |
| DRAWN Zafar | TITLE | **MISCELLANEOUS REINFORCEMENT DETAILS (SHEET 1 OF 2)** | | |
| CHECKED Abid Sheikh | | | | |
| APPROVED Abid Sheikh | DATE Mar, 2021 | SCALE AS SHOWN | DWG No: AFS- MIS - 438 | REVISIONS |

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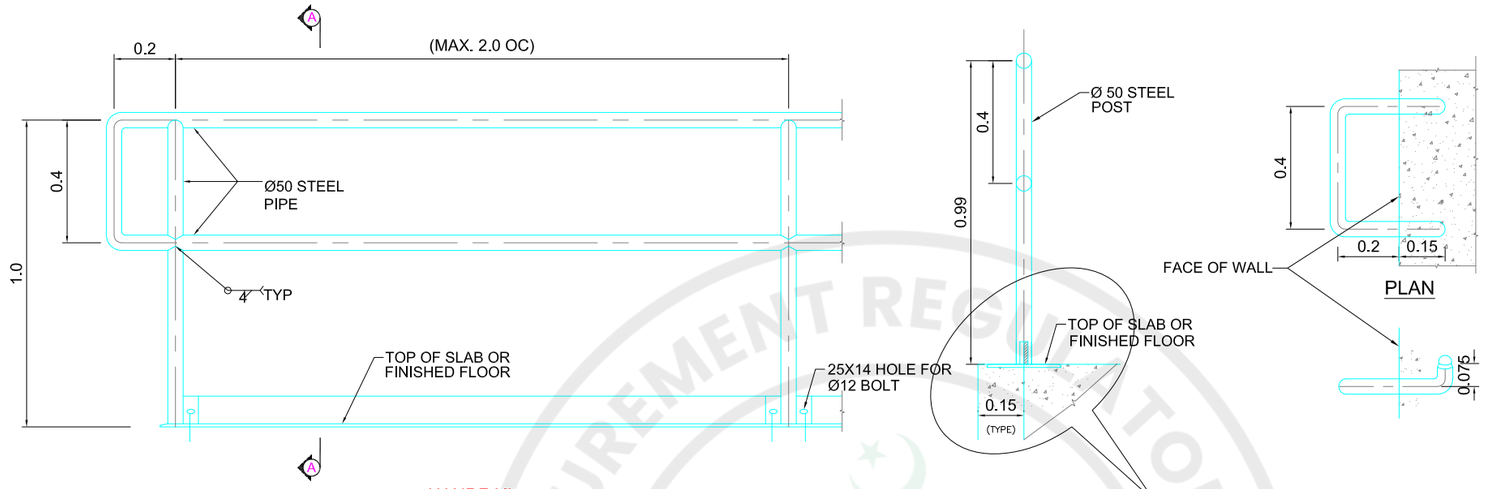



HANDRAIL
(FLOOR MOUNTED)




SECTION A - A

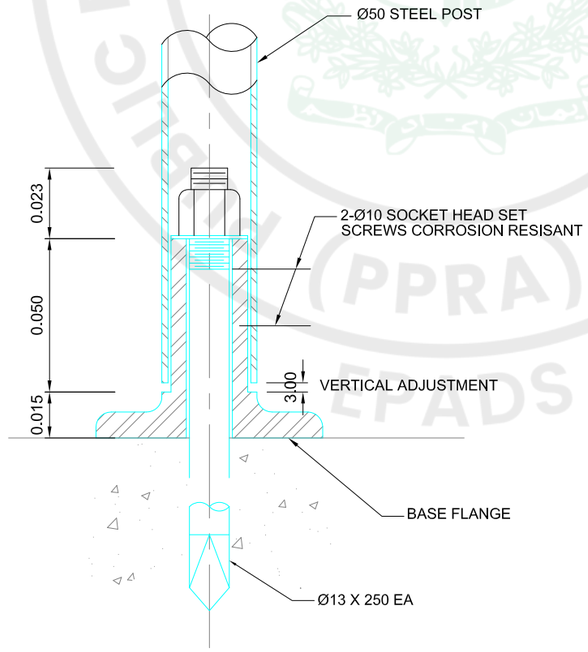
DETAIL - E




EMBEDDED RUNGS

## NOTES

1. ALL DIMENSIONS ARE IN METERS




DETAIL 'E'

| | | | | | |
|---|---|---|---|---|---|
| PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | | | | | |
| PREPARED<br>Zafar | PROJECT | ATTABAD LAKE HYDRO POWER PROJECT | | | |
| DRAWN<br>Zafar | TITLE | **MISCELLANEOUS REINFORCEMENT DETAILS (SHEET 2 OF 2)** | | | |
| CHECKED<br>Abid Sheikh | | | | | |
| APPROVED<br>Abid Sheikh | DATE<br>Mar, 2021 | SCALE<br>N.T.S | DWG No:<br>AFS-MIS - 439 | REVISIONS | |

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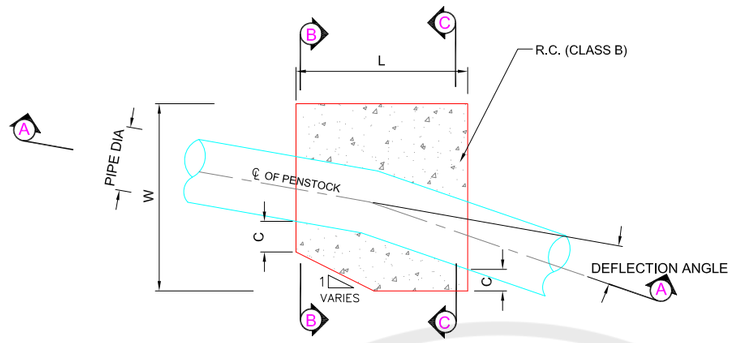
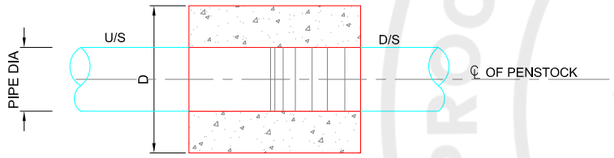
## NOTES

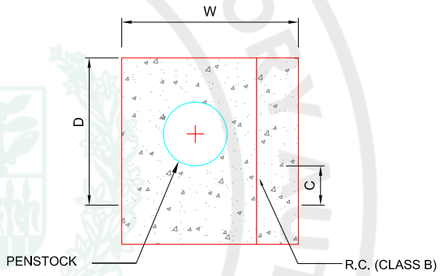
1. ALL DIMENSIONS ARE IN METERS.
2. ALL LEVELS ARE IN METER. (MASL)



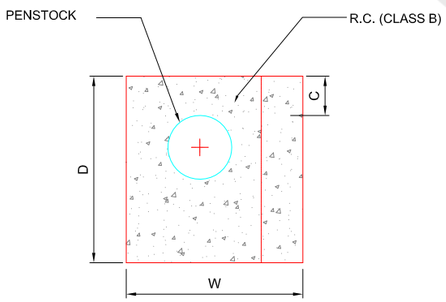

PLAN OF ANCHOR BLOCK
FOR HORIZONTAL BENDS



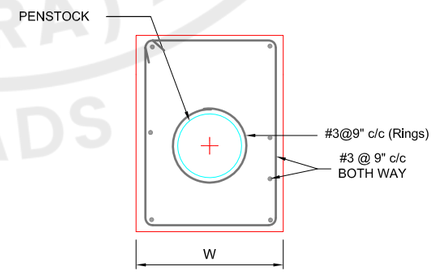

SECTION A - A
BURRIED PIPE




SECTION B - B




SECTION C - C




SECTION C - C
TYPICAL REINFORCEMENT

| | | | | |
|---|---|---|---|---|
| PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | | | | |
| PREPARED<br>Zafar | PROJECT | ATTABAD LAKE HYDRO POWER PROJECT | | |
| DRAWN<br>Zafar | TITLE | PENSTOCK DETAIL OF HORIZONTAL ANCHOR BLOCKS | | |
| CHECKED<br>Abid Sheikh | | | | |
| APPROVED<br>Abid Sheikh | DATE<br>Mar, 2021 | SCALE<br>N.T.S | DWG No:<br>AFS- MIS - 440 | REVISIONS |

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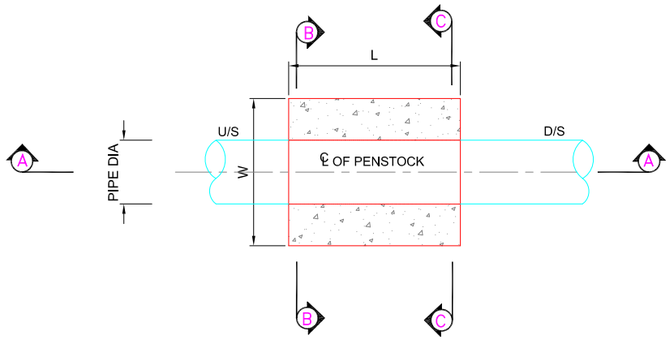
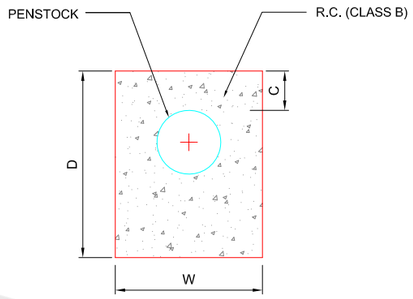


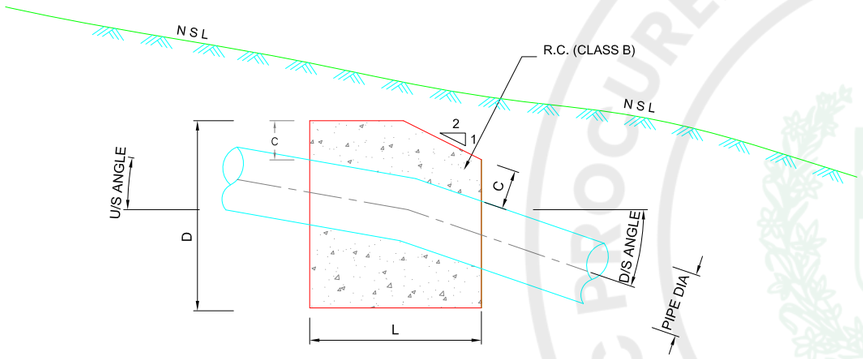

PLAN OF ANCHOR BLOCK
FOR VERTICAL BENDS



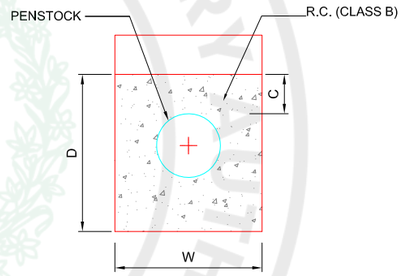

SECTION B - B

## NOTES

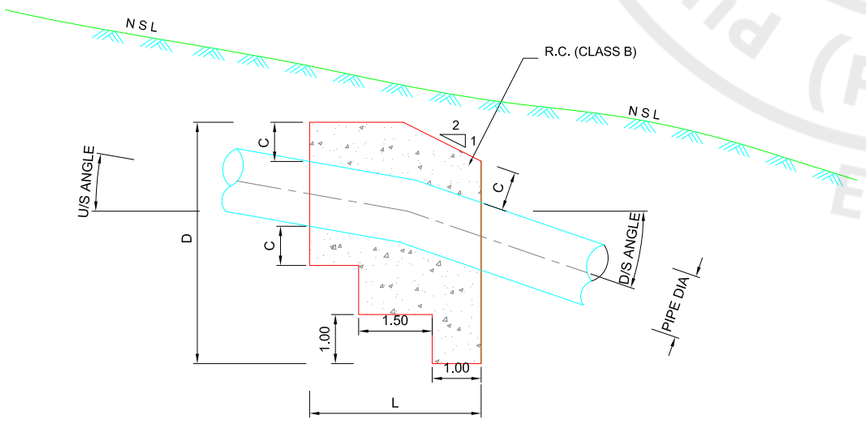
1. ALL DIMENSIONS ARE IN METERS.
2. ALL LEVELS ARE IN METER. (MASL)



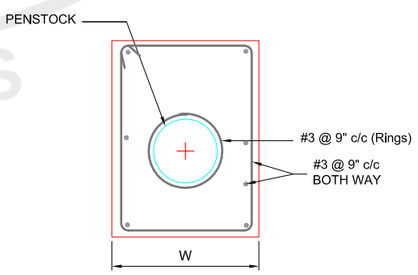

SECTION A - A
BURRIED PIPE
(FOR D/S ANGLE <25°)




SECTION C - C




SECTION A - A
BURRIED PIPE
(FOR D/S ANGLE >25°)




SECTION C - C
TYPICAL REINFORCEMENT

| | | | | | |
|---|---|---|---|---|---|
| PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | | | | | |
| PREPARED<br>Zafar | PROJECT | ATTABAD LAKE HYDRO POWER PROJECT | | | |
| DRAWN<br>Zafar | TITLE | PENSTOCK DETAIL OF VERTICAL ANCHOR BLOCKS | | | |
| CHECKED<br>Abid Sheikh | | | | | |
| APPROVED<br>Abid Sheikh | DATE<br>Mar, 2021 | SCALE<br>N.T.S | DWG No:<br>AFS- MIS - 441 | REVISIONS | |

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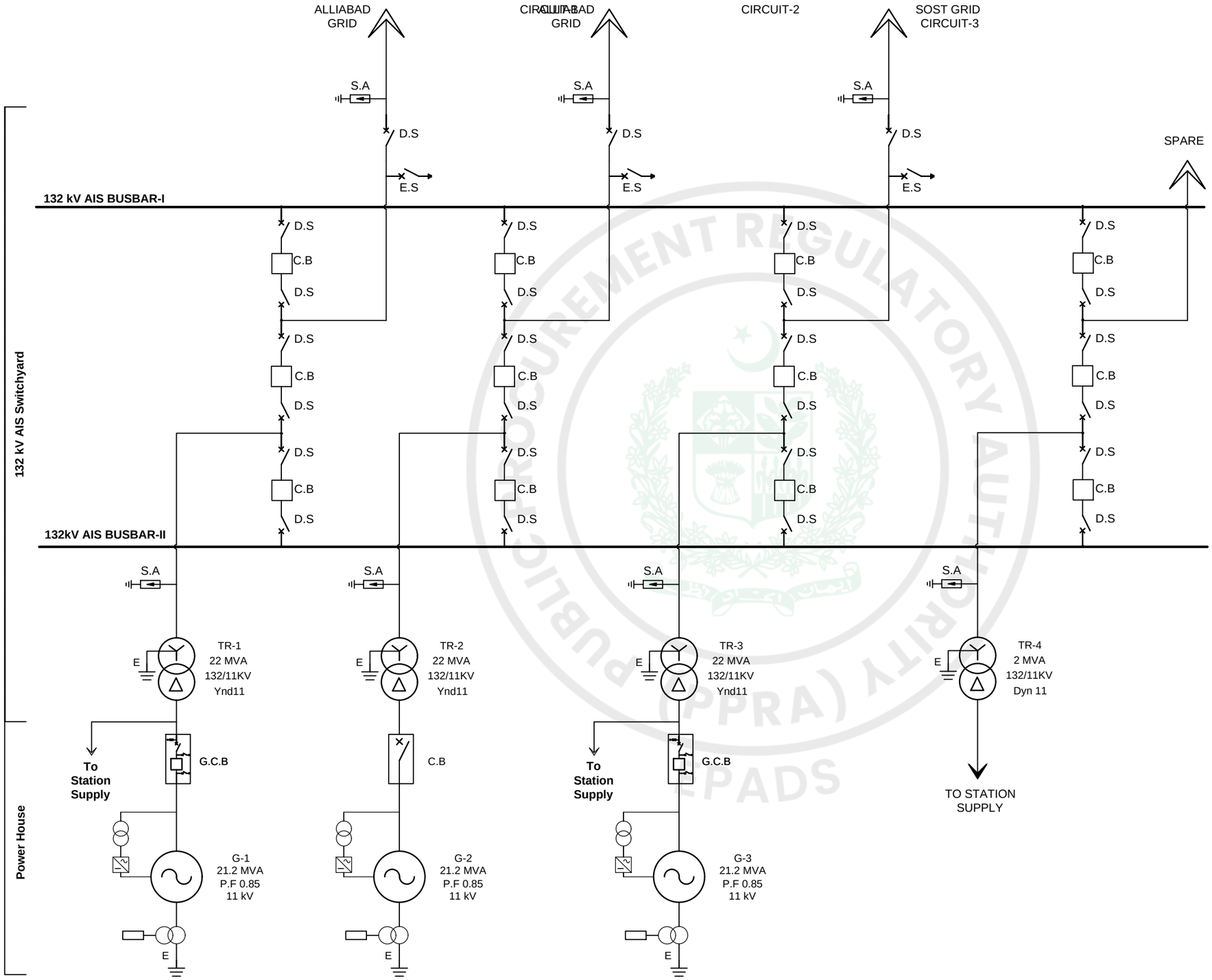



| LEGEND: | |
|---|---|
| SYMBOL | DESCRIPTION |
| | 3~ GENERATOR |
| | 132 kV CIRCUIT BREAKER |
| | TRANSFORMER |
| | TRANSMISSION LINE |
| | SURGE ARRESTER |
| | EARTH/GROUND |
| | NEUTRAL GROUND RESISTOR |
| | EARTHING SWITCH |
| | DISCONNECTOR SWITCH |
| | 11 kV GENERATOR C.B |

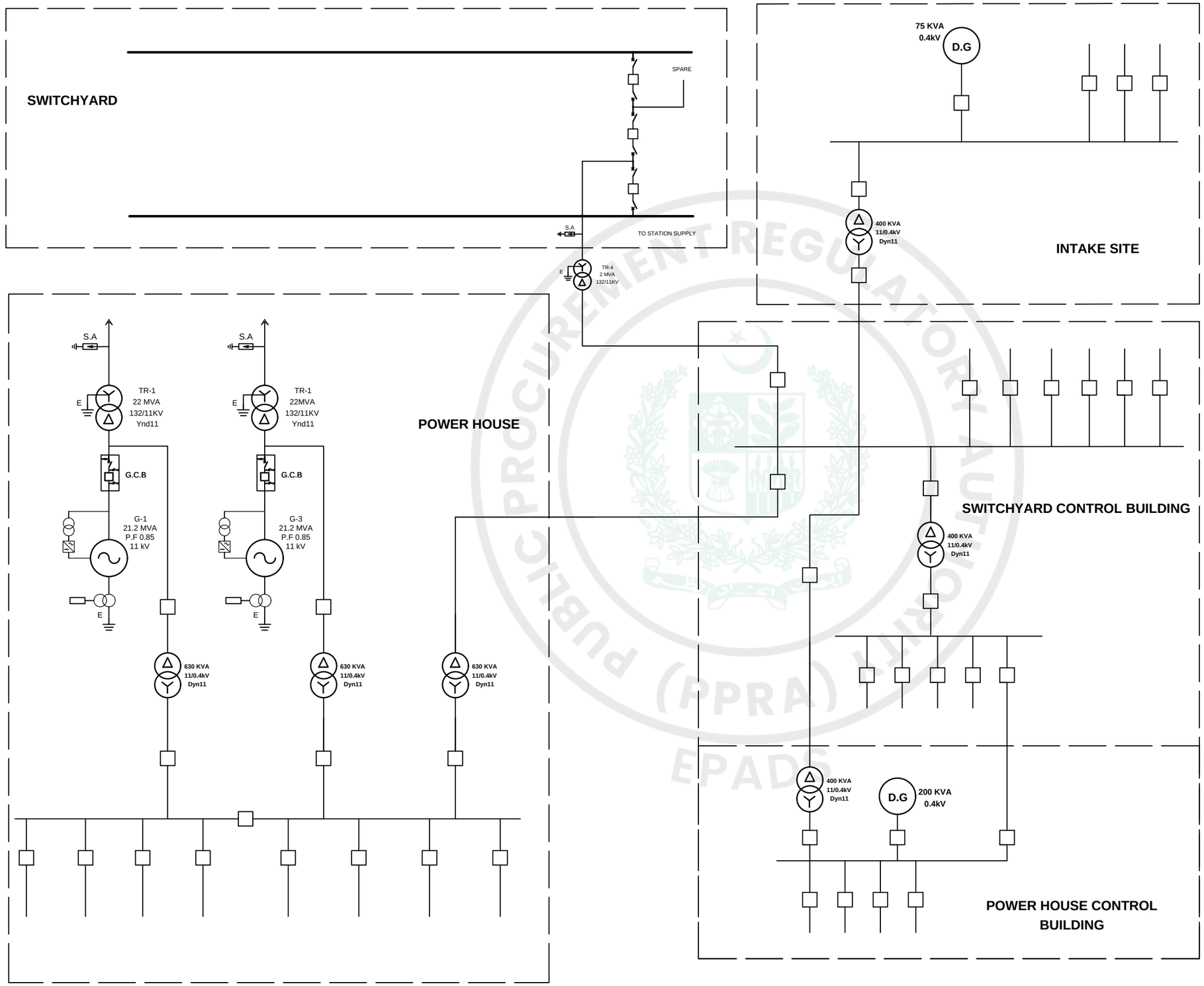
NOTE:

- DRAWING SHOWS THE BASIC CONCEPT OF ELECTRICAL SYSTEM. FINAL DESIGN SHALL BE DEVELOPED BY ENGINEER/CONTRACTOR DURING FINAL DESIGN STAGE.
- FINAL RATINGS OF VARIOUS EQUIPMENT SHALL BE DETERMINED ON DETAILED DESIGN STAGE.

**PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY**
HYDRO PLANNING ORGANIZATION

| | | | | |
|---|---|---|---|---|
| PREPARED: Bilal Nawaz | PROJECT | **ATTABAD LAKE HPP FEASIBILITY STUDY REPORT** | | |
| DRAWN: M.Saad | TITLE | **MAIN SINGLE LINE DIAGRAM** | | |
| CHECKED: Faiz Rasool | | | | |
| APPROVED | DATE: Jun: 2021 | SCALE: NTS | DWG No: ASF-EM-451 | REVISIONS |

PROCUREMENT REGULATORY AUTHORITY (PPRA) PUBLIC EPADS




| LEGEND: | |
|---|---|
| SYMBOL | DESCRIPTION |
| | MV CIRCUIT BREAKER |
| | LV CIRCUIT BREAKER |
| | TRANSFORMER |
| D.G | DIESEL GENERATOR |
| N.C | NORMALLY CLOSE |
| N.O | NORMALLY OPEN |

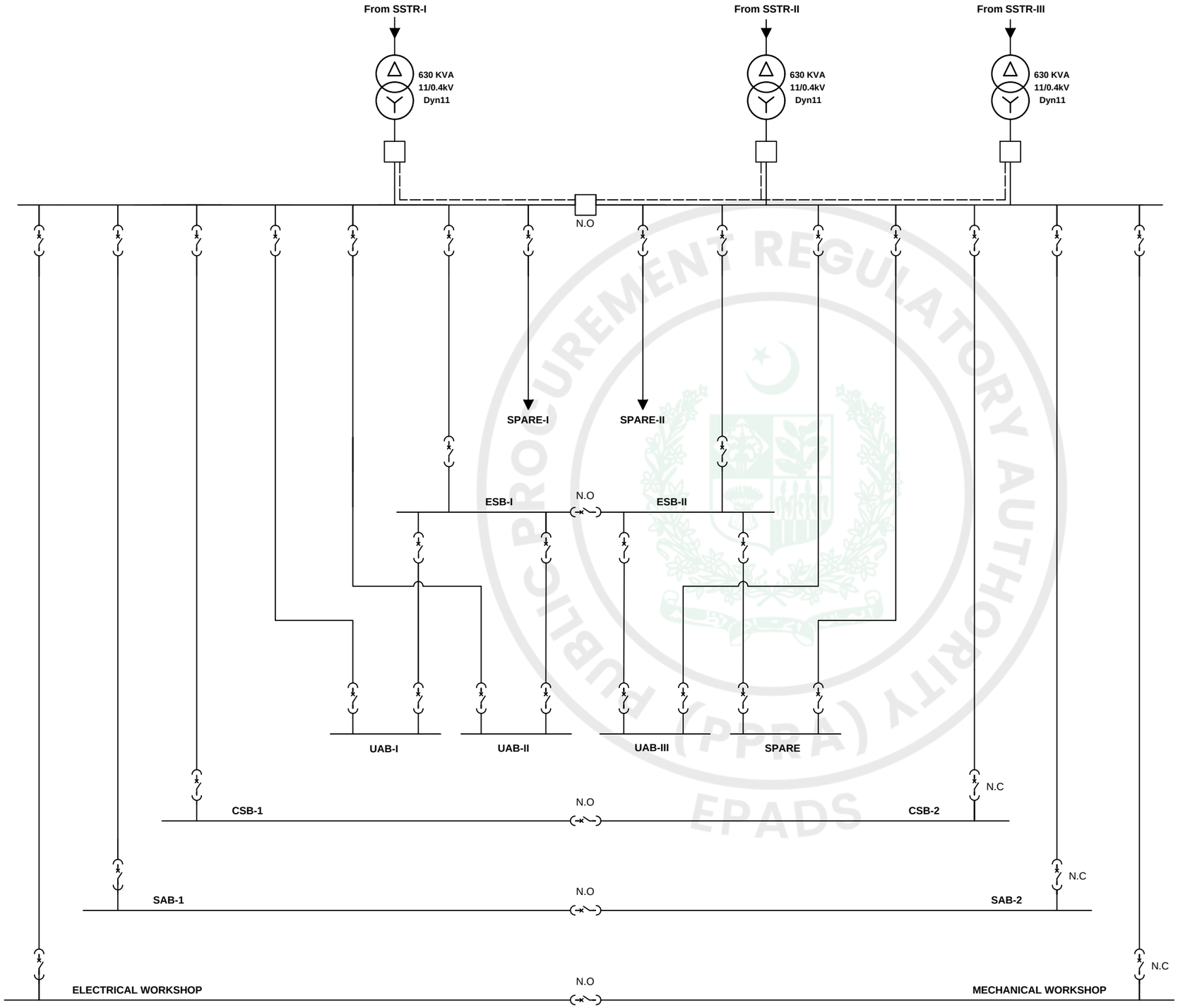
NOTES:

- DRAWING SHOWS THE BASIC CONCEPT OF ELECTRICAL SYSTEM. FINAL DESIGN SHALL BE DEVELOPED BY ENGINEER/CONTRACTOR DURING FINAL DESIGN STAGE.
- FINAL RATINGS OF VARIOUS EQUIPMENT SHALL BE DETERMINED ON DETAILED DESIGN STAGE.
- THE NUMBER OF 11 kV & 400V SUPPLY SHALL BE DETERMINED BY THE ENGINEER/CONTRACTOR BASED ON THE AUXILIARY LOAD OF THE PLANT.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | | | | |
|---|---|---|---|---|---|
| PREPARED: Bilal Nawaz | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT | | | |
| DRAWN: M.Saad | TITLE | AC SUPPLY SYSTEM | | | |
| CHECKED: Faiz Rasool | | | | | |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: NTS | DWG No: ASF-EM-452 | REVISIONS | |

PROCUREMENT REGULATORY AUTHORITY PUBLIC PPRA EPADS




| LEGEND: | |
|---|---|
| SYMBOL | DESCRIPTION |
| □ ■ | MV CIRCUIT BREAKER |
| | LV CIRCUIT BREAKER |
| | TRANSFORMER |
| D.G | DIESEL GENERATOR |
| N.C | NORMALLY CLOSE |
| N.O | NORMALLY OPEN |

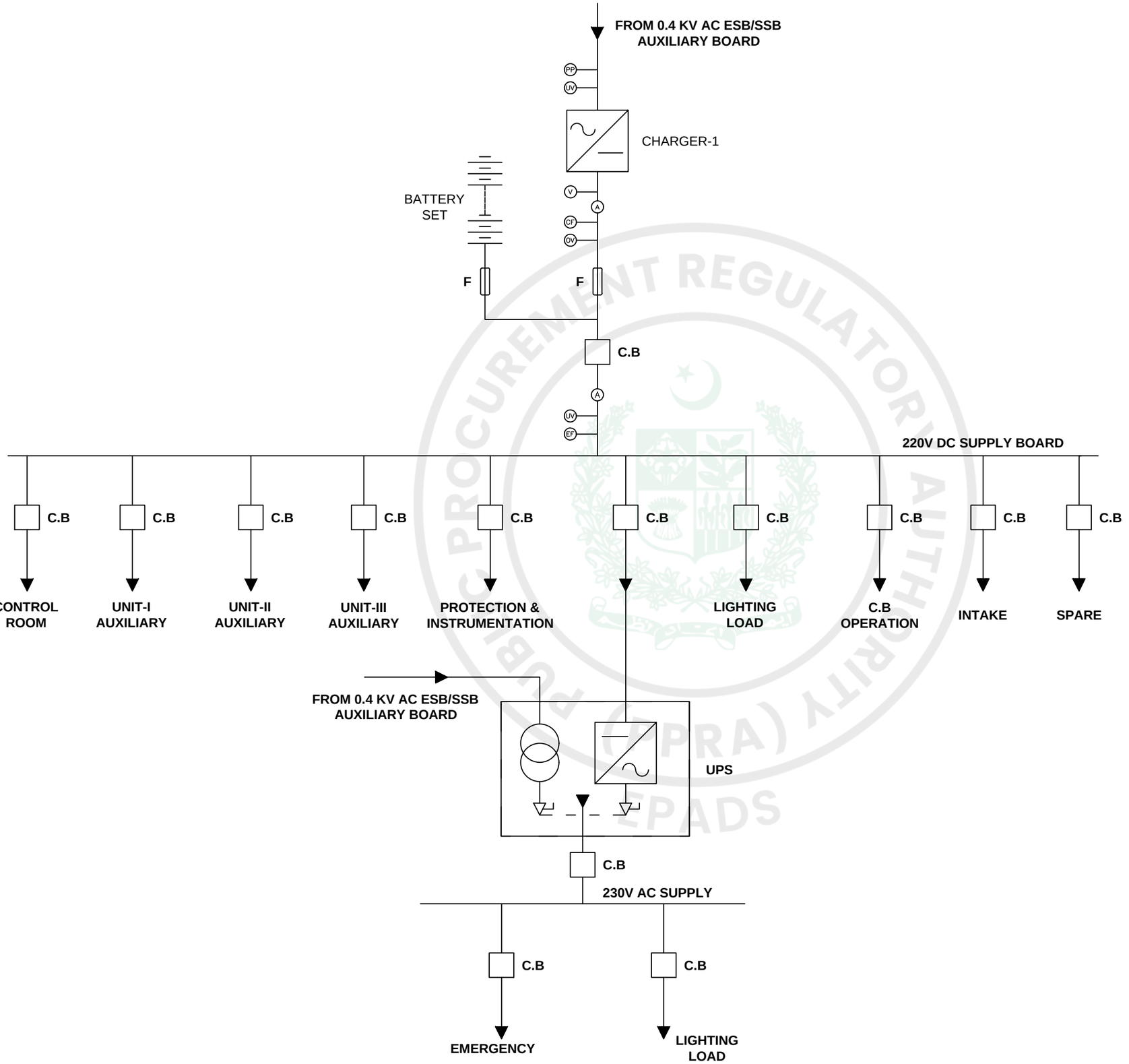
NOTES:

- DRAWING SHOWS THE BASIC CONCEPT OF ELECTRICAL SYSTEM. FINAL DESIGN SHALL BE DEVELOPED BY ENGINEER/CONTRACTOR DURING FINAL DESIGN STAGE.
- FINAL RATINGS OF VARIOUS EQUIPMENT SHALL BE DETERMINED ON DETAILED DESIGN STAGE.
- THE NUMBER OF 400V SUPPLY SHALL BE DETERMINED BY THE ENGINEER/CONTRACTOR BASED ON THE AUXILIARY LOAD OF THE PLANT.

**PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY**
HYDRO PLANNING ORGANIZATION

| | | | | |
|---|---|---|---|---|
| PREPARED: Bilal Nawaz | PROJECT | **ATTABAD LAKE HPP FEASIBILITY STUDY REPORT** | | |
| DRAWN: M.Saad | TITLE | **AC LV SUPPLY SYSTEM** | | |
| CHECKED: Faiz Rasool | | | | |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: NTS | DWG No: ASF-EM-453 | REVISIONS |

PROCUREMENT REGULATORY AUTHORITY (PPRA) PUBLIC EPADS




| LEGEND: | |
|---|---|
| SYMBOL | DESCRIPTION |
| | AC/DC INVERTER |
| | UPS |
| | L.V BREAKER |
| | FUSE |
| | BATTERY |
| EF | EARTH FAULT RELAY |
| PP | PHASE FAILURE RELAY |
| UV | UNDER VOLTAGE RELAY |
| V | VOLTMETER |
| A | AMMETER |
| CF | CHARGER FAILURE RELAY |
| OV | OVER VOLTAGE RELAY |
| | Manual Bypass Switch |

NOTES:

- DRAWING SHOWS THE BASIC CONCEPT OF ELECTRICAL SYSTEM. FINAL DESIGN SHALL BE DEVELOPED BY ENGINEER/CONTRACTOR DURING FINAL DESIGN STAGE.
- FINAL RATINGS OF VARIOUS EQUIPMENT SHALL BE DETERMINED ON DETAILED DESIGN STAGE.
- THE QUANTITY OF EQUIPMENT SHALL BE DETERMINED BY ENGINEER/ CONTRACTOR TO MEET THE PLANT DC LOAD.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Bilal Nawaz | PROJECT | ATTABAD LAKE HPP<br>FEASIBILITY STUDY REPORT |
| DRAWN: M.Saad | TITLE | DC SUPPLY SYSTEM |
| CHECKED: Faiz Rasool | | |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: NTS |
| | DWG No: ASF-EM-454 | REVISIONS |

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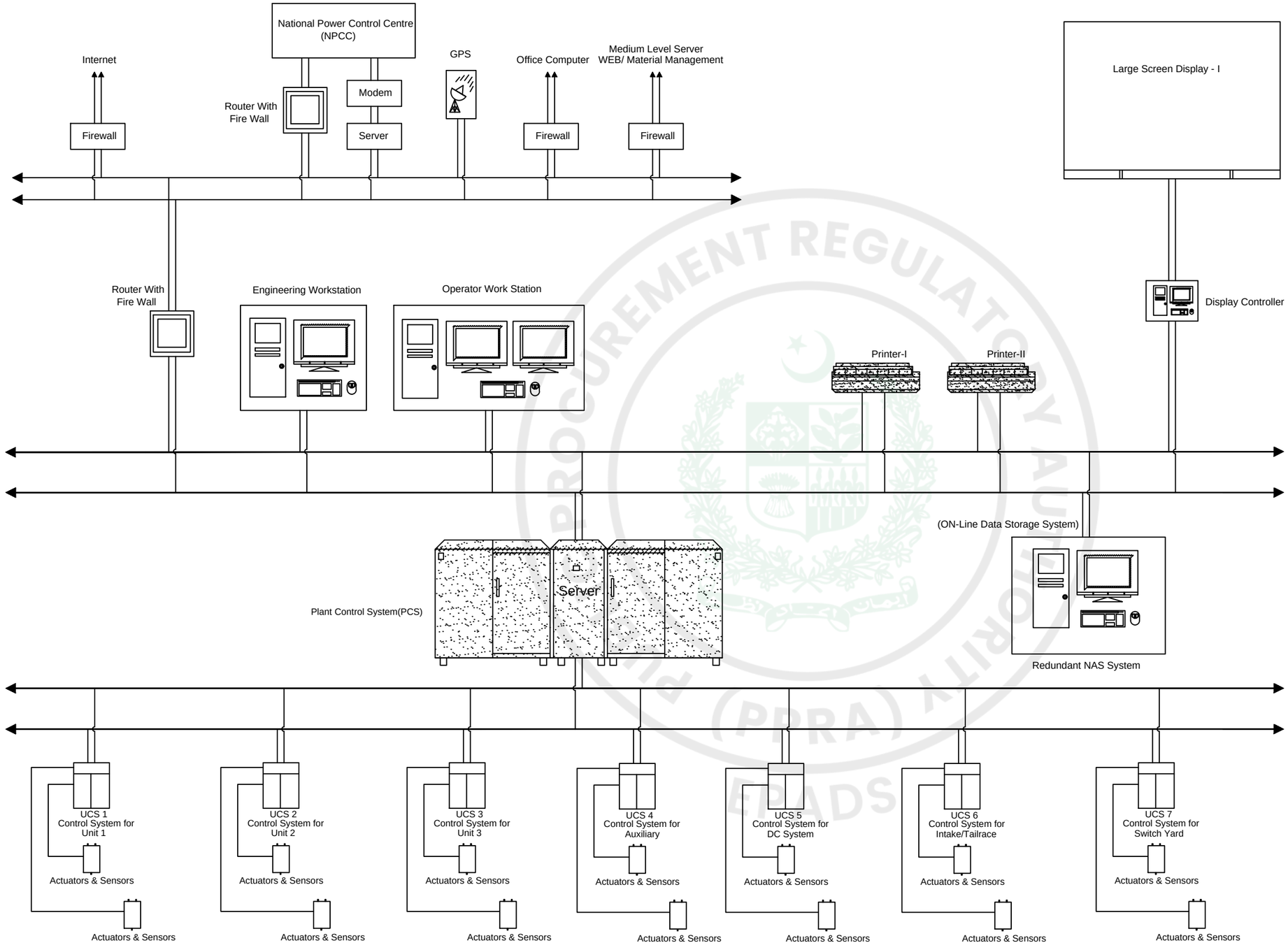


NOTES:

- DRAWING SHOWS THE BASIC CONCEPT OF ELECTRICAL PROTECTION SYSTEM. FINAL DESIGN & EQUIPMENT SHALL BE DETERMINED BY ENGINEER/ CONTRACTOR DURING FINAL DESIGN STAGE.

**PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY**
HYDRO PLANNING ORGANIZATION

| | | | | | |
|---|---|---|---|---|---|
| PREPARED: Bilal Nawaz | PROJECT | **ATTABAD LAKE HPP FEASIBILITY STUDY REPORT** | | | |
| DRAWN: M.Saad | TITLE | **PLANT CONTROL SYSTEM** | | | |
| CHECKED: Faiz Rasool | | | | | |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: NTS | DWG No: ASF-EM-455 | REVISIONS | |

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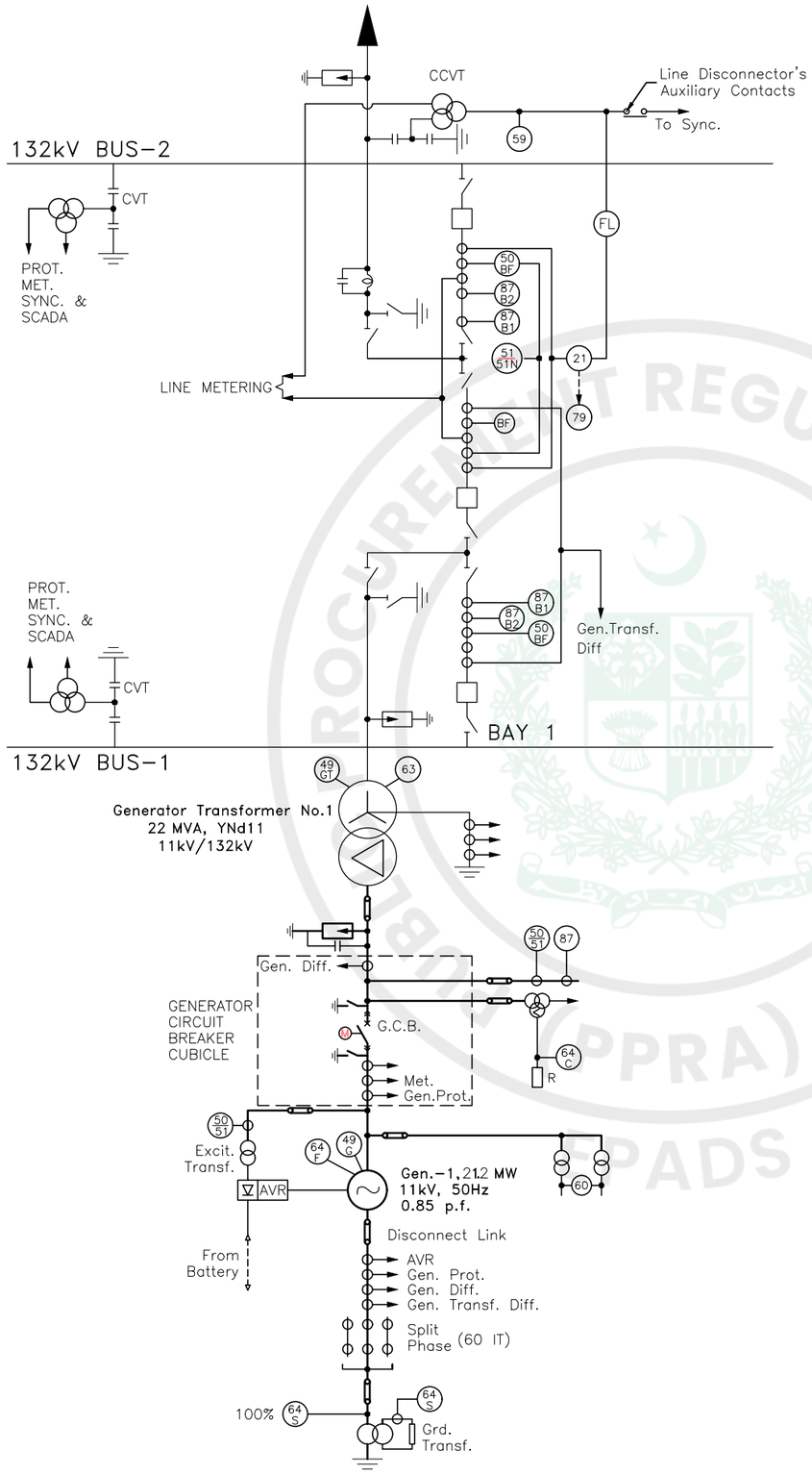


NOTES:

- DRAWING SHOWS THE BASIC CONCEPT OF ELECTRICAL PROTECTION SYSTEM. FINAL PROTECTION DESIGN EQUIPMENT RATINGS SHALL BE DETERMINED BY ENGINEER/ CONTRACTOR DURING FINAL DESIGN STAGE.

**PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY**
HYDRO PLANNING ORGANIZATION

| | | | | |
|---|---|---|---|---|
| PREPARED: Bilal Nawaz | PROJECT | **ATTABAD LAKE HPP FEASIBILITY STUDY REPORT** | | |
| DRAWN: M.Saad | TITLE | **PROTECTION SCHEMES** | | |
| CHECKED: Faiz Rasool | | | | |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: NTS | DWG No: ASF-EM-456 | REVISIONS |

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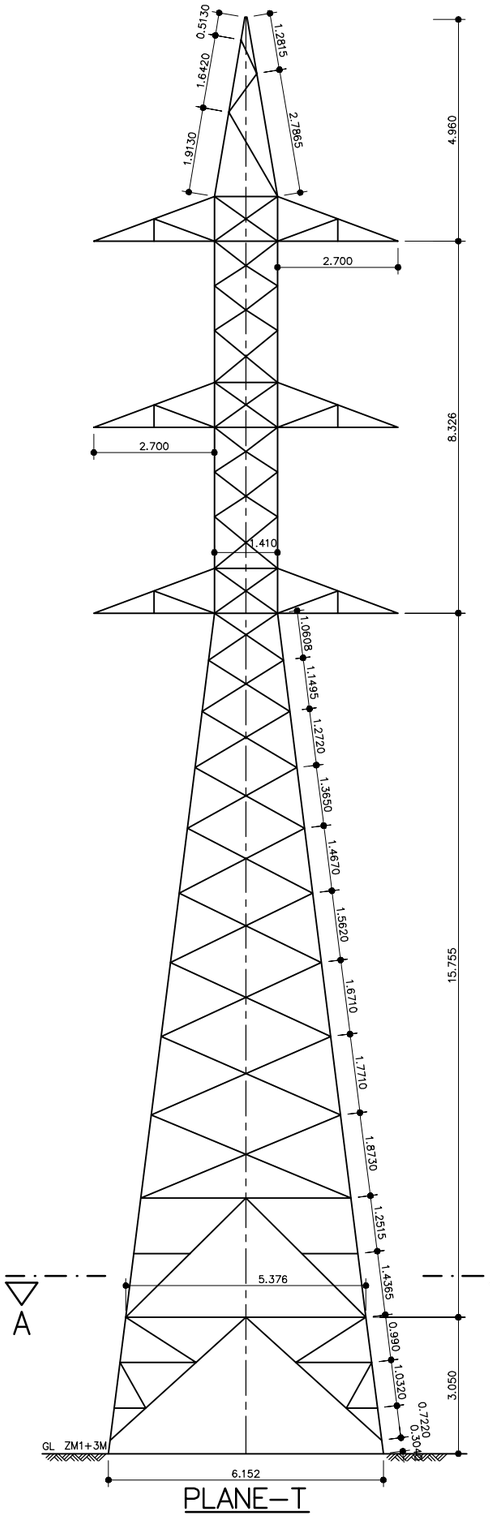
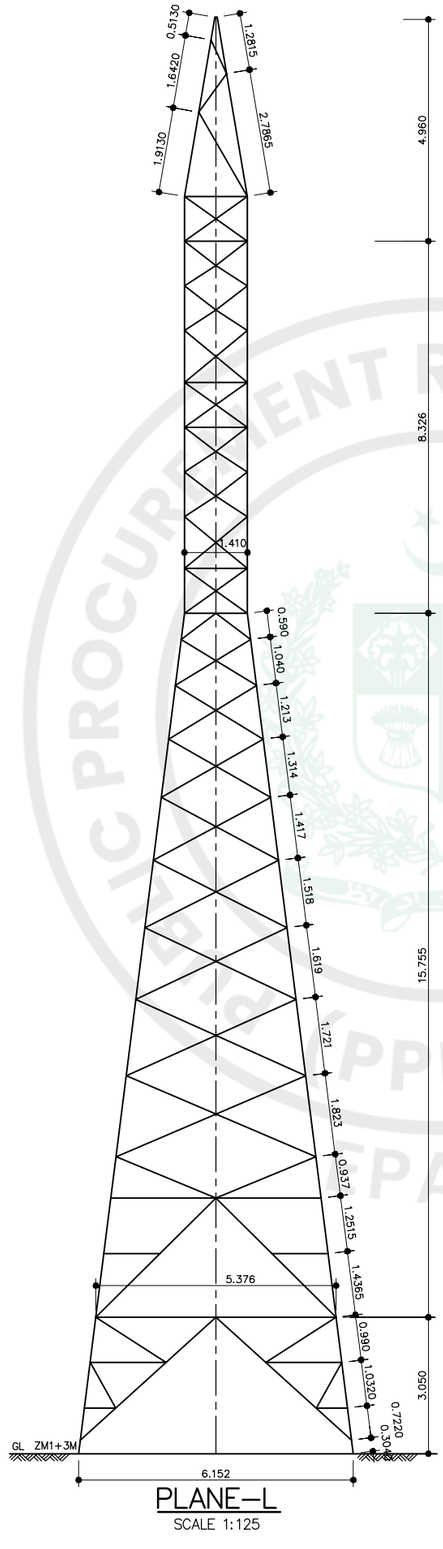
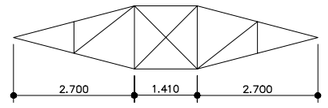



PLANE–T

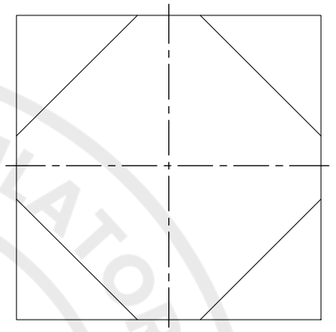



PLANE–L

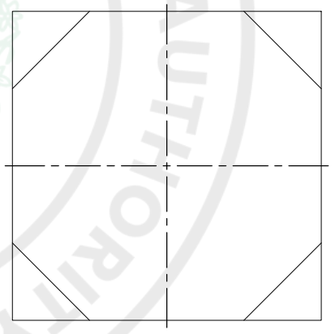
SCALE 1:125



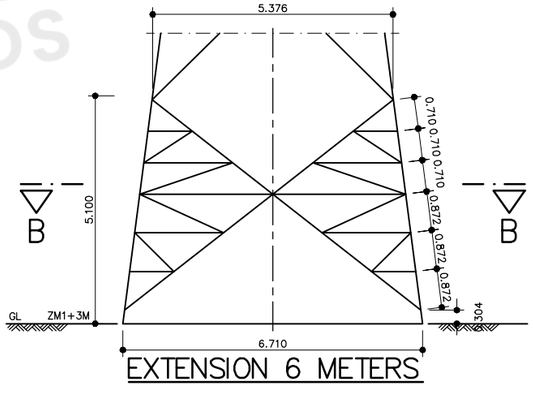

CROSS ARM



SECTION A–A



SECTION B–B




EXTENSION 6 METERS

NOTES:

- FINAL TOWER DESIGN SHALL BE DETERMINED BY ENGINEER/ CONTRACTOR DURING FINAL DESIGN STAGE.
- ALL LENGTHS IN METER.

| | | | | |
|---|---|---|---|---|
| PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | | | | |
| PREPARED<br>Bilal Nawaz | PROJECT | **ATTABAD LAKE HPP**<br>**FEASIBILITY STUDY REPORT** | | |
| DRAWN<br>M.Saad | TITLE | **132kV-TRANSMISSION LINE**<br>**TYPE-ZM 1** | | |
| CHECKED<br>Faiz Rasool | | | | |
| APPROVED<br>Abid Sheikh | DATE<br>Jun: 2021 | SCALE<br>NTS | DWG No:<br>ASF-EM-457 | REVISIONS |

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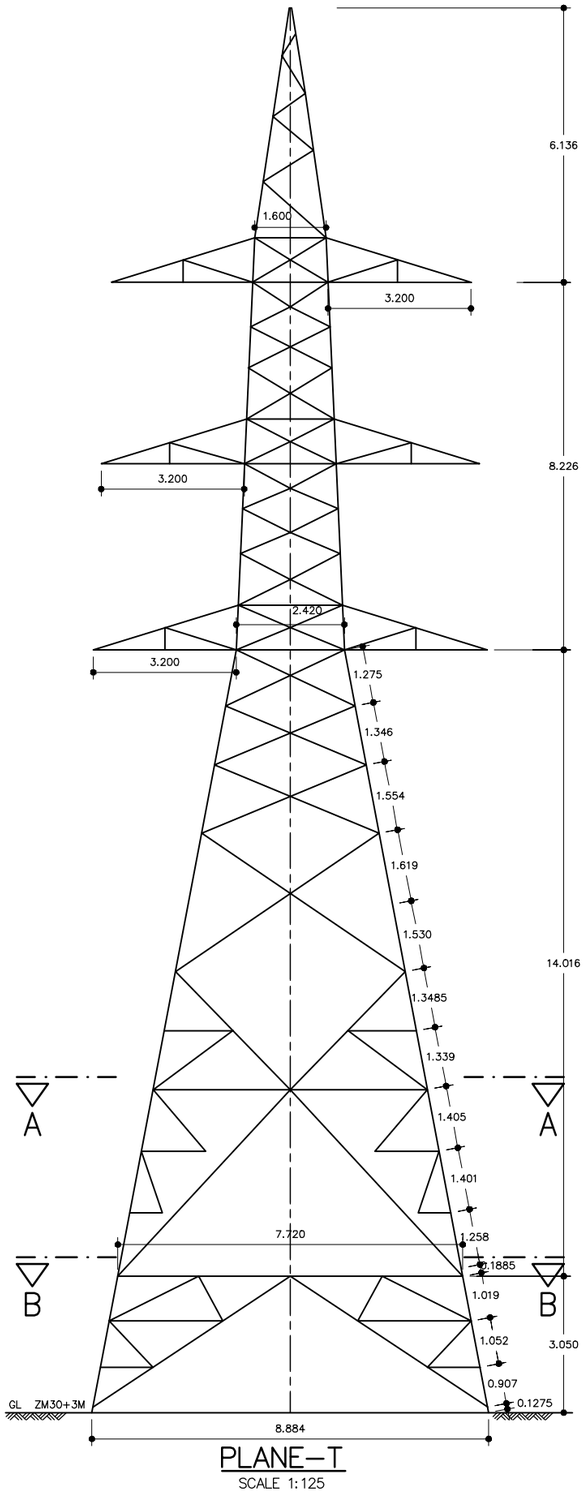
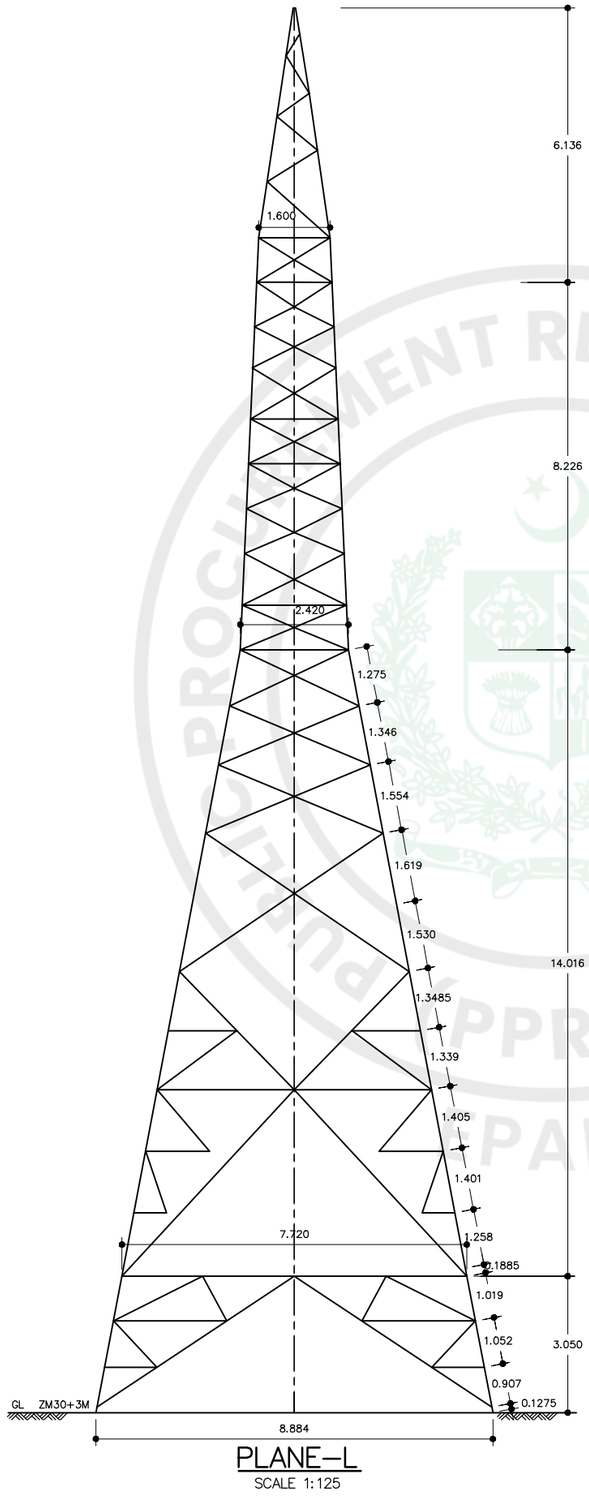
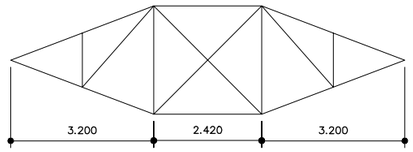


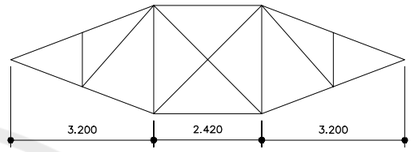

PLANE–T
SCALE 1:125



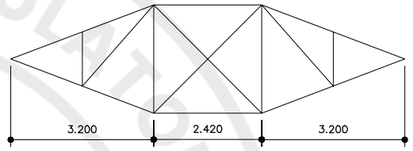

PLANE–L
SCALE 1:125




UPPER CROSS ARM
SCALE 1:125

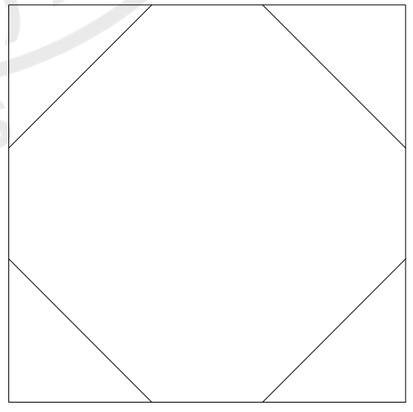



MIDDLE CROSS ARM
SCALE 1:125




LOWER CROSS ARM
SCALE 1:125

SECTION A–A
SCALE 1:125



SECTION B–B
SCALE 1:125

NOTES:
- FINAL TOWER DESIGN SHALL BE DETERMINED BY ENGINEER/ CONTRACTOR DURING FINAL DESIGN STAGE.
- All LENGTHS IN METER.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | | | | |
|---|---|---|---|---|---|
| PREPARED Bilal Nawaz | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT | | | |
| DRAWN M.Saad | TITLE | 132kV-TRANSMISSION LINE TYPE-ZM 30 | | | |
| CHECKED Faiz Rasool | | | | | |
| APPROVED Abid Sheikh | DATE Jun: 2021 | SCALE NTS | DWG No: ASF-EM-458 | REVISIONS | |

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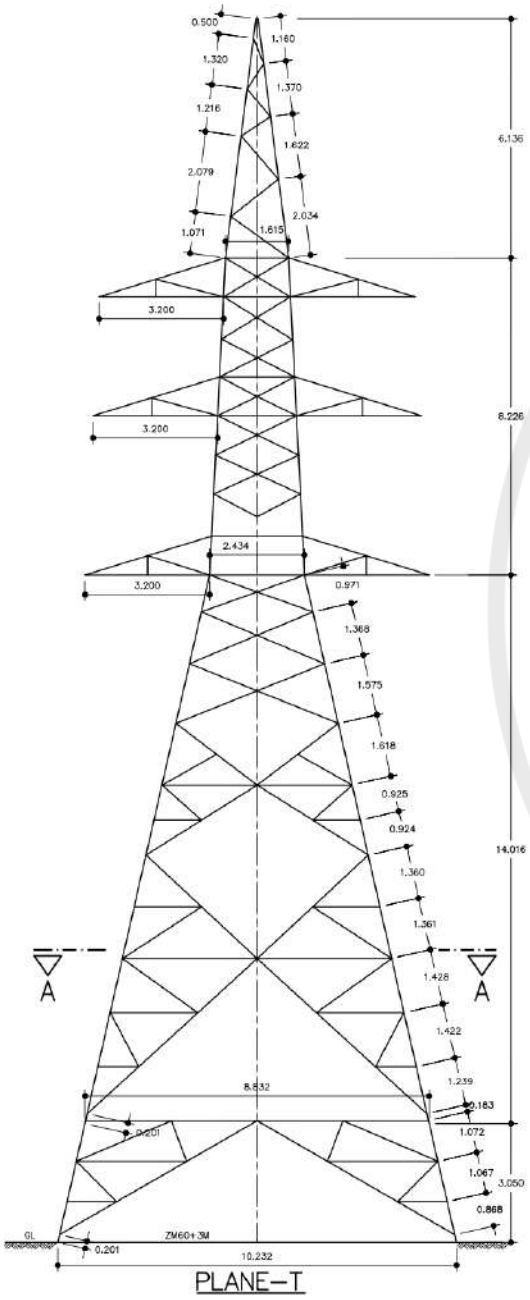


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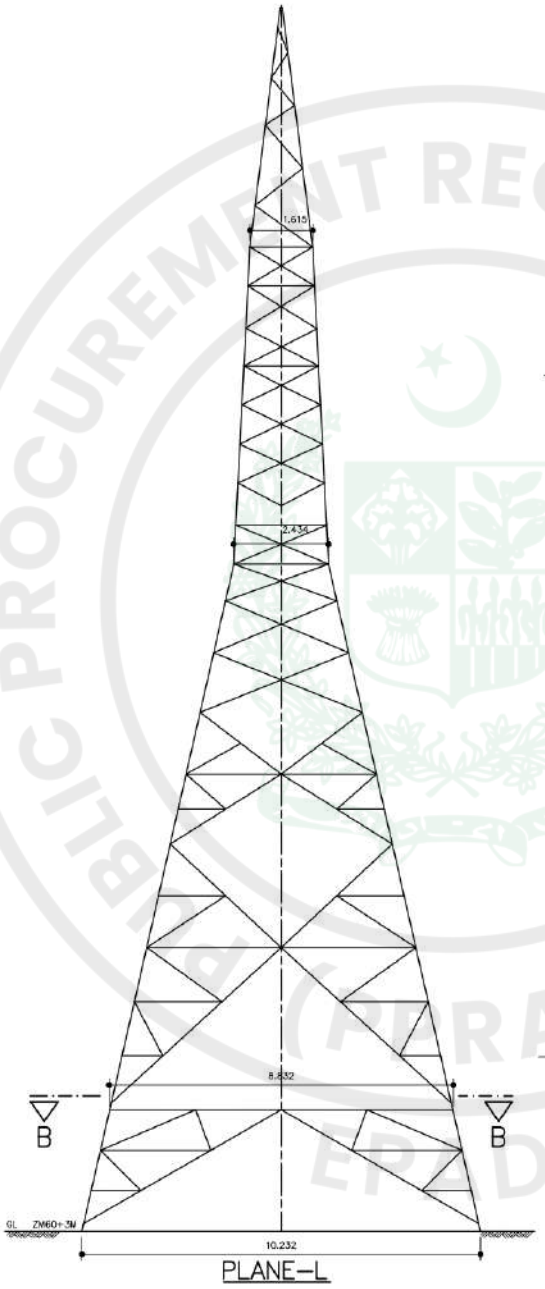


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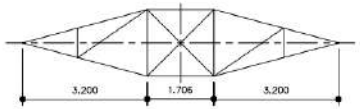
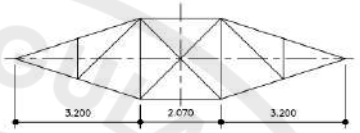
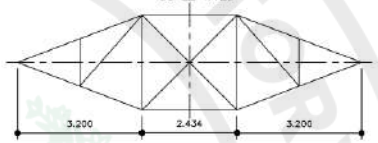


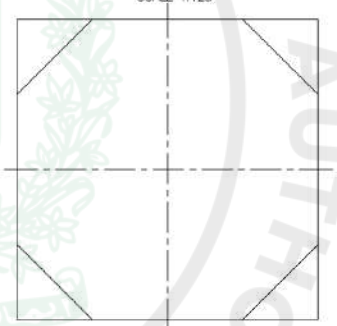

UPPER CROSS ARM
SCALE 1:125



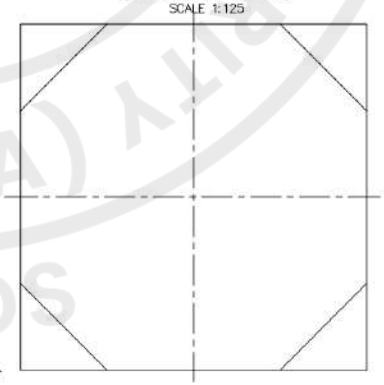

MIDDLE CROSS ARM
SCALE 1:125




LOWER CROSS ARM
SCALE 1:125



SECTION A–A
SCALE 1:125



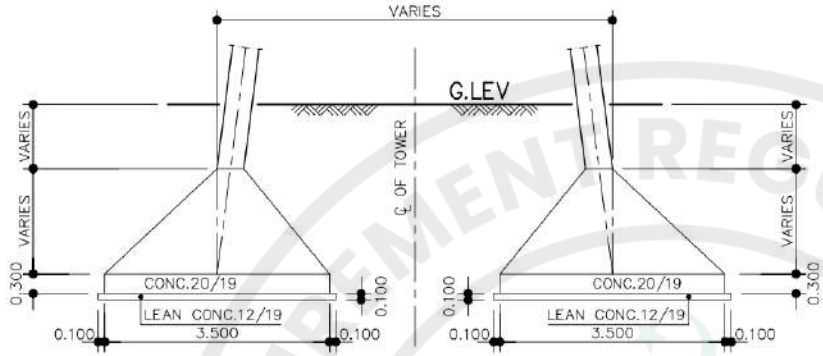
SECTION B–B
SCALE 1:125

NOTES:
- FINAL TOWER DESIGN SHALL BE DETERMINED BY ENGINEER/ CONTRACTOR DURING FINAL DESIGN STAGE.
- All LENGTHS IN METER.

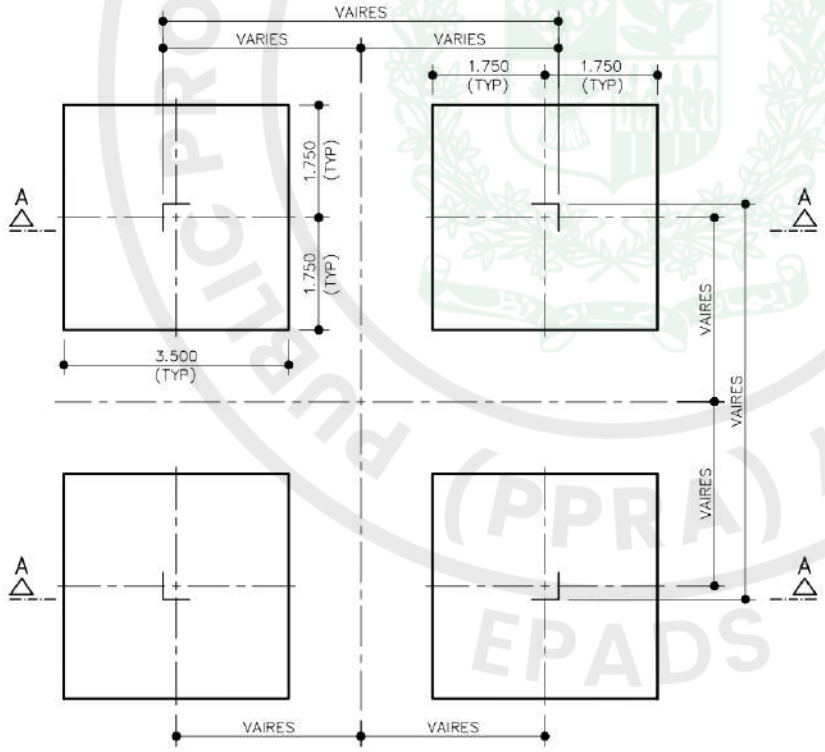
PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Bilal Nawaz | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN: M.Saad | TITLE | 132kV-TRANSMISSION LINE TYPE-ZM 60 |
| CHECKED: Faiz Rasool | | |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: NTS |
| | DWG No: ASF-EM-459 | REVISIONS |

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS




SECTION A–A

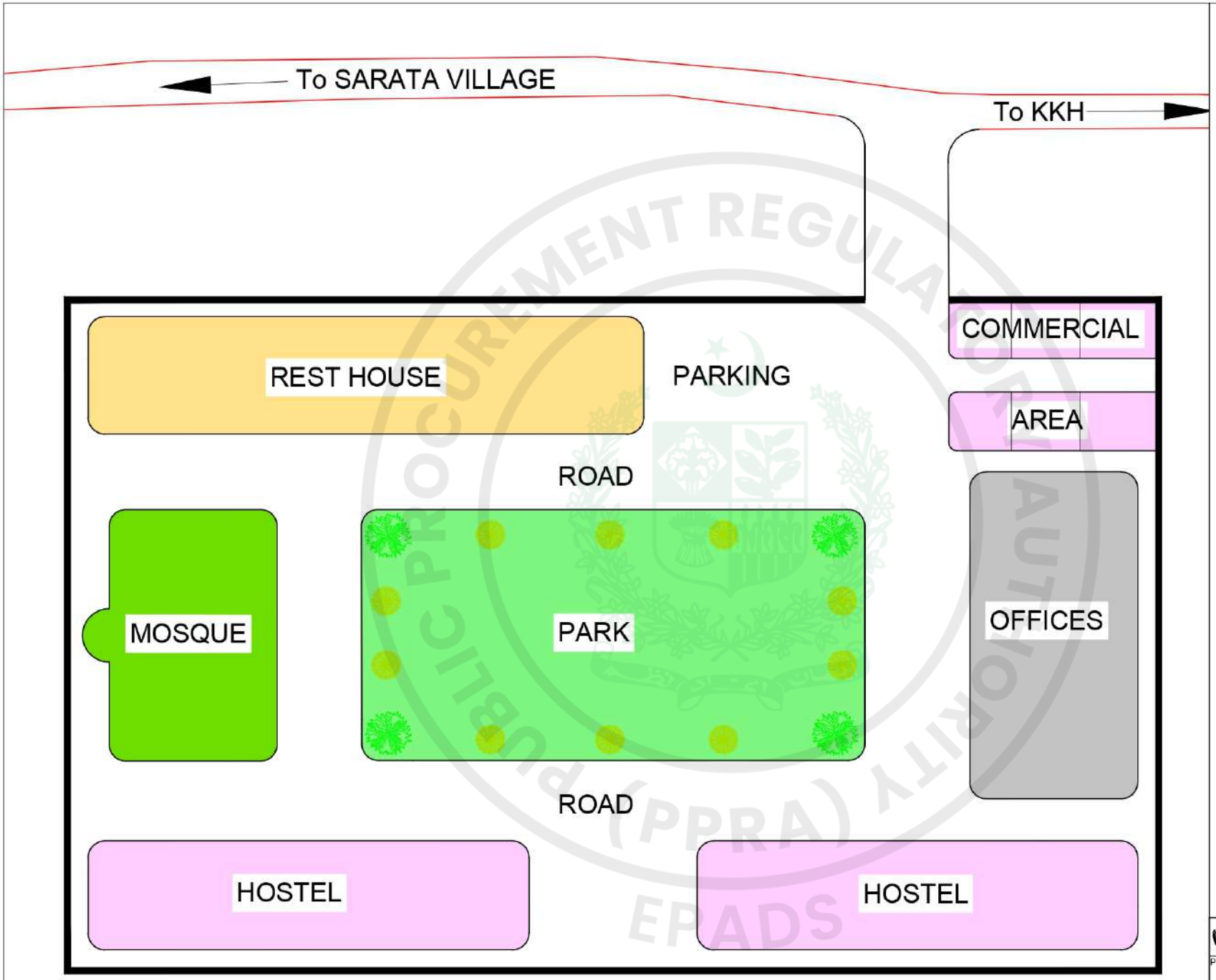



TYPICAL FOUNDATION PLAN

NOTES:
- FINAL DESIGN SHALL BE DETERMINED BY ENGINEER/ CONTRACTOR DURING FINAL DESIGN STAGE.
- All LENGTHS IN METER.

| | | | | |
|---|---|---|---|---|
| | PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | | | |
| PREPARED<br>Bilal Nawaz | PROJECT | ATTABAD LAKE HPP<br>FEASIBILITY STUDY REPORT | | |
| DRAWN<br>M.Saad | TITLE | TYPICAL TOWER FOUNDATION | | |
| CHECKED<br>Faiz Rasool | | | | |
| APPROVED<br>Abid Sheikh | DATE<br>Jun: 2021 | SCALE<br>NTS | DWG No:<br>ASF-EM-460 | REVISIONS |

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS




NOTE.
1. ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED
2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FILED OBSERVATIONS.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Ismail | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE | OFFICES AND RESIDENTIAL COMPLEX MASTER PLAN |
| CHECKED: Zahid | | |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 2,000 |
| | DWG No.: AFS-ORG-471 | REVISIONS |

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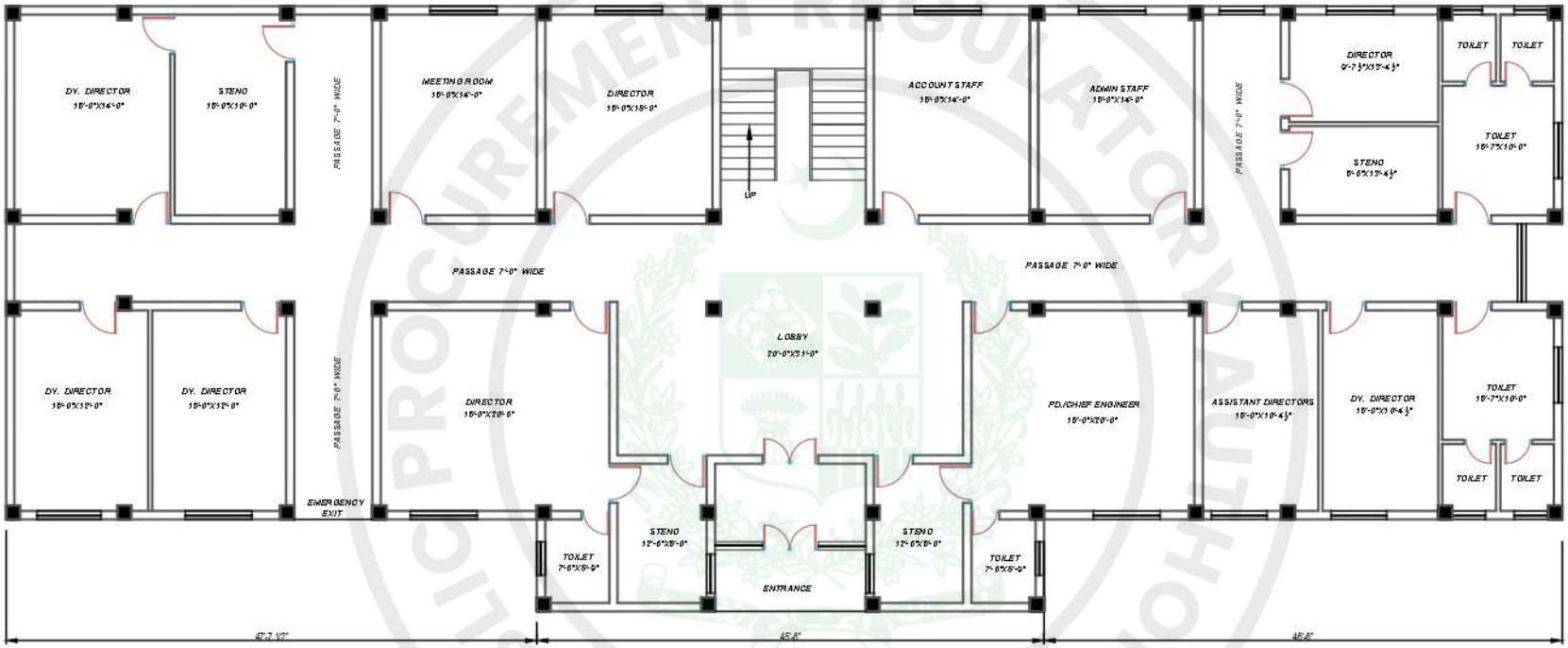
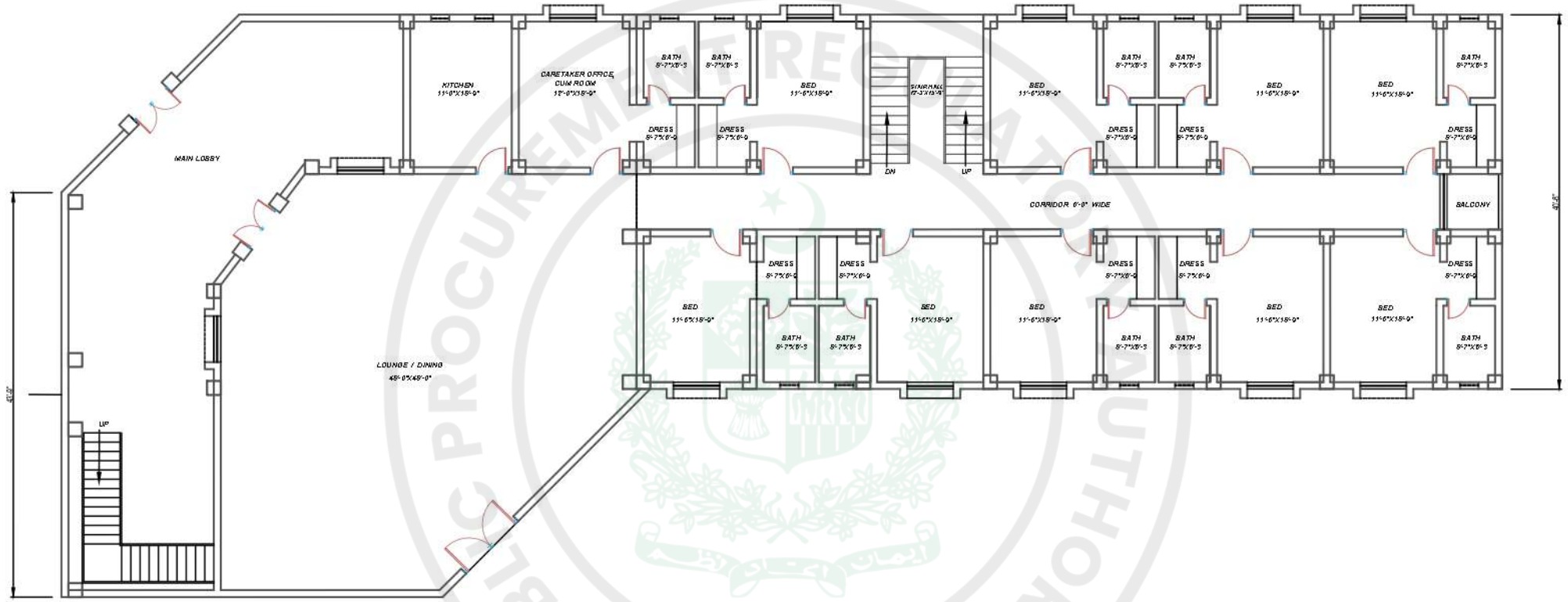



**NOTE:**

1. *ALL DIMENSIONS ARE IN FEET UNLESS INDICATED.*
2. *ALL LEVELS ARE IN FEET.*
3. *THE SCALE SHOWN ARE FOR A DRAWING PRINTED.*

| | | | | | |
|---|---|---|---|---|---|
| | PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | | | | |
| PREPARED<br>ISMAIL | PROJECT | ATTABAD LAKE HPP<br>FEASIBILITY STUDY REPORT | | | |
| DRAWN<br>AZEEM<br>CHECKED<br>ZAHID MAJEED | TITLE | OFFICE BUILDING PLAN | | | |
| APPROVED<br>Abid Sheikh | DATE<br>Jun: 2021 | SCALE<br>1"=8' | DWG No:<br>AFS-ORC=472 | REVISIONS | |

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS




**NOTE:**

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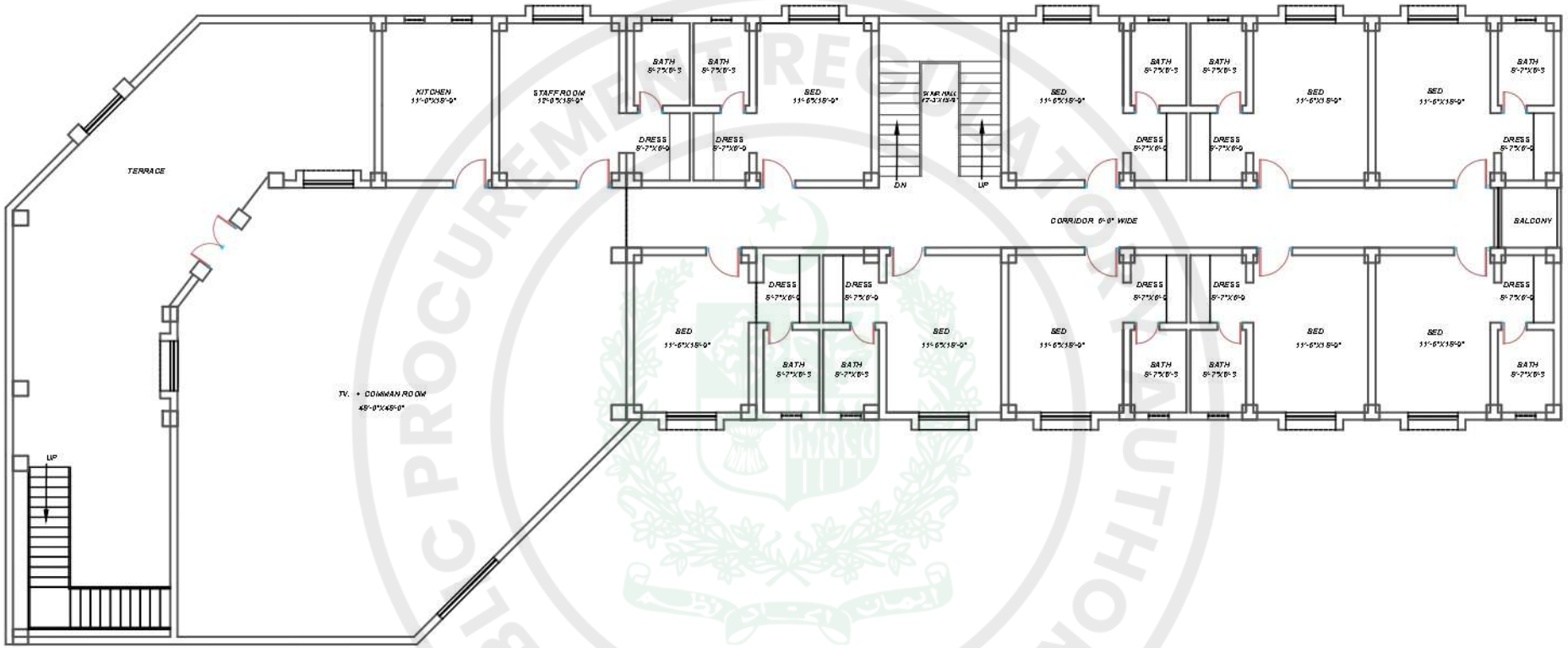
|---|---|---|---|---|---|
| | PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | | | | |
| PREPARED<br>ISMAIL | PROJECT | ATTABAD LAKE HPP<br>FEASIBILITY STUDY REPORT | | | |
| DRAWN<br>AZEEM | TITLE | OFFICERS HOSTEL<br>GROUND FLOOR PLAN | | | |
| CHECKED<br>ZAHID MAJEED | | | | | |
| APPROVED<br>Abid Sheikh | DATE<br>Jun: 2021 | SCALE<br>1"=8' | DWG No:<br>AFS-ORC-473 | REVISIONS | |

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS




**NOTE:**

1. *ALL DIMENSIONS ARE IN FEET UNLESS INDICATED.*
2. *ALL LEVELS ARE IN FEET.*
3. *THE SCALE SHOWN ARE FOR A DRAWING PRINTED.*

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|---|---|---|---|---|---|
| | PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | | | | |
| PREPARED<br>ISMAIL | PROJECT | ATTABAD LAKE HPP<br>FEASIBILITY STUDY REPORT | | | |
| DRAWN<br>AZEEM | TITLE | OFFICERS HOSTEL<br>FIRST FLOOR PLAN | | | |
| CHECKED<br>ZAHID MAJEED | | | | | |
| APPROVED<br>Abid Sheikh | DATE<br>Jun: 2021 | SCALE<br>1"=8' | DWG No:<br>AFS-ORC-474 | REVISIONS | |

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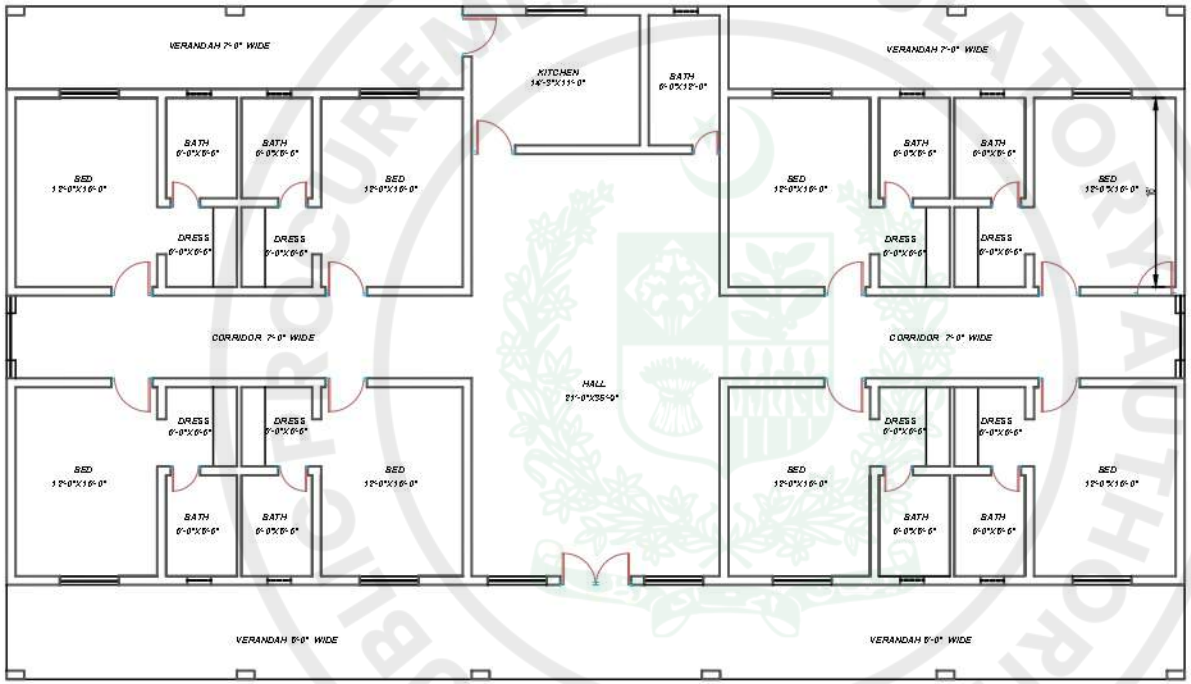


**NOTE:**

1. *ALL DIMENSIONS ARE IN FEET UNLESS INDICATED.*
2. *ALL LEVELS ARE IN FEET.*
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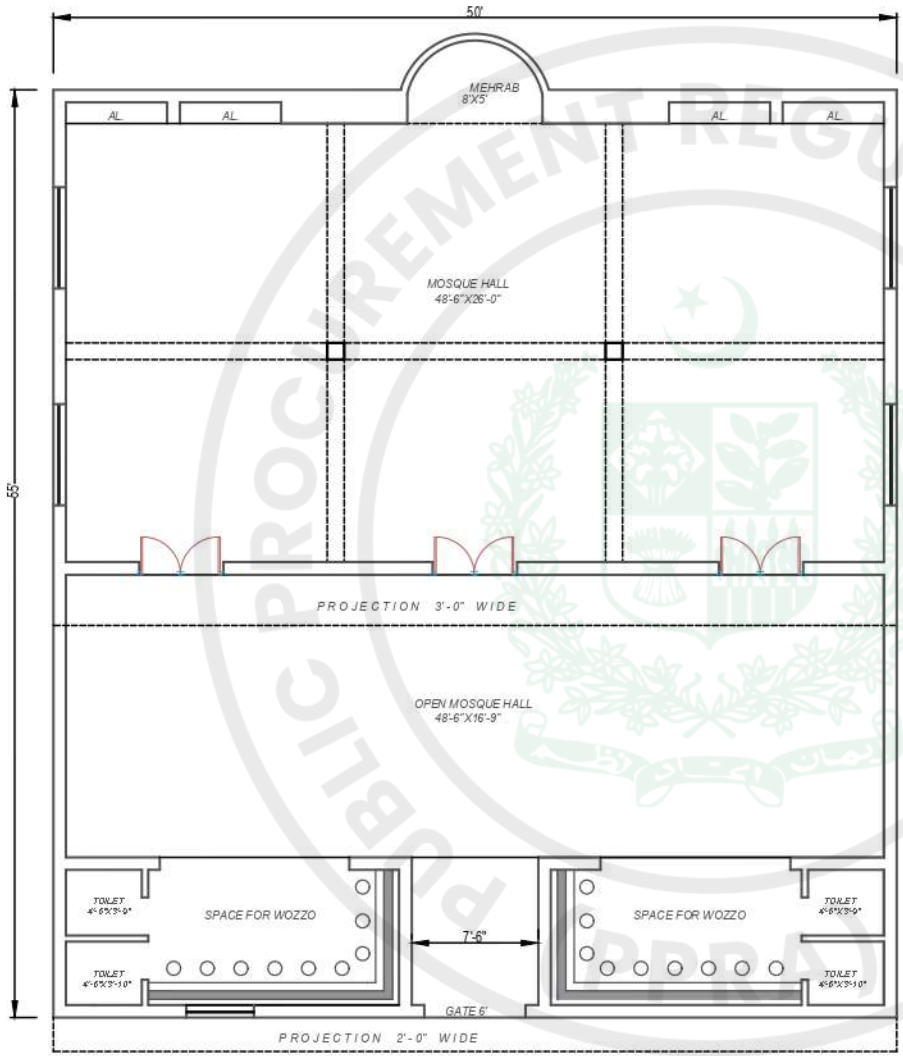
|---|---|---|---|---|---|
| | PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | | | | |
| PREPARED<br>ISMAIL | PROJECT | ATTABAD LAKE HPP<br>FEASIBILITY STUDY REPORT | | | |
| DRAWN<br>AZEEM<br>CHECKED<br>ZAHID MAJEED | TITLE | REST HOUSE PLAN | | | |
| APPROVED<br>Abid Sheikh | DATE<br>Jun: 2021 | SCALE<br>1"=8' | DWG No:<br>AFS-ORC-475 | REVISIONS | |

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS




**NOTE:**

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3. *THE SCALE SHOWN ARE FOR A DRAWING PRINTED.*

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|---|---|---|---|---|
| PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY<br>HYDRO PLANNING ORGANIZATION | | | | |
| PREPARED<br>ISMAIL | PROJECT | ATTABAD LAKE HPP<br>FEASIBILITY STUDY REPORT | | |
| DRAWN<br>AZEEM<br>CHECKED<br>ZAHID MAJEED | TITLE | MOSQUE PLAN | | |
| APPROVED<br>Abid Sheikh | DATE<br>Jun: 2021 | SCALE<br>1"=8' | DWG No:<br>AFS-ORC-476 | REVISIONS |

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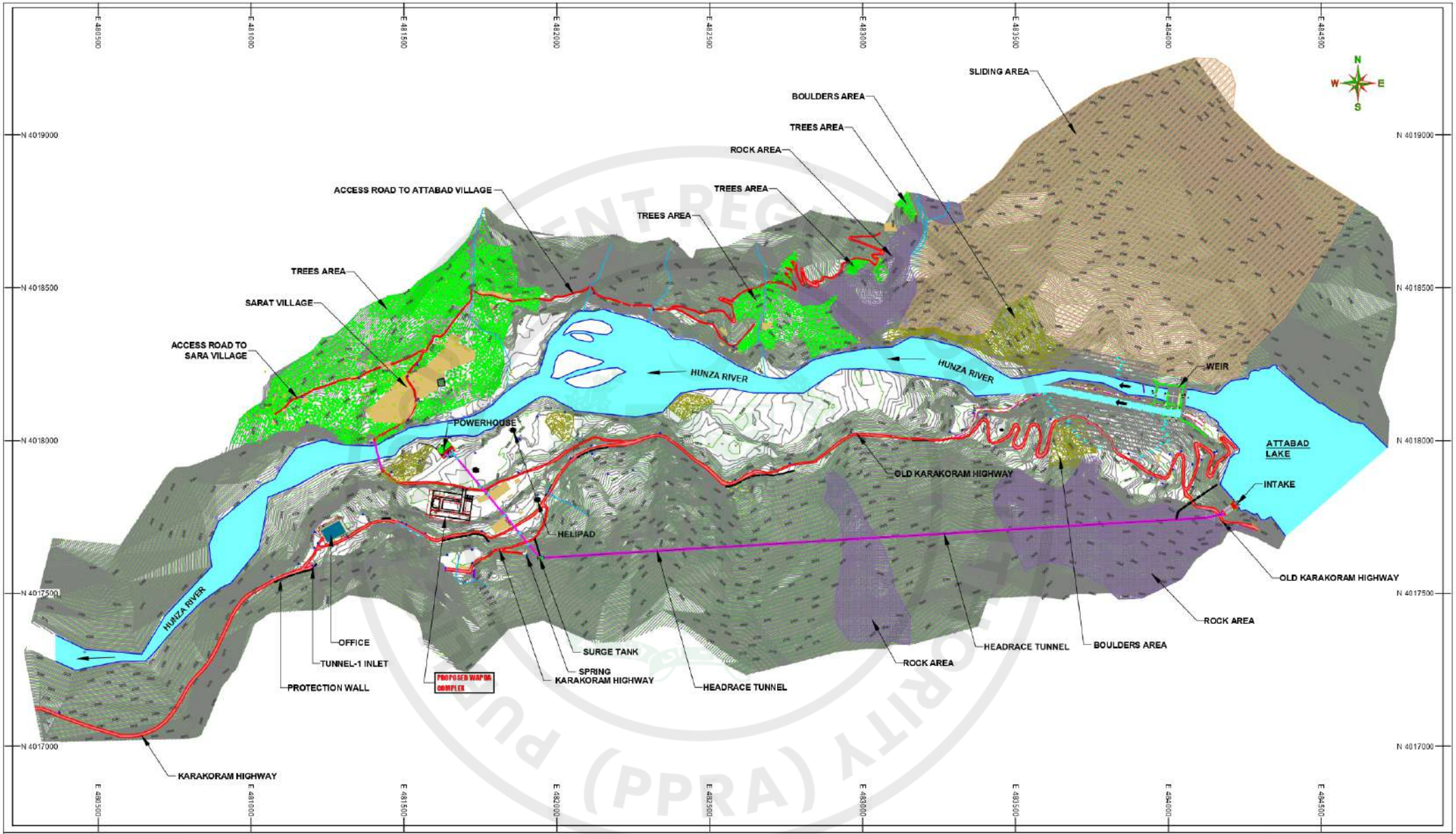


## LEGENDS:

- RIVER/NALLA
- HOUSES/SHOPS
- ROAD
- KATCHA ROAD/TRACK
- CONTROL POINTS
- CONTOURS
- ELECTRIC POLE/T.POLE
- RETAINING WALL
- TREES AREA
- DRAIN AND NULLAH
- BRIDGE AND CULVERT
- BOULDERS
- WATER TANK
- SPRING
- JAMAT KHANA
- HFL
- HELLIPAD
- SLIDING
- ROCK

100 0 100 200 300 400 500m
SCALE

NOTE.
1. ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED
2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FILED OBSERVATIONS.

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDRO PLANNING ORGANIZATION

| | | |
|---|---|---|
| PREPARED: Ehsan | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN: Arshad | TITLE | PROJECT LAND REQUIREMENT |
| CHECKED: Ehsan | | |
| APPROVED: Abid Sheikh | DATE: Jun: 2021 | SCALE: 1 : 12,000 |
| | DWG No.: APS-EN-477 | REVISIONS |

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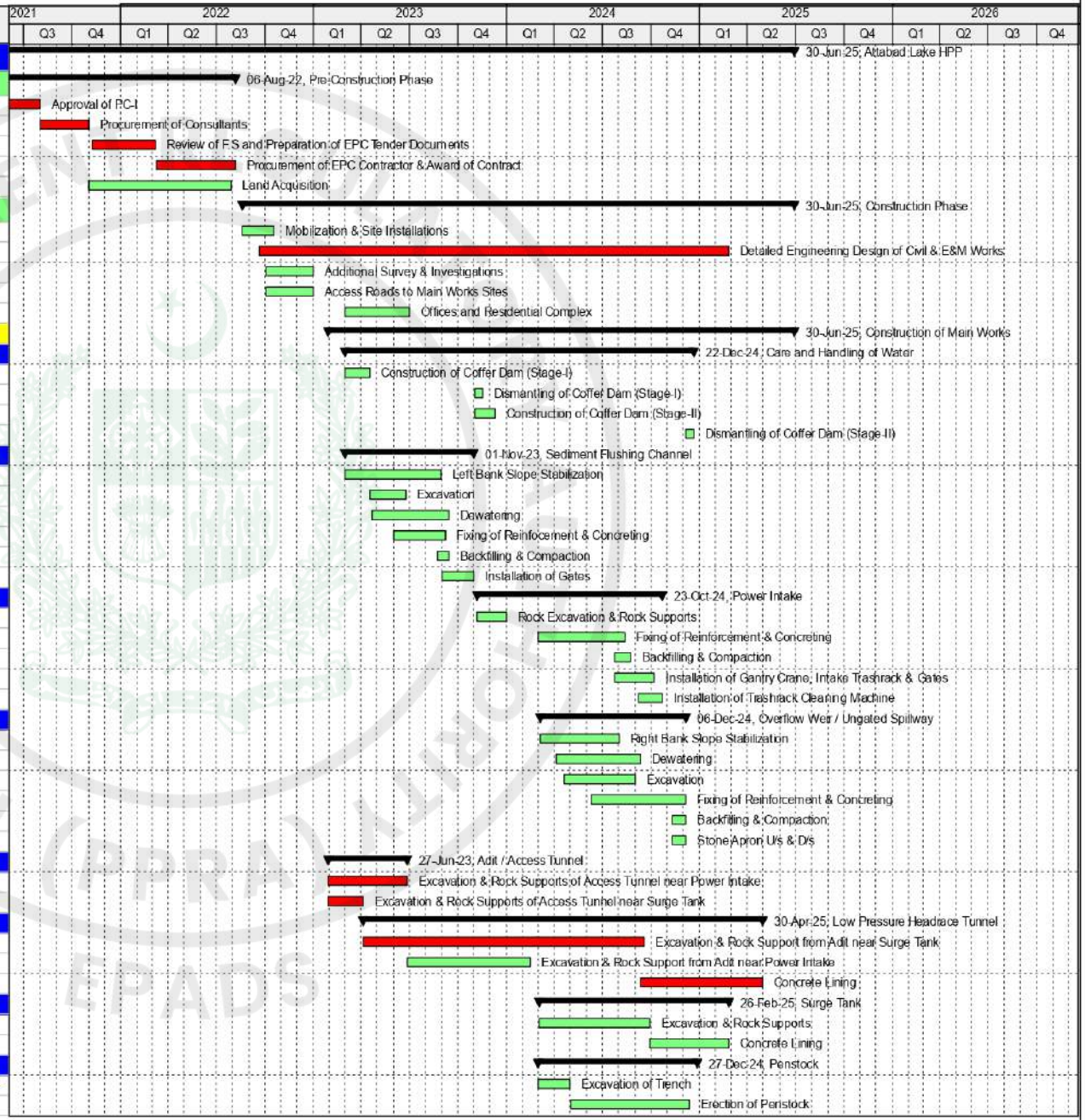
Page 475 of 2270

# ATTABAD LAKE HYDROPOWER PROJECT

## IMPLEMENTATION SCHEDULE

| Activity ID | Activity Name | Original Duration | Start | Finish |
|---|---|---|---|---|
| **Attabad Lake HPP** | | 1519 | 03-May-21 | 30-Jun-25 |
| **Pre-Construction Phase** | | 460 | 03-May-21 | 06-Aug-22 |
| A1000 | Approval of PC-I | 90 | 03-May-21 | 01-Aug-21 |
| A1010 | Procurement of Consultants | 90 | 03-Aug-21 | 01-Nov-21 |
| A1020 | Review of F.S and Preparation of EPC Tender Documents | 120 | 08-Nov-21 | 08-Mar-22 |
| A1030 | Procurement of EPC Contractor & Award of Contract | 150 | 09-Mar-22 | 06-Aug-22 |
| A1040 | Land Acquisition | 270 | 01-Nov-21 | 29-Jul-22 |
| **Construction Phase** | | 1045 | 20-Aug-22 | 30-Jun-25 |
| A1050 | Mobilization & Site Installations | 60 | 20-Aug-22 | 19-Oct-22 |
| A1060 | Detailed Engineering Design of Civil & E&M Works | 890 | 20-Sep-22 | 26-Feb-25 |
| A1070 | Additional Survey & Investigations | 90 | 04-Oct-22 | 02-Jan-23 |
| A1080 | Access Roads to Main Works Sites | 90 | 04-Oct-22 | 02-Jan-23 |
| A1160 | Offices and Residential Complex | 120 | 03-Mar-23 | 01-Jul-23 |
| **Construction of Main Works** | | 884 | 28-Jan-23 | 30-Jun-25 |
| **Care and Handling of Water** | | 660 | 03-Mar-23 | 22-Dec-24 |
| A1700 | Construction of Coffer Dam (Stage-I) | 45 | 03-Mar-23 | 17-Apr-23 |
| A1710 | Dismantling of Coffer Dam (Stage-I) | 15 | 02-Nov-23 | 17-Nov-23 |
| A1720 | Construction of Coffer Dam (Stage-II) | 40 | 02-Nov-23 | 12-Dec-23 |
| A1730 | Dismantling of Coffer Dam (Stage-II) | 15 | 07-Dec-24 | 22-Dec-24 |
| **Sediment Flushing Channel** | | 243 | 03-Mar-23 | 01-Nov-23 |
| A1090 | Left Bank Slope Stabilization | 180 | 03-Mar-23 | 30-Aug-23 |
| A1100 | Excavation | 70 | 17-Apr-23 | 26-Jun-23 |
| A1110 | Dewatering | 145 | 22-Apr-23 | 14-Sep-23 |
| A1130 | Fixing of Reinfocement & Concreting | 100 | 01-Jun-23 | 09-Sep-23 |
| A1140 | Backfilling & Compaction | 20 | 25-Aug-23 | 14-Sep-23 |
| A1150 | Installation of Gates | 60 | 02-Sep-23 | 01-Nov-23 |
| **Power Intake** | | 350 | 08-Nov-23 | 23-Oct-24 |
| A1260 | Rock Excavation & Rock Supports | 55 | 08-Nov-23 | 02-Jan-24 |
| A1280 | Fixing of Reinforcement & Concreting | 165 | 02-Mar-24 | 14-Aug-24 |
| A1290 | Backfilling & Compaction | 30 | 25-Jul-24 | 24-Aug-24 |
| A1300 | Installation of Gantry Crane, Intake Trashrack & Gates | 75 | 25-Jul-24 | 08-Oct-24 |
| A1500 | Installation of Trashrack Cleaning Machine | 45 | 08-Sep-24 | 23-Oct-24 |
| **Overflow Weir / Ungated Spillway** | | 275 | 06-Mar-24 | 06-Dec-24 |
| A1190 | Right Bank Slope Stabilization | 150 | 06-Mar-24 | 03-Aug-24 |
| A1200 | Dewatering | 160 | 05-Apr-24 | 12-Sep-24 |
| A1210 | Excavation | 135 | 20-Apr-24 | 02-Sep-24 |
| A1230 | Fixing of Reinforcement & Concreting | 180 | 09-Jun-24 | 06-Dec-24 |
| A1240 | Backfilling & Compaction | 25 | 11-Nov-24 | 06-Dec-24 |
| A1370 | Stone Apron U/s & D/s | 25 | 11-Nov-24 | 06-Dec-24 |
| **Adit / Access Tunnel** | | 150 | 28-Jan-23 | 27-Jun-23 |
| A1310 | Excavation & Rock Supports of Access Tunnel near Power Intake | 150 | 28-Jan-23 | 27-Jun-23 |
| A1320 | Excavation & Rock Supports of Access Tunnel near Surge Tank | 67 | 28-Jan-23 | 05-Apr-23 |
| **Low Pressure Headrace Tunnel** | | 756 | 05-Apr-23 | 30-Apr-25 |
| A1330 | Excavation & Rock Support from Adit near Surge Tank | 533 | 05-Apr-23 | 19-Sep-24 |
| A1340 | Excavation & Rock Support from Adit near Power Intake | 234 | 27-Jun-23 | 16-Feb-24 |
| A1660 | Concrete Lining | 230 | 12-Sep-24 | 30-Apr-25 |
| **Surge Tank** | | 360 | 03-Mar-24 | 26-Feb-25 |
| A1350 | Excavation & Rock Supports | 210 | 03-Mar-24 | 29-Sep-24 |
| A1360 | Concrete Lining | 150 | 29-Sep-24 | 26-Feb-25 |
| **Penstock** | | 300 | 02-Mar-24 | 27-Dec-24 |
| A1380 | Excavation of Trench | 60 | 02-Mar-24 | 01-May-24 |
| A1390 | Erection of Penstock | 225 | 02-May-24 | 13-Dec-24 |




Remaining Work | Critical Remaining Work | summary



AFS-CP-478

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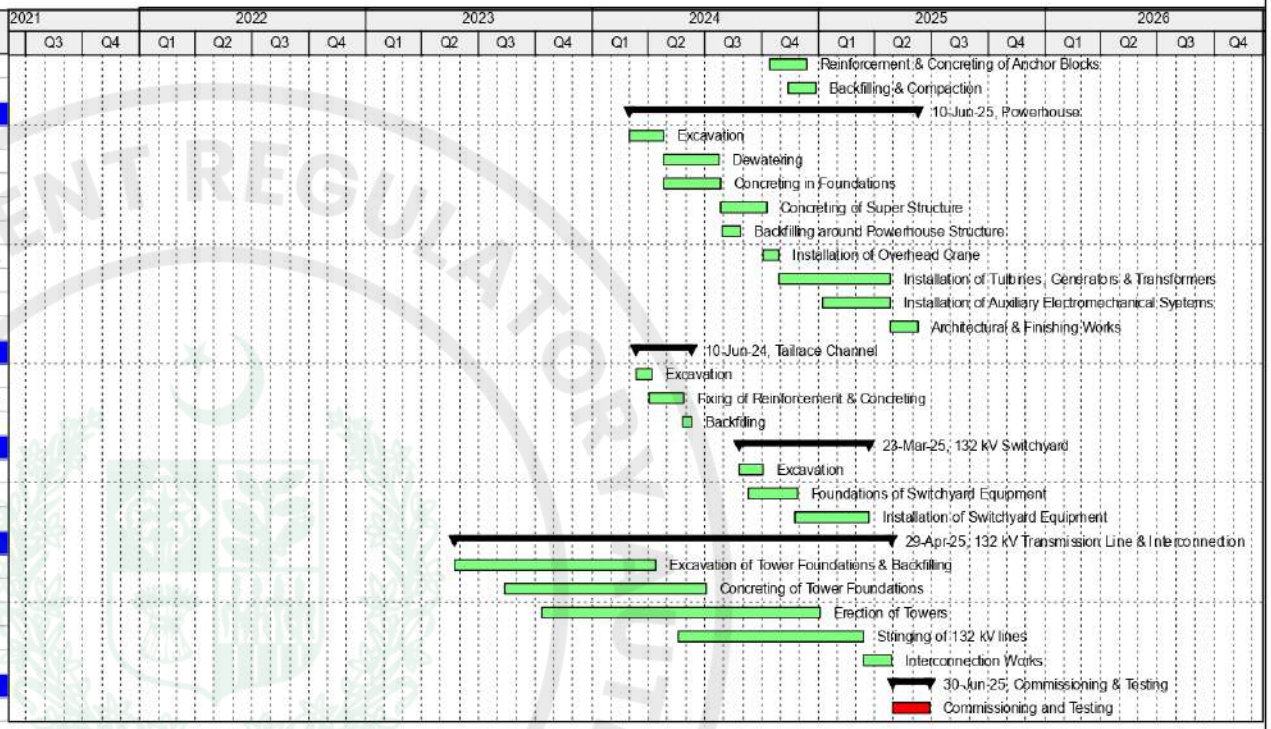
# ATTABAD LAKE HYDROPOWER PROJECT

## IMPLEMENTATION SCHEDULE

| Activity ID | Activity Name | Original Duration | Start | Finish |
|---|---|---|---|---|
| A1400 | Reinforcement & Concreting of Anchor Blocks | 60 | 14-Oct-24 | 13-Dec-24 |
| A1410 | Backfilling & Compaction | 45 | 12-Nov-24 | 27-Dec-24 |
| **Powerhouse** | | 465 | 02-Mar-24 | 10-Jun-25 |
| A1420 | Excavation | 55 | 02-Mar-24 | 26-Apr-24 |
| A1430 | Dewatering | 90 | 26-Apr-24 | 25-Jul-24 |
| A1440 | Concreting in Foundations | 90 | 27-Apr-24 | 26-Jul-24 |
| A1450 | Concreting of Super Structure | 75 | 26-Jul-24 | 09-Oct-24 |
| A1460 | Backfilling around Powerhouse Structure | 30 | 29-Jul-24 | 28-Aug-24 |
| A1470 | Installation of Overhead Crane | 25 | 03-Oct-24 | 28-Oct-24 |
| A1480 | Installation of Turbines, Generators & Transformers | 180 | 29-Oct-24 | 27-Apr-25 |
| A1490 | Installation of Auxiliary Electromechanical Systems | 110 | 07-Jan-25 | 27-Apr-25 |
| A1520 | Architectural & Finishing Works | 45 | 26-Apr-25 | 10-Jun-25 |
| **Tailrace Channel** | | 90 | 12-Mar-24 | 10-Jun-24 |
| A1530 | Excavation | 25 | 12-Mar-24 | 06-Apr-24 |
| A1550 | Fixing of Reinforcement & Concreting | 55 | 03-Apr-24 | 28-May-24 |
| A1560 | Backfilling | 15 | 26-May-24 | 10-Jun-24 |
| **132 kV Switchyard** | | 210 | 25-Aug-24 | 23-Mar-25 |
| A1570 | Excavation | 40 | 25-Aug-24 | 04-Oct-24 |
| A1580 | Foundations of Switchyard Equipment | 80 | 09-Sep-24 | 28-Nov-24 |
| A1590 | Installation of Switchyard Equipment | 120 | 23-Nov-24 | 23-Mar-25 |
| **132 kV Transmission Line & Interconnection** | | 705 | 25-May-23 | 29-Apr-25 |
| A1600 | Excavation of Tower Foundations & Backfilling | 325 | 25-May-23 | 14-Apr-24 |
| A1620 | Concreting of Tower Foundations | 325 | 13-Aug-23 | 03-Jul-24 |
| A1630 | Erection of Towers | 450 | 12-Oct-23 | 04-Jan-25 |
| A1640 | Stringing of 132 kV lines | 300 | 19-May-24 | 15-Mar-25 |
| A1650 | Interconnection Works | 45 | 15-Mar-25 | 29-Apr-25 |
| **Commissioning & Testing** | | 60 | 01-May-25 | 30-Jun-25 |
| A1670 | Commissioning and Testing | 60 | 01-May-25 | 30-Jun-25 |




Remaining Work | Critical Remaining Work | summary



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# PAKISTAN

## WATER AND POWER DEVELOPMENT AUTHORITY

# ATTABAD LAKE HYDROPOWER PROJECT

# FEASIBILITY STUDY

# VOLUME 3

# GEOLOGICAL AND GEOTECHNICAL STUDIES

**June 2021**

## HYDRO PLANNING ORGANIZATION

WAPDA, SUNNY VIEW ESTATE, LAHORE ☎ 99202717 🖷 99202722 ✉ gmhydroplanning@gmail.com

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# ATTABAD LAKE HYDROPOWER PROJECT
# LIST OF VOLUMES

VOLUME – 1 MAIN REPORT

VOLUME – 2 DRAWINGS

**VOLUME – 3 GEOLOGICAL AND GEOTECHNICAL STUDIES**

VOLUME – 4 NEOTECTONICS STUDIES & SESIMIC HAZARDS ANALYSIS

VOLUME – 5 BOREHOLE LOGS AND LABORTORY TESTING

VOLUME – 6 ENVIRONOMENTAL AND SOCIAL IMPACT ASSESSMENT

VOLUME – 7 APPENDICES

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

# LIST OF ABBREVIATION

| | |
|---|---|
| **A** | |
| ADB | Asian Development Bank |
| AKCSP | Aga Khan Cultural Service Pakistan |
| AKDN | Aga Khan Development Network |
| AKF | Aga Khan Foundation |
| AKHS | Aga Khan Health Service |
| AKRSP | Aga Khan Rural Support Program |
| **C** | |
| CBM | Confidence-Building Measure |
| CBOs- | Community-based organizations |
| CPEC | China Pakistan Economic Corridor |
| DLP | Defect Liability Period |
| **E** | |
| EIA | Environmental Impact Assessment |
| EL | Elevation Level |
| EMMP | Environment Monitoring Management Plan |
| EOT | Electric Overhead Bridge Type Traveling |
| EPA | Environment Protection Agency |
| ESIA | Environmental Impact Assessment |
| **G** | |
| GB | GilgitBaltistan |
| GEF | Global Environment Facility |
| GHG | Green House Gases |
| GLOF | Glacial Lake Outburst Floods |
| GSP | Geological Survey of Pakistan |
| **H** | |
| ha | Hectare |
| HPO- | Hydro Planning Organization |
| HPP | Hydropower Project |
| **I** | |
| ICT- | Information and Communication Technologies |
| IEE | Initial Environmental Examination |
| IRS | Indus River System |
| IUCN | International Union for Conservation of Nature |
| **K** | |
| KKH | Karakoram Highway |
| KNP- | Khunjerab National Park |



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## LIST OF ABBREVIATION

| | |
|---|---|
| KPK- | Khyber Pakhtunkhwa |
| **L** | |
| LAA | Land Acquisition Act |
| LGO | Local Government Ordinance |
| **M** | |
| MASL | Meters Above Sea Level |
| MBT | Main Boundary Thrust |
| MKT | Main Karakoram Thrust |
| MMM | Mitigation Management Matrix |
| MMT | Main Mantle Thrust |
| MW | Mega Watt |
| **N** | |
| NA | Northern Areas |
| NCS | National Conservation Strategy |
| NEQS | National Environment Quality Standards |
| NGO | Non- Governmental Organizations |
| NOC | No Objection Certificate |
| **P** | |
| PAP | Project Implementation and Resettlement of the Affected Persons |
| PEPA | Pakistan Environmental Protection Act |
| PEPC | Pakistan Environmental Protection Council |
| PMAC | Program for Mountain Areas Conservation |
| PPC | Pakistan Penal Code |
| **R** | |
| RAP | Resettlement Action Plan |
| RNR | Renewable Natural Resources |
| **S** | |
| SC | Supervisory Consultants |
| SWHP | Surface Water Hydrology Project |
| **T** | |
| TOR | Terms of Reference |
| **U** | |
| UNDP | United Nations Development Program |
| **V** | |
| VO | Village Organizations |
| **W** | |
| WAPDA | Water and Power Development Authority |



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## LIST OF ABBREVIATION

| | |
|---|---|
| WCSDO | Wildlife Conservation and Social Development Organizations |
| WCS | Wildlife Conservation Society |
| WHO | World Health Organization |
| WUO | Water Users' Organizations |
| WWF | World Wide Fund |

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## UNITS: CONVERSION FACTORS: SI TO FPS

| Length | To convert from | To | Multiply by |
|---|---|---|---|
| | M | Ft | 3.281 |
| | Cm | Ft | 0.0328 |
| | Km | Ft | 3,280.84 |
| | M | Mi | 0.0006214 |
| | Km | Mi | 0.6214 |
| **Area** | $m^2$ | $ft^2$ | 10.764 |
| | $km^2$ | $mi^2$ | 0.3861 |
| | $m^2$ | acre | 0.0002471 |
| | $km^2$ | acre | 247.105 |
| | Hectare | acre | 2.471 |
| **Volume** | $m^3$ | $ft^3$ | 35.315 |
| | $m^3$ | US gal | 264.172 |
| | $m^3$ | UK gal | 219.969 |
| | L | $ft^3$ | 0.035315 |
| | $m^3$ | Acre Feet | 0.000810714 |
| **Velocity** | m/s | ft/s | 3.281 |
| | cm/s | ft/s | 0.03281 |
| | m/s | mi/h | 2.237 |
| | km/h | mi/h | 0.622 |
| **Acceleration** | $m/s^2$ | $ft/s^2$ | 3.281 |
| **Mass** | Kg | $lb_m$ | 2.205 |
| | Kg | ton | 0.00110 |
| **Pressure and Stress** | Pa or $N/m^2$ | psi | 0.000145 |
| **Discharge** | $m^3/s$ | $ft^3/s$ | 35.315 |
| | L/s | $ft^3/s$ | 0.035315 |
| | $m^3/s$ | US gal/min | 15850.3 |
| | $m^3/s$ | UK gal/min | 13198.2 |
| | L/s | US gal/min | 15.850 |
| | L/s | UK gal/min | 13.198 |



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# TABLE OF CONTENTS

**1 INTRODUCTION ..... 1-1**
1.1 GENERAL ..... 1-1
1.2 SCOPE OF WORK ..... 1-2
1.3 OBJECTIVES ..... 1-2
1.4 METHODOLOGY ..... 1-2
**2 REGIONAL GEOLOGY ..... 2-1**
2.1 GENERAL ..... 2-1
2.2 STRATIGRAPHIC SEQUENCE ..... 2-1
2.2.1 Misgar Unit ..... 2-2
2.2.2 Sost Unit ..... 2-2
2.2.3 Gojal Unit ..... 2-2
2.2.4 Karakorum Axial Batholith ..... 2-3
2.2.5 Ganesh Formation ..... 2-3
2.2.6 Hassanabad Granite: ..... 2-3
2.2.7 Chalt Formation ..... 2-3
2.3 REGIONAL TECTONICS ..... 2-3
2.4 REGIONAL FAULTS ..... 2-5
2.4.1 Karakorum Fault ..... 2-5
2.4.2 Upper Hunza Fault ..... 2-6
2.4.3 Main Karakorum Thrust ..... 2-6
2.4.4 Main Mantle Thrust ..... 2-6
**3 SITE GEOLOGY ..... 3-1**
3.1 GENERAL ..... 3-1
3.2 SURFACE GEOLOGICAL MAP ..... 3-1
3.2.1 Lithological Units ..... 3-1
3.3 GEOLOGICAL STRUCTURES ..... 3-3
3.3.1 Faults ..... 3-3
**4 GEOLOGICAL & GEOTECHNICAL INVESTIGATIONS ..... 4-1**
4.1 SURFACE INVESTIGATIONS ..... 4-1
4.1.1 Surface Geological Mapping ..... 4-1
4.1.2 Neo-tectonics Study ..... 4-1
4.2 SUBSURFACE INVESTIGATIONS ..... 4-2
4.2.1 Drilling ..... 4-2



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4.2.2 Test Pits ..... 4-4
4.2.3 Laboratory Testing ..... 4-4
**5 EVALUATION OF LABORATORY TESTS ..... 5-1**
5.1 PETROGRAPHIC ANALYSIS ..... 5-1
5.2 DIRECT SHEAR TEST ..... 5-1
5.3 ROCK CORE MODULUS ..... 5-2
5.4 POINT LOAD STRENGTH INDEX (PLSI) TEST ..... 5-2
5.5 UNIAXIAL COMPRESSIVE STRENGTH (UCS) TEST ..... 5-3
5.6 INDIRECT TENSILE STRENGTH (ITS) TEST ..... 5-3
5.7 HOEK TRIAXIAL COMPRESSIVE STRENGTH (HTCS) TEST ..... 5-3
5.8 PROPERTY INDEX ..... 5-4
5.9 LOS ANGELES ABRASION (LAA) TEST ..... 5-5
5.10 SULPHATE SOUNDNESS TEST ..... 5-5
5.11 CRUSHING VALUE OF AGGREGATE ..... 5-6
5.12 FLAKINESS/ELONGATION INDEX ..... 5-6
5.13 CONSOLIDATION TEST ..... 5-6
5.14 SWELLING POTENTIAL, UNIT WEIGHT AND NMC ..... 5-7
5.15 MODIFIED PROCTOR TEST ..... 5-7
5.16 ACCELERATED MORTAR BAR TEST ..... 5-8
5.17 GRAIN SIZE ANALYSIS ..... 5-8
5.18 ATTERBERG LIMITS ..... 5-9
**6 GEOLOGY AND FOUNDATION EVALUATION ..... 6-1**
6.1 GENERAL ..... 6-1
6.2 WEIR SITE ..... 6-1
6.2.1 Surface Geological Mapping ..... 6-1
6.2.2 Boreholes Drilling at Weir Site ..... 6-2
6.3 INTAKE AREA ..... 6-3
6.4 POWER TUNNEL ..... 6-4
6.4.1 Surface Geological Mapping ..... 6-4
6.5 SEDIMENT FLUSHING CHANNEL ..... 6-6
6.5.1 Surface Geological Mapping ..... 6-6
6.5.2 Borehole Drilling ..... 6-7
6.5.3 Test Pits ..... 6-9
6.6 SURGE TANK AND PENSTOCK ALIGNMENT ..... 6-9
6.7 POWER HOUSE ..... 6-10



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6.7.1 Borehole Drilling ..... 6-11
6.8 TAILRACE CHANNEL ..... 6-13
**7 CONSTRUCTION MATERIAL ..... 7-1**
7.1 GENERAL ..... 7-1
7.2 FINE AGGREGATE ..... 7-1
7.2.1 Sand Quarry ..... 7-1
7.2.2 Silt and Clay Quarry ..... 7-2
7.3 COARSE AGGREGATE ..... 7-3
7.3.1 Passu Area ..... 7-3
7.3.2 Power House Area ..... 7-4
7.3.3 Slided Mass ..... 7-5
7.4 BUILDING STONE ..... 7-5
7.5 FILL MATERIAL ..... 7-6
7.6 CEMENT AND STEEL ..... 7-6
**8 NEOTECTONICS AND SEISMIC HAZARD ANALYSIS ..... 8-1**
8.1 GENERAL ..... 8-1
8.2 OBJECTIVES ..... 8-1
8.3 METHODOLOGY ..... 8-1
8.4 FIELD OBSERVATIONS ..... 8-2
8.4.1 Passu Village ..... 8-3
8.4.2 Road Section from Murradabad to Hussani Village ..... 8-6
8.4.3 At Sarat Village ..... 8-7
8.4.4 Inside Tunnel 2 ..... 8-10
8.4.5 Power House Area ..... 8-11
8.4.6 At Murtazabad- Shahyar Road: ..... 8-13
8.4.7 In Tashot Village ..... 8-15
8.5 SEISMIC HAZARD ANALYSIS ..... 8-16
8.5.1 PROBABILISTIC HAZARD ANALYSIS ..... 8-16
8.6 DETERMINISTIC SEISMIC HAZARD ANALYSIS (DSHA) ..... 8-18
8.7 DETERMINISTIC RESPONSE SPECTRA ..... 8-19
8.7.1 Deterministic Pseudo Spectral Acceleration (PSA) ..... 8-19
8.8 SELECTION OF SEISMIC DESIGN PARAMETERS ..... 8-20
8.8.1 Safety Evaluation Earthquake (SEE) ..... 8-20
8.8.2 Operating Basis Earthquake (OBE) ..... 8-21
8.8.3 Uniform Hazard Spectra (UHS) ..... 8-21



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8.9 CONCLUSION AND RECOMMENDATIONS ..... 8-22

**9 CONCLUSIONS ..... 9-1**

**10 RECOMMENDATIONS ..... 10-1**

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# LIST OF PHOTOS

Photo 4-1 Surface Geological Mapping ..... 4-1
Photo 4-2 Drilling Rig at BH-02 Sediment Flushing Channel (Intake area). ..... 4-3
Photo 6-1 A View of Weir Site. ..... 6-1
Photo 6-2 Proposed Intake Area for Power Tunnel ..... 6-4
Photo 6-3 Rolling Down of Boulders at Active Slide ..... 6-4
Photo 6-4 Intake Area of Sediment Flushing Channel. ..... 6-7
Photo 6-5 Proposed Area for Surge Tank. ..... 6-10
Photo 6-6 Proposed Alignment of Penstock. ..... 6-10
Photo 6-7 Proposed Power House Area. ..... 6-11
Photo 7-1 Quarry Area Selected for Sand near Shishkat Bridge. ..... 7-1
Photo 7-2 TP-3, Excavated for Clayey Silt in P/H Area. ..... 7-2
Photo 7-3 View of Clayey Silt in P/H Area. ..... 7-3
Photo 7-4 Exposure of Marble in Passu VillageAarea. ..... 7-4
Photo 7-5 View of RBGM in TP-2 at P/H Area. ..... 7-4
Photo 7-6 View of Slided Mass in TP-6 at Left Side Slope of Hunza River. ..... 7-5
Photo 7-7 Fill Material (Boulder and Gravels) in Slided Mass. ..... 7-6
Photo 8-1 Inclined Gravel Layer under Effect of Shearing ..... 8-3
Photo 8-2 Recumbant Fold Strata with Crenulation in Limbs in Clay Strata. ..... 8-4
Photo 8-3 Stylolite/Pressure Solutions in Clay Strata. ..... 8-4
Photo 8-4 Micro Fault in Clay Beds. ..... 8-5
Photo 8-5 Horst and Graben Structure along Micro Fault in Clay Beds. ..... 8-5
Photo 8-6 View of Brecciated Rock Upstream of Passu Village. ..... 8-6
Photo 8-7 View of Folded ABGM just Upstream of Passu Village. ..... 8-7
Photo 8-8 Change of Dip along Shear Joint. ..... 8-7
Photo 8-9 View of Vertical and Oblique Joints in Clayey Silt at Sarat Village. ..... 8-8
Photo 8-10 Tiltness in Clayey Silt Beds, Left Side of Road at Sarat Village. ..... 8-8
Photo 8-11 Tiltness in Clayey Silt Beds, Right Side of Road at Sarat Village. ..... 8-9
Photo 8-12 Folded and Sheared Clayey Silt at Sarat Village. ..... 8-9
Photo 8-13 Sheared and Smeared Clayey Silt at Sarat Village. ..... 8-10
Photo 8-14 Fault Breccia Just D/S of Suspension Bridge at Sarat Village. ..... 8-10
Photo 8-15 View of Recently Generated Joints Tunnel-2. ..... 8-11
Photo 8-16 View of Recently Generated Joints between Tunnel-2 & 3. ..... 8-11
Photo 8-17 Micro Thrust Fault in Clayey Silt Beds near Helipad. ..... 8-12
Photo 8-18 Inclination of Clayey Silt near Helipad. ..... 8-12
Photo 8-19 Folding in Clayey Silt near Helipad/Power House Area. ..... 8-13
Photo 8-20 Development of Parallel Joints near SCO Building. ..... 8-13
Photo 8-21 Inclination in Clay Silt and Gravels. ..... 8-14
Photo 8-22 Ramp and Flat Geometry along Fault. ..... 8-14
Photo 8-23 Development of Micro Faults in Sand. ..... 8-15
Photo 8-24 Development of Micro Faults in Clayey Silt. ..... 8-15
Photo 8-25 Inclination in RBGM in Tashot Village along Road. ..... 8-16



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# LIST OF FIGURES

Figure 6-1 Graphical Representation of CR Vs Depth of BH-01. 6-3
Figure 6-2 Graphical Representation of RQD&CR Vs Depth of BH-04. 6-6
Figure 6-3 Graphical Representation of CR Vs Depth . 6-8
Figure 6-4 Graphical Representation of CR Vs Depth of BH-03. 6-9
Figure 6-5 Graphical Representation of CR Vs Depth. 6-12
Figure 6-6 Graphical Representation of CR Vs Depth 6-13
Figure 8-1 Development of Normal Faults under Compressional Regime. 8-6
Figure 8-2 Total Hazard Curve for ALHPP. 8-17
Figure 8-3 Earthquake Hazard by Seismic Sources, Showing Spectral Response. 8-17
Figure 8-4 Deterministic Spectra at 50th Percentile Level Weighted Average 8-19
Figure 8-5 Deterministic Spectra at 84th Percentile 8-19
Figure 8-6 Deterministic Pseudo Spectral Acceleration (g) at 5% Damping. 8-20
Figure 8-7 Deterministic Spectra at 66th Percentile Level of SEE. 8-21
Figure 8-8 Uniform Hazard Spectra (UHS) Showing Mean Hazard for Various Return Periods. 8-22
Figure 8-9 Deaggregation of Mean Hazard, Mean Magnitude and Mean Distance 8-22



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# LIST OF TABLES

Table 4-1 Co-ordinates of Boreholes ..... 4-2
Table 4-2 Location of Boreholes ..... 4-3
Table 4-3 Proposed Laboratory Test on Rock Core Samples ..... 4-5
Table 4-4 Lab Testing On Test Pits Samples and Borrow area ..... 4-6
Table 5-1 Petrographic Analysis Results ..... 5-1
Table 5-2 Rock Core Modulus Test Results ..... 5-2
Table 5-3 Point Load Strength Index Test Results ..... 5-2
Table 5-4 Uniaxial Compressive Strength Test Results ..... 5-3
Table 5-5 Hoek Triaxial Compressive Strength Test Results ..... 5-4
Table 5-6 Property Index Test (Core) Results ..... 5-4
Table 5-7 Property Index Test (Test Pits) Results ..... 5-4
Table 5-8 Los Angeles Abrasion Test Results ..... 5-5
Table 5-9 Sulphate Soundness Test Results ..... 5-5
Table 5-10 Crushing Value of Aggregate Test Results ..... 5-6
Table 5-11 Flakiness/Elongation Index Test Results ..... 5-6
Table 5-12 Consolidation Test Results ..... 5-7
Table 5-13 Swell Potential, Unit Weight and NMC ..... 5-7
Table 5-14 Modified Proctor Test Results ..... 5-8
Table 5-15 Accelerated Mortar Bar Test Results ..... 5-8
Table 5-16 Grain Size Analysis Results ..... 5-9
Table 5-17 Atterberg Limits Results ..... 5-9
Table 6-1 Summary of BH-01 (Weir Site Left abutment) ..... 6-2
Table 6-2 Summary of Borehole BH-4 ..... 6-5
Table 6-3 Summary of Borehole BH-02 ..... 6-7
Table 6-4 Summary of Borehole BH-03 ..... 6-8
Table 6-5 Summary of Borehole BH-05 ..... 6-11
Table 6-6 Summary of Borehole BH-06 ..... 6-12
Table 8-1 Seismic Source Parameters for Probabilistic Analysis ..... 8-17
Table 8-2 The Controlling Faults with Quantitative Features (Input Values of DSHA) ..... 8-18



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# 1 INTRODUCTION

## 1.1 GENERAL

Attabad Lake Hydro Power Project (ALHPP) is proposed on Hunza River, a left tributary of Gilgit River. A large slide occurred on January 4, 2010 from right side slope of Attabad chocked the Hunza River. The total height of the slide as estimated by GSP (Geological Survey of Pakistan) was about 100 m and the blocked length of river was about 2 km that destroyed 1.3 km of Karakorum Highway (KKH) (ISSMGE Bulletin: Volume 4, Issue 3 Page 21). WAPDA Authority planned to utilize the potential of hydropower due to this lake. Firstly, Govt. of GB carried out Feasibility Study by engaging Local Consultants. The study was deficient in many aspects including geotechnical investigations, laboratory testing, layout planning, pros and cons of sliding, Neo-tectonic study and environmental issues. Therefore Govt. of GB requested WAPDA to carryout Feasibility Study again and Hydro Planning Organization (HPO), WAPDA updated the Feasibility Study.

The HPO, WAPDA entrusted to carry out the Feasibility Study of ALHPP. During the detailed analysis and investigations, it is estimated that Lake potential of 0.1MAF (125 $Mm^3$) can be utilized to generate about 54 MW of electricity.The coordinates of weir site are 484036.834 m E and 4018143.837 m N with mean bed elevation about 2368 m a s l **(DRW No: AFS- WR - 403)**

The proposed weir site is located about 20 km upstream of Aliabad (Central Hunza), near Attabad village, District Hunza. The site is accessible by metaled road from Gilgit, the capital of GB. From Islamabad, the site is reachable through Karakorum Highway (KKH) by covering about 750 km. It is also accessible through PIA airplane from Islamabad to Gilgit and there on to Hunza via Karakurum Highway **(DRW No: AFS- GN- 102)**. Recently PIA operated direct flights from Lahore and Karachi to Gilgit.

Geologically the site is located in Karakorum Block further north of Main Karakorum Thrust (MKT). The Karakorum Block consists of Sedimentary, Metasedimentary, Igneous as well as Metamorphic rock, throughout its extension from Karakorum Fault in the east, Chaman and Herat Fault in west (Zanchi 1993) ranging in age from Precambrian to Cretaceous. The overburden material, consist mainly of Angular Boulder Gravel with Sand and appreciable amount of fines (ABGM) and Rounded Boulder Gravels with Sand and appreciable amount of fines (RBGM). The talus deposits are main constituents of ABGM and well developed mostly in Shamshal valley and along Hunza River in upstream reaches. There are many evidences (the deposition of clayey silt along both banks of Hunza River) along the road indicate that river might have chocked many times in recent past. Prior to Attabad slide, the slope failure occurred at Salamanabad in 1958 and chocked the Hunza River.

The topography and geological conditions present in this valley indicates that it is glacial originated valley modified later on by river system. There are many glaciers that feed the Hunza River, from south to north i.e. Hassanabad, Gulmit , Gulkin, Passu and Batura Glaciers, from right side and Shamshal Valley Glacier from left side. Morphologically the valley is lithological as well as structurally controlled. Weak lithology i.e. slates as well as fault system attribute for the development of present shape of the Hunza valley in upper reaches and near MKT.



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This report is mainly based on the annotations observed during geotechnical investigations carried out at ALHPP. The geological and geotechnical investigations include Surface Geological Mapping, Drilling and Test pits at weir site, sediment flushing channel/under sluice, headrace tunnel and powerhouse area, and identification of borrow area for construction material. Samples collected during geotechnical investigations have been tested to ascertain geotechnical properties at Central Material Testing Laboratory (CMTL), Lahore.

## 1.2 SCOPE OF WORK

During the Feasibility Study of ALHPP, HPO, WAPDA, has identified the deficiencies of geotechnical investigations in pervious Feasibility Study (FS) and carried out detailed geotechnical investigations for comprehensive FS at present. The layout plan was completely changed during present FS and investigation were conducted according to new layout. One of most important aspect is Neo-tectonic studies, because this area is affected by Attabad Slide in 2010. It is very important for the development of hydropower project in this area to develop the understanding of Neo-tectonic setting operating under regional tectonic forces for the stability and planning of the hydropower project. All the geotechnical data procured during geotechnical investigations have been utilized for foundation evaluation of all the structures of ALHPP.

## 1.3 OBJECTIVES

Main objectives are:

- Evaluation of the surface condition of rock mass i.e. shearing, fracturing, jointing, faulting, appropriately during surface geological mapping.
- To investigate the subsurface geological conditions by drilling at weir, sediment flushing channel/undersluice, tunnel and powerhouse area.
- Test pits have been carried out to explore the shallow subsurface conditions of different project structures.
- Core samples from different boreholes, selected and sent to CMTL to conduct testing, for design of different structures.
- Identification of borrow area for coarse as well as for fine aggregate. Samples from these areas were collected and sent to laboratory to carry out different tests for their suitability for construction as well as for rip rap material.

## 1.4 METHODOLOGY

These include:

- Collection of previous research on regional as well as on local geology, geomorphology and tectonics of Project Area.
- In-depth studies on GT sheets of the area after enlargement at scale of 1:10,000.
- Detailed topographical survey at scale of 1:1000 to study all the aspects of slided mass and slope area along both banks of the Hunza River.
- Detailed geological map of the Project Site using plane table , brunton compass, long range Topcon Total Station, used to mark the contacts among different lithological units as well as different soil units at geological map.



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- During field visit keen concentration has been given to characterize the kinematics of fault where possible e.g. sense of fault (Strike and Dip), alignment and type of fault, dip direction and other associated characteristics.
- Total 400 m drilling consist of 6 boreholes have been drilled at weir site, sediment flushing channel/undersluice, tunnel and powerhouse area to observe the subsurface conditions. Drilling activity was executed by Drilling and Investigation Division (DID) of Hydro Planning Organization, WAPDA with Longyear as well as Acker Drilling rigs, from September to December 2020.
    - A total 10 test pits were excavated to explore the shallow subsurface conditions. Composite samples have been collected and sent to CMTL for testing.
    - Borrow areas for fine as well as for coarse aggregate has been identified. Samples from these areas have been collected and sent to laboratory for different testing, to check their suitability for construction work.

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# 2 REGIONAL GEOLOGY

## 2.1 GENERAL

Information and data relating to regional geology of Project Area is taken from already published literature and research papers. The catchment area lies in Karakorum Block (KB) where snow covered peaks are quite common. The geological features in 40 km upstream and 50 km downstream of the Project Area have been studied in detail. In the Project Area many neo-tectonic features have been observed/recorded in the recent deposits which indicate that the regional tectonic forces are operating there.

The Project Area lies in the KB bounded in north by Central Pamir through Rushan Pshart Suture, in east by Karakorum Fault, in the west by Herat Fault and in south by Kohistan Island Arc (KIA) through Main Karakorum Thrust (MKT) (Pashkov & Shvol'man, 1979 & 1981). The KB have classified as a part of Gondwana land in pre-collision history. The rocks of KB have stratigraphic association with rocks of Indian Plate as indicated by Paleozoic to Mesozoic sequence of both plates. It is likely to be considered that Karakorum Micro Plate and Indian Plate were united till Mesozoic Era.

The stratigraphic sequence of the Karakorum Plate is metamorphic equivalent of Sedimentary Rock in Indian Plate shows that both plates have pre-collision similarities. Also the Karakorum Plate consists of sedimentary (well exposed is in Chitral along Mastuj River), Ignoeus rocks (Karakorum Batholith) and Metamorphic rock (slates, schist and marbles).

The rocks of KB include a thick sedimentary cover, which is mainly Paleozoic in the western termination and Permian to Cretaceous in the central and eastern area. In the Hunza valley, the cover consists of a thick pile of Permian-Cretaceous sediments cropping out north of the Karakorum Axial Batholith (KAB). It separates the sedimentary cover to the north, named North Karakorum terrain by Searl (1991), from high to low grade metamorphic present south of the KAB just north of the MKT.

## 2.2 STRATIGRAPHIC SEQUENCE

The area under study mostly includes part of the Northern Karakorum Terrain, which comprises intensively folded and thrusted sedimentary rocks with a very low metamorphic imprint, locally reaching low grade conditions (Zanchi,1993). The Lower Permian to Upper Cretaceous succession of the North Karakorum represents one of the few terrains which escaped strong metamorphism during the Indian-Eurasian collision, thus permitted a detailed reconstruction of its stratigraphic framework **(DWG No: AFS-GE-291).** Plutonic bodies mainly of mid-Cretaceous age intruded the sedimentary cover forming a discontinuous granitic belt developed about 100 km north of the KAB. Four main tectonic units have recognized in the Project Region (Gaetani et all., 1990). These include;

- Misgar Unit
- Sost Unit



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- Gojal Unit
- Karakorum Axial Batholith (KAB)

The brief description of these units are given below;

### 2.2.1 Misgar Unit

This unit consists mostly of slates, with few intercalations of metacarbonate quartzite and black terrigenous slates, mostly exposed at the Northern part of the Project Area. In some areas, its thickness increases upto thousand meter. It is strongly folded with intensive development of slaty cleavage. The fold axes generally trend E-W upto the Khunjerab Pass, where they turn to NNW-SSE. The unit has low grade metamorphism indicated by chlorite, biotite, and muscovite. This unit is intruded by granitoide pluton in northern and eastern terrain having western extension upto Sost. This unit belongs to different stratigraphic formations of Paleozoic age.

The southern boundary of Misgar Unit is faulted with south vergent thrust plane, the northern fault stacking the Misgar Slate over Jurassic limestone and sandstones of Sost belt (Gaetani et al. 1990). Large recumbent folds present along the northern flank of the Chapursan valley suggest southward movement of Misgar Unit.

### 2.2.2 Sost Unit

It consists of grey to dark grey slates, meta-limestone, and quartzite. At places, it has dolomitic patches (Gojal Formation). Some sandstone beds with slate intercalations overlain by argillaceous limestone (Gircha Formation). Some sandstone, siltstone limestone and dolomites of Lupghar Formation, Panjshah Formation, Lashkargaz Formation of middle to late Permian age.

It comprises thick pile of folded and thrusted sheets forming in the whole antiformal stack, later disrupted by strike-slip faults. The unit is bounded by two major faults, the Upper Hunza Fault (Desio, 1979) to the south-east and the Northern Fault to the north. Complexity of the tectonic pattern often prevented the reconstruction of continuous stratigraphic successions, as in the Middle Late Jurassic sediments. Fold axes and fault striations along the main thrust surface generally indicate a N-S compression. The well-developed schistosity is defined by sericite, muscovite and fine grained biotite with occasional occurrence of epidote and chloritoid. This suggests that low grade condition of metamorphism with an important increase of temperature with respect to other thrust sheets of the Sost Unit. These shear zones are still poorly understood and may possibly be related to the eastward prosecution of Hunza Fault juxtaposing the Gircha Slates of Gojal Unit to analogues metasediments of Sost Unit. The stratigraphic succession present in the Sost Unit spans from Permian to Late Cretaceous.

### 2.2.3 Gojal Unit

This tectonostratigraphic unit was defined by Gaetani et al. (1990) and includes the sediments lying between the Karakorum Axial batholith and the Upper Hunza Fault (UHP). It is composed of two units, a terrigenous unit (Passu Slates) below and a calcerous-dolomitic unit above. In the lower Shamshal valley, dolomitic marbles terminate along a subvertical NS trending fault while southward this unit is intruded by KAB. Contact metapelites generally undeformed or



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poorly deformed intrusive that grades into biotite, muscovite, and andalusite. Folds within the unit trend from NW-SE to NNW-SSE and are generally NE-facing. Thrust planes show the same trends and are NE-vergent, as in case of UHF.

### 2.2.4 Karakorum Axial Batholith (KAB)

The KAB crops out along the southern part of the study area, where two major plutonic complexes were recognized, the Hunza and Batura Units (Debon et al., 1987). The Hunza Unit consists in a huge plutonic unit extending for more than 250km, made up of medium grained granodioritic in composition, locally recrystallized. They represent a calc-alkaline association. Mafic enclaves of various sizes are abundant and a conspicuous network of Cenozoic leucocratic dykes is locally present.

The Batura Unit intrusive, spanning in age from Paleocene to Eocene, is mostly new, as well as the findings of plutonic bodies belonging to this unit in Upper Chapursan valley. The Batura Unit includes two main intrusives; The Kuk and Sarbzea Plutons.

The Kuk Pluton consists in pinkish, un-deformed and un-foliated granitoides of various grain size, locally with porphyritic, microgranular and rapakivi textures. The Sarbzea Pluton mainly differs from the Kuk Pluton by its very coarse to medium grained rocks, sometimes deformed.

### 2.2.5 Ganesh Formation

This Formation consists of pelite-psammite turbidite unit and overlying calc-pelite marble unit and are intercalated with each other. These units are metamorphosed up to upper amphibolite facies and therefore have well developed sheets of amphibolite. The Formation has well developed ruby and spinal. Different mines are also established in this unit as can be observed along road near Ganesh Bridge.

### 2.2.6 Hassanabad Granite

It is well exposed in the Lower Hunza valley and consists mainly of lower s-type granitoid-migmatite complex with metasedimentary enclaves. These garnet-tourmaline bearing two mica granitoids and migmatites are well exposed in Hasanabad Nullah and in Hunza valley along Hunza River.

### 2.2.7 Chalt Formation:

It consists of dark grey quartz biotite schist with subordinate quartz, marble and conglomerate. It is exposed along overturned anticline and faulted against Dumordo Formation. Permo-Carboniferous age is assigned to this Formation.

## 2.3 REGIONAL TECTONICS

Before the northward flight of the Indian Plate, small continental pieces (Cimmerids, i.e. Karakorum, Helmad , Hasha ocks etc) were broken up from the northern edge of Gondwana and welded with the southern edge of Eurasian Plate, consuming the old Tethey and opening the Neo Tethey, (Tapponnier, 1975, 1977; Molnar, 1977a).



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In general, due to the subduction of the oceanic part of the Indian Plate beneath the Eurasian Plate, the Island Arc emerged in Middle Cretaceous age. The Arc Complex consists of Calc-Alkaline Plutonic Rocks mainly mafic in nature. The presence of Blue Schist Metamorphism in Swat and Shangla Area indicates the trench environment.

The collision of the Indian and Asian Plates has been described as a “head on” north-south collision (Shackleton and Ries, 1984). This is generally accepted by many workers to have occurred in Eocene times (55-40 Ma) (Powell, 1979; Klootwijk et al, 1979; Dewery et al, 1988; Treloar and Coward, 1991; Serrle et al, 1987, 1988). The terminal collision between Indian and Asian Plates is suggested to have occurred between 45-40 Ma (Molnar and Tapponnier, 1975; Klootwijk et al, 1985). It is generally agreed however, that by 55 Ma, the Kohistan Island Arc was already sutured to the Asian Plate, probably since the Late Cretaceous, forming the MKT Zone. This is confirmed by the presence of 85-80 Ma thermal event at this time (Treloar and Rex, 1990).

The rocks of Shyok Suture Zone are interpreted to represent the tectonised remainder of a marginal basin. The closure of the marginal basin occurred at the Eocene-Oligocene time boundary, and crustal shortening was responsible for generation of Neogene 2-mica granites of the Karakorum Plutonic complex and regional metamorphism of the Pangong Tso Group (V.C Thakur, D.K. Misra, 2007).

The collision between the Indian Plate and Kohistan Island Arc is recognized as when the Tethyan Ocean disappeared and the continental masses docked. Following features recognize the main arguments for the Eocene age of collision: -

- Sediments deposited on the northern margin of the Indian Plate being of Eocene age.
- Subduction of the oceanic crust stopping, as recognized by the end of calc-alkaline magnetism north of the Indus Suture.
- The blue schist facies are not developed along MKT zone showing the collisional belt.
- Slowing down of the Indian Plate motion, as recognized by magnetic anomalies.
- After collision, continued suturing occurred, associated with a 35˚ anticlockwise rotation of the Indian Plate relative to Eurasia. As a result of collision mighty mountain ranges of Himalayas were developed having Island Arc Sequence in the north.

There are some topographic observations about the Himalayas that were immediately noticeable:

- The general curvature of the mountain chain.
- The mass of high land behind the mountain belt (Tibetan Plateau)
- The lineament of the high peaks confined in a rather smaller area.

This seemingly simplified chain becomes very disturbed, with a complete loss of these features in the Northern Himalaya. The general curving of the Higher Himalayan Peaks and the suture around angles of some 180˚, is related to the structural anomalies that are present in Northwestern Himalaya: i.e. the syntaxes (Nanga Parbat Syntaxis, Hazara-Kashmir Syntaxis etc). These are absent in Central Himalaya. This shows that the collision between two Plates is



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not a simpler phenomenon but there was a much greater extent of deformation to which the collision was accommodated. The accommodation was not constant, but suggested to be partitioned with different mechanisms occurring in different places of the orogenic belt.

Anticlock wise rotation of Mega Lhasa followed the Late Triassic docking of the Iranian Spur, using the later as pivot. The rotation was completed during the Middle Jurassic, when SE Pamir, Shaksgam and Karakorum joined the Qiangtang, more closely assembling Mega Lhasa as it approached the Asian margin (Maurizio Gaetani, 2007). The KB bounded in the east by Karakorum Fault, in the north by Rushan- Pshart Suture, in the west by Herat Fault and in south by Main MKT.

Structurally the KB is characterized by broad asymmetrical to tight, isoclinal folds which are commonly imbricated. A number of large regional scale thrust faults, e, g. the Tirchmir Fault, Reshun Fault, Baltit Fault, UHF, and Chapursan Fault and the MKT extends for a distance upto 100 km or more. The KB has undergone multiple deformation since the Cambrian. Parts of the KB have undergone at least four more deformations since the Kohistan-Karakorum collision from Paleocene to Pliocene.

After the collision, due to further northward subduction of the Indian Plate, still active 45mm/yr, the stresses were accommodated by the imbricate thrust faults from north to south (Treloar et al, 1989). The collisional history along with metamorphic events, trapped many clues between these fault systems. These are very useful to delineate the historic events and to unravel the movement of Indian Plate, collisional environment and modern deformational style.

## 2.4 REGIONAL FAULTS

The major regional faults of the region include, from north to south, the MKT, Main Mantle Thrust (MMT), Panjal Thrust (PT), Main Central Thrust (MCT), Main Boundary Thrust (MBT), Kashmir Boundary Thrust (KBT) / Himalayan Frontal Thrust (HFT) and Salt Range Thrust (SRT) **(DWG No: AFS-GE-292).**

Along with these regional faults, many local faults were developed to accommodate the regional stresses; these may be thrust fault or strike slip fault in nature. In most of the area many small scale strike slip faults are associated with the thrust faults to accommodate the deformation.

The general trend of these faults excluding MKT is predominantly east-west with change in trend due to syntaxial bends. The general descriptions of these major faults are given as follows: -

### 2.4.1 Karakorum Fault

Dextral Strike Slip fault of about 800 Km long bounds Western Tibet. The Karakorum Fault (KF) represents a much younger terrane boundary, juxtaposing rocks of the Ladakh and Saltoro Blocks to those of Karakorum terrane. U-Pb zircon age of leuco-granites intrusion shows that it is younger than 15 Ma old. Movement on the fault displaces the sequence approximately 200-250 Km to Southeastern Tibet where the regional rock sequence can be regained (Burtman et



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al. 1963, Srimal 1983). It merges at the confluence defining a triple point and three blocks; the Ladakh Block to the south, Saltoro Block to the northwest, and the KB to the northeast.

A number of teleseismic events have occurred along the fault. Interpretation of seismic data from 1975 Kinnaur earthquake confirms right-lateral strike slip motion on this fault. Three events were recorded from Karakorum Fault Zone (KFZ) at the head of the Nubra valley, since 1980, recorded by portable seismic stations, established by International Karakorum Project (IKP). It is seismically an active fault.

### 2.4.2 Upper Hunza Fault

It is east west trending thrust fault that runs along the depression formed by the Chapursan and Upper Yarkhun valleys (Zanchi 1973, Kazmi 1979b, Gaetani ey al. 1995). In this region it runs parallel to the northern margin of the Karakorum Axial Batholith (KAB). Southeast of morkun (Upper Hunza) three teleseismic events of magnitude 5-7 and focal depth of less than 50 km have been recorded. These epicenters form a cluster very close to the mapped trace of the UHF. It means that the northern and western margins of the KAB is characterized by active zone of faulting along Upper Hunza-Reshun Fault zone.

### 2.4.3 Main Karakorum Thrust

The MKT is a low angle mega-shear with strike slip component, which on eastern side passes through Machlu in Hushe valley, Shigar valley, Zuhri Brook in Shyok valley and Chalt in Hunza valley extends westward through Ishkuman, Yasin and Shishi valleys **(DWG No: AFS-GE-292).**. Its general trend swings between east and - east-northeast at low to medium dips towards the north. It is believed that this Fault is seismically active.

### 2.4.4 Main Mantle Thrust

The MMT, which is aligned with the Nanga Parbat-Haramosh tectonic line on east, span an area of about 400 km through Diamir, Kohistan, Swat, Dir and Banjaur, before entering Afghanistan **(DWG No: AFS-GE-292).** The general trend of MMT is NE-SW. It is located along the contact of the mafic/calc-alkaline meta igneous rocks and the meta-sediments belonging to the Indo-Pakistan continental mass. Along this Megashear near Jijal village on Indus River (right bank), the igneous rocks have overthrusted the meta-sediments to the south over a 10-15 km wide zone. The thrust also manifests as the broad high topography of Kohistan relative to the Hazara adjacent to the south. In addition, numerous auxiliary fractures are developed and across the thrust frequent brecciation and mylonitization are also present along the contact. It is seismically active fault.



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# 3 SITE GEOLOGY

## 3.1 GENERAL

The Project Area lies in KB north of MKT. It is V-shape valley, originated by glacier and modified later on by Hunza River. It is stratigraphically as well as structurally controlled. The second highest peak of the World K-2 lies in this Range. The rock units comprise granitoides with pellite and psammite sequence ranging in age from Paleozoic to Cretaceous age.

## 3.2 SURFACE GEOLOGICAL MAP

The surface geological mapping has been carried out at scale of 1:1000, consists of 16 topo-sheets prepared by Survey Division Peshawar, HPO, WAPDA. During the site visit at left and right side of the Hunza River, different rock units have been studied and marked on the map and presented as drawing **(DWG No: AFS-GE-293 to 312).** Different geological units marked on map are summarized below:

### 3.2.1 Lithological Units

#### 3.2.1.1 Soil Units

The recent deposits are the most widely spread soil units overlies the bed rocks. The slopes are covered with overburden having variable thickness. Terrace deposits comprise mixtures of clay, sandy silt, boulders and gravel in various proportions. These units are mostly present in Aliabad, Karimabad, Nagar and Gojal **(DWG No: AFS-GE-293 to 312).**

The soil units present in the Project Area are described below: -

##### 3.2.1.1.1 Angular Boulder Gravels with Sand and Appreciable Amount of Fines (ABGM)

Most of the slopes are covered by material comprising of ABGM. This is colluvial material broken from the rock units rolled down slope and settled at the foothill or along the slopes.

These deposits are mainly associated with crushed/brecciated rock units, originated/caused by brittle deformation due to faulting/shearing at both sides. It has modified by erosion/weathering and accumulated as ABGM at foothills, forming active slides, along both side slopes.

##### 3.2.1.1.2 Rounded Boulder Gravels with Sand and Appreciable Amount of Fines (RBGM)

River bed is mainly occupied by RBGM material. Some exposure is also present at power house site near old Chinese Camp and Helipad Area. Due to formation of lake, the bed of the River is mostly covered with silt and sand extends up to Shishkat Bridge.



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#### 3.2.1.1.3 Terrace Deposits

Terrace Deposits consist mainly of mixture of clay, silt, sand and gravels with occasional boulders. These are mostly developed in loose material (RBGM, ABGM, Morainic and Breccia) **(DWG No: AFS-GE-302,305 & 309)** in all villages, depending upon the availability of water. Most of the irrigation water channels are coming from glaciers. In Central Hunza (Hyderabad, Aliabad and Karimabad) water coming from Ultar and Hassanabad Glaciers. Similarly, from Gulmit and Passu Glacier. The Terrace Deposits are excavated to fulfil requirement for irrigation water from the melting of these glaciers.

#### 3.2.1.1.4 Morainic Deposits

It consists mainly of material ranging in size from large boulders to clay size particles, angular to sub-angular, elongated and have flat surface **(DWG No: AFS-GE-299 & 302).** The direction of elongation indicates the route of advancement of glacier. These are well exposed throughout the valley.

### 3.2.1.2 Rock Units

The main rock units exposed in Project Area explored during Neo-tectonic Studies are as follows:

- Granitic gneiss
- Granodiorite
- Passu Slates
- Marbles

It is 70 to 120 km wide and 1400 km long structural zone comprises the Karakorum crustal plate which is one of the fragment of Cimmerian Collage derived from Gondwanaland and accerated to Eurasia. The stratigraphic history of the Karakorum is similar as that of Himalaya up to Cretaceous. The Project Site mostly present in the KAB consist of igneous and metamorphic rocks.

The brief description of the rock units is given below;

#### 3.2.1.2.1 Granitic Gneiss

It is light grey to grey in color on fresh surface and weathers to light brown, coarse to very coarse grained, moderately to highly jointed, highly sheared up to higher elevation due to faulting, sparsely to moderately weathered, moderately hard to hard. It has well developed foliation with trending value N61ºW and plunging value 79ºNE. It is exposed at the right as well as at the left bank of the Hunza River. Some shear zones are also present within the unit **(DWG No: AFS-GE-293 to 312).**

On the basis of petrographic analysis, it is evident that the major constituents' minerals present in Granitic Gneiss are Quartz, oligoclase, biotite while amphibole, chlorite, muscovite, epidote, and tourmaline are present as minor constituent minerals. The high percentage of quartz grains show strong strain extinction, indicating that this unit has Alkali Silica Reaction (ASR) potential.



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The rock may therefore not be used as a coarse aggregate with Ordinary Portland Cement (OPC) or High Alkali Cement. It may be used with low alkali cement, fly ash, pozzolan. Some chemical additives like lithium nitrate or silica fume can also be used to control this reaction. The Schmidt Hammer values ranges from **35** to **45 MPa** indicating that rock is moderately strong to very strong. But in some shear zone where rock is tectonized locally; this value reduces upto **18-22 MPa**.

#### 3.2.1.2.2 Granodiorite

It is dark grey to blackish grey in color, weathers to brownish grey, medium to coarse grained, moderately weathered, moderately hard to hard, moderately jointed intruded by pegmatite and granitic gneiss. It is foliated with trend and plunge values of N60ºW/79ºNE. Further downstream it becomes light grey to grey in color, coarse to very coarse grained. It is crushed, mylonized, and sheared at places. It is well exposed at both banks where it is intruded by many pegmatite dykes. Some shear zones are also present in this unit.

On the basis of petrographic analysis, it is evident that granodiorite is quite dominate in the Project Area. The major constituents' minerals present in this unit are plagioclase, quartz, biotite, and amphibole while Iron, muscovite, chlorite, and epidote are minor constituents. The high percentage of Quartz grains show strong strain extinction, indicating that this unit has Alkali Silica Reaction (ASR) potential. The rock may therefore not be used as an aggregate with Ordinary Portland Cement (OPC) or High Alkali Cement or it may be used with low alkali cement, slag, fly ash, pozzolana. Some chemical additives like lithium nitrate or silica fume can also be used to control this reaction.

## 3.3 GEOLOGICAL STRUCTURES

The Project Area tectonically lies in KB . These units have undergone Karakorum as well as Himalayan Orogeny. The whole area has undergone/modified by two major fault systems MKT and Karakorum Strike Slip Fault (KSSF). The MKT system which accommodated southward thrusting. Karakorum Fault 800 km long dextral strike-slip fault that bounds western Tibet, extending from the Pamirs to Gar Basin. As the Project Area has undergone multiple episodes of tectonics events, many regional as well as local faults and their splays have formed as discussed below.

### 3.3.1 Faults

Many thrust fault system related to regional faults are present in the Project Area. There are many faults present in the vicinity of proposed ALHPP **(DWG No: AFS-GE-293 to 312).** These faults are splays of MKT and KSSF, and lies in between these two fault systems. These include:

- Batura Glacier- Hussaini Fault
- Borith Lake-Shamshal Nullah Fault
- Shishkat- Gulkin Glacier Fault
- Attabad -Hispar Valley Fault
- Central Hunza/Nagar- Chalt Fault



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- Hassanabad Nullah Fault
- Hunza River-Nagar Fault

All these faults have been marked on the GT sheets and presented as **(DWG No: AFS-GE-318 to 320)**. The dip and strike values of major faults have been plotted on the drawings.

Some of these faults have been observed during Surface Geological mapping and marked on geological maps **(DWG No: AFS-GE-293 to 312).** The brief description of these units are: -

#### 3.3.1.1 Attabad-Hispar Valley Fault :

It is thrust fault striking N30°E and dipping 40°SE, and is well exposed at the left side slope near the Project Area **(DWG No: AFS-GE-293 to 312).** This fault crosses the Hunza River and forming a junction point with Hunza River and Attabad Fault in Attabad village. The whole rock mostly granitic gneiss along its alignment is sheared / brecciated, forming fault breccia at many places. Due to high degree of shearing, many active slides have been originated along the whole slope. Rolling down of large boulder is quite common, and can be seen on old KKH. The retaining wall along this slide is fractured/jointed into parts due to operational stresses and downslope load movement. The ABGM along the slope is folded. It is clear indication that this fault has some movement, and is seismically active.

#### 3.3.1.2 Attabad Fault:

This Thrust Fault is striking N60°W and dipping 52°NE, exposed in area rear of Attabad village. It is small scale fault and terminates along junction point of three faults. A large brecciated and sheared rock is present along this Thrust Fault. At the junction point of these faults **(DWG No: AFS-GE-293 to 312)** a large slide originated and destroyed about 2 Km of KKH. Sheared and brecciated rock can be seen on outcrop at right side slope up to higher elevation.

#### 3.3.1.3 Attabad River Fault:

The exposure of this fault is present at right side slope of Hunza River. The breccia is well exposed at right side, just downstream of Sarat Suspension Bridge. The intensity of brecciation increases towards Salamanabad village. In fact, Salamanabad village is established on this breccia. It may be present up to higher elevation **(DWG No: AFS-GE-293 to 312).**



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# 4 GEOLOGICAL & GEOTECHNICAL INVESTIGATIONS

## 4.1 SURFACE INVESTIGATIONS

The surface investigations / observations are one of the most important tools to reveal the geological conditions prevailing at the site. The natural processes operating on surface left clues to reveal the environments persisting in ancient time. Surface geological mapping is one of the best tool to check the geological conditions existing at site and to explore the deformation for the assessment of rock condition during the Feasibility Study.

### 4.1.1 Surface Geological Mapping

The Surface geological mapping of the Project Area has been carried out on 16 topographic sheets prepared by Survey Division Peshawar, HPO, WAPDA on scale 1:1000 with contour interval of 2 m, with the help of Total Station, Plane Table and Brunton compass and presented at scale of 1:2000 **(DWG No: AFS-GE-293 to 312).**The contacts between different rock units e,g granitic gneiss and granodiorite as well as between different soil units have been marked. Structural features like joint sets, faults, foliation and shear zones along with dip and strike values have been marked on these sheets.

Four geological cross sections were prepared along different alignments including, weir site, power tunnel intake area, penstock alignment & powerhouse area.

**Photo 4-1 Surface Geological Mapping**

### 4.1.2 Neo-tectonics Study

During the study of ALHPP, HPO, WAPDA, has identified the importance of Neo-tectonic studies, of this area being affected by Attabad slide in 2010. It is very important for the development of hydropower project in this area to develop the understanding of the Neo-tectonic setting operating under regional tectonic forces for the stability and planning of the hydropower project. All the geotechnical data procured during geotechnical investigations were



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utilized for foundation evaluation of weir, sediment flushing channel/ undersluices and power house.

The area under study has covered by the 2 GT sheets 42 L/15 and 42 L/11 at scale of 1:50,000, covering 40 km upstream and 50 km downstream of slided mass. These GT sheets were enlarged and printed at a scale of 1:15000 and presented at scale of 1:40,000, and used in field for alignment of local as well as regional faults **(DWG No: AFS-GE-318 to 320).**.

## 4.2 SUBSURFACE INVESTIGATIONS

Sub-surface geological and geotechnical investigation program was prepared to probe the sub-surface foundation conditions at weir, sediment flushing channel/ under sluices and power house including borehole drilling and test pits excavation. Drilling of exploratory bore holes was executed by Drilling Division, Hydroplaning, and supervised by Directorate of Geology, Hydro Planning WAPDA, Lahore.

### 4.2.1 Drilling

The main objective of drilling was to determine the nature and engineering characteristics of soil and rock units at weir sediment flushing channel/ undersluices and power house. It was performed to observe the subsurface geological conditions at depth in order to find out nature of the different strata in subsurface, to estimate the behavior and nature of overburden material, the depth of water table encountered. The bearing capacity of the soil, “N” values were obtained by performing Standard Penetration Test (SPT) in soil, determine depth to bed rock. To assess the f conductivity, insitu permeability test in overburden and water pressure test (Lugeon) in rock have been carried out.

A total 06 bore holes with total drilling of 401m have been drilled for subsurface exploration at different structures. **(DWG No: AFS-GE-316).** The coordinates, structure, and depths of borehole are given in **Table 4.1 & 4.2**

**Table 4-1 Co-ordinates of Boreholes**

| Sr. No | Borehole | Northing | Easting | Elevation (masl) |
|---|---|---|---|---|
| 1 | BH-1 | 4018100.45 | 484075.46 | 2415.79 |
| 2 | BH-2 | 4017996.26 | 484089.59 | 2452.81 |
| 3 | BH-3 | 4018061.58 | 483541.73 | 2456.92 |
| 4 | BH-4 | 4017721.34 | 482609.57 | 2445.37 |
| 5 | BH-5 | 4017906.94 | 481690.72 | 2318.04 |
| 6 | BH-6 | 4017906.55 | 481605.02 | 2313.84 |



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**Table 4-2 Location of Boreholes**

| Sr. No. | Borehole | Depth (m) | Location |
|---|---|---|---|
| 1 | BH-1 | 90 | Weir Site (Left abutment) |
| 2 | BH-2 | 60 | Sediment Flushing Channel |
| 3 | BH-3 | 61 | Sediment Flushing Channel |
| 4 | BH-4 | 80 | Power Tunnel Alignment |
| 5 | BH-5 | 50 | Power House Area |
| 6 | BH-6 | 60 | Power House Area |

**Photo 4-2 Drilling Rig at BH-02 Sediment Flushing Channel** .

For foundation evaluation of different structures, bore holes of varying depths have been drilled accordingly to estimated geological conditions prevailing in subsurface. Permeability tests have been performed using constant head method in overburden material at 3 m interval whereas water pressure tests (Lugeon tests) in bed rock have been performed at interval of 5 m or at change of strata. Rock cores and soil samples have been collected from all the bore holes at various depths for lab testing. All the tests have been conducted at CMTL, WAPDA Lahore. The logs of bore holes at different structures have been prepared. Permeability values in overburden material and lugeon values in rock have been calculated.

#### 4.2.1.1 Standard Penetration Tests (SPT)

SPT has been carried out in boreholes in overburden which mainly consists of silty sand with clay intercalations. Split spoon samplers have been used to collect the samples. The material encountered in SPT sampler mainly consists of clayey silt. SPT relied upon to provide information about the properties of soils / weak rocks. The principal use of the SPT is to examine, i.e., subsurface investigation profile, soil classification, the determination of geotechnical design parameters estimating liquefaction potential of soils. In foundation designs, SPT in overburden material, blow counts (N Values) are typically used to estimate nature and



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strength properties of soils used to calculate the bearing capacity for foundation. The results are presented in bore hole logs **Volume 4A**.

#### 4.2.1.2 Cone Penetration Test (CPT)

CPT have been carried out in boreholes in gravelly Silty Sand with Clay intercalations. CPT relied upon to provide information about the properties of soils / weak rocks. The principal use of the CPT is to examine geotechnical design parameters, estimating liquefaction potential of soils. In foundation designs, CPT blow counts are typically used to estimate nature and strength properties of soils, used to calculate the bearing capacity for foundation evaluation.

### 4.2.2 Test Pits

A total of 10.test pits (3 m×3 m ×3 m) have been excavated in overburden material at weir site, slope along sediment flushing channel and power house area. Composite samples by cone and quarter method have been collected from each test pit. Different tests have been conducted on these samples to estimate the engineering properties of material.

To identify and proven source for coarse as well as fine aggregate, 4 test pits have been excavated. Samples collected from these pits were sent to CMTL, WAPDA, Lahore for testing to check their suitability for fine as well as coarse aggregate. The logs of test pits have been prepared and presented in **Volume 4A.**

### 4.2.3 Laboratory Testing

To investigate the engineering properties of rock and overburden material different rock cores and soil samples at weir, sediment flushing channel / under sluices and power house site have been sent to CMTL Lahore.

A total of 10 rock core samples from BH-04 (Power tunnel alignment)have been selected for evaluation of geotechnical engineering parameters for design purpose **(Table 4.3)**. The table below shows the testing program proposed in BH-04 at different depths.

A total of 15 samples, i.e. 3 block sample, 3 samples from borrow area, and 9 test pit samples have been selected for investigations. Samples from all tests pits have been selected by cone and quarter method and different test given in **(Table 4.4),** have been proposed to check their engineering properties and confirm their suitability as aggregate material.

All the laboratory tests on rock core samples have been conducted in CMTL WAPDA, Lahore. The detailed results are presented in laboratory testing **Volume 4B.**



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**Table 4-3 Proposed Laboratory Test on Rock Core Samples**

| Sr.No | Borehole No. | Location | Sample Name | Depth (m) | Sample length (cm) | Index Properties Test | Point Load Test | Hoek Triaxial Compression Test | Uniaxial Compressive Strength test | Indirect Tensile Strength | Rock Core Modulus | Hoek Direct Shear | Petrographic Analysis |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | BH-04 | Head Race Tunnel | ALHPPBH4-01 | 21.00-21.15 | 15 | | √ | | | | | | |
| 2 | | | ALHPPBH4-02 | 31.21-31.52 | 31 | | √ | | | | | | |
| 3 | | | ALHPPBH4-03 | 38.14-38.43 | 29 | √ | | | √ | | | | |
| 4 | | | ALHPPBH4-04 | 43.25-43.55 | 30 | √ | √ | | | √ | | | |
| 5 | | | ALHPPBH4-05 | 48.00-48.25 | 25 | | | | | | √ | | |
| 6 | | | ALHPPBH4-06 | 52.60-53.00 | 40 | √ | | √ | | | | | |
| 7 | | | ALHPPBH4-07 | 56.00-56.39 | 39 | √ | | | √ | | | √ | √ |
| 8 | | | ALHPPBH4-08 | 61.00-61.24 | 24 | | | | | | √ | | |
| 9 | | | ALHPPBH4-09 | 63.00-63.35 | 35 | √ | | √ | | | | | |
| 10 | | | ALHPPBH4-10 | 68.00-68.23 | 23 | √ | | | √ | | | | |



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**Table 4-4 Lab Testing On Test Pits Samples and Borrow area**

| Sr. No | TEST PIT | Depth (m) | Grain Size Analysis | Hydrometer | Unit Weight | NMC | UCS | Alkali Carbonate Reaction | Point Load Test | Rock Core Modulus | Petrographic Analysis | Specific Gravity | Flakiness | Water Absorption | Crushing Value | Los angeles Abrasion Test | Sulphate Soundness | Accelerated Motorbar | Atterberg Limits and Shrinkage Limit | Swelling Potential | Modified Proctor test | Consolidation Test | Organic Contents |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | TP-1 | 0.0-1.3 | √ | | | | | | | | | √ | | √ | | | | | | | | | √ |
| 2 | TP-2 | 0.0-2.0 | √ | | | | | | | | | √ | | √ | | | | | | | | | √ |
| | | 2.0-3.0 | √ | √ | | | | | | | | | | √ | | | | | √ | √ | √ | | |
| 3 | TP-3 | 0.0-3.0 | √ | √ | | | | | | | | √ | | √ | | | | | √ | √ | √ | | √ |
| 4 | TP-4 | 0.0-1.5 | √ | √ | | | | | | | | √ | | √ | | | | | √ | | √ | | √ |
| | | 1.5-3.0 | √ | √ | | | | | | | | √ | | √ | | | | | √ | √ | | | |
| 5 | TP-5 | 0.0-1.5 | √ | | | | | | | | | √ | | √ | | | | | | | | | √ |
| | | 1.5-3.0 | √ | √ | | | | | | | | | | | | | | | √ | √ | | | |
| 6 | TP-6 | 0.0-3.0 | √ | | | | | | | | | √ | | √ | √ | | | | | | | | |
| 7 | TP-7 | 0.0-3.0 | √ | | | | √ | | | | | | | | | √ | | | | | | | |
| 8 | TP-8 | 0.0-3.0 | √ | | | | √ | | √ | | | √ | √ | √ | √ | | | | | | | | |
| 9 | TP-9 | 0.0-3.0 | √ | | | | √ | | | | | | √ | | | | | | | | | | |
| 10 | Block (TP-3) | 1.0 | √ | √ | √ | √ | | | | | | √ | | √ | | | | | √ | √ | √ | √ | |
| 11 | Block (A) TP-10 | 0.5 | √ | √ | √ | √ | | | | | | √ | | √ | | | | | √ | √ | √ | √ | |
| 12 | Block (B) TP-10 | 1.5 | √ | √ | √ | √ | | | | | | √ | | √ | | | | | √ | √ | | √ | |
| 13 | Passu | | | | | | √ | √ | √ | √ | | √ | √ | √ | √ | √ | √ | √ | | | | | |
| 14 | P/H Area | | | | | | √ | | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | | | | | |
| 15 | Slided Mass | | | | | | √ | | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | | | | | |



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# 5 EVALUATION OF LABORATORY TESTS

## 5.1 PETROGRAPHIC ANALYSIS

A total of 06 petrographic analyses have carried out to confirm the mineral assemblage in the particular rock unit. Another important feature of petrographic analysis is to determine Alkali Silica Reaction (ASR) by estimating the percentage of deleterious mineral especially quartz grains showing strong extinction to check it suitability in concrete mix design with Ordinary Portland Cement (OPC). For this purpose, 2 samples have been collected through excavation of test pits, 2 samples from different locations have been collected during surface geological mapping, and 01 drilling core sample has been collected from power tunnel alignment. The mineral assemblage more than 5% is considered as major mineral while other with less than 5% is consider as minor minerals. The detail is given in table below: -

**Table 5-1 Petrographic Analysis Results**

| Sr. No. | Borehole No. | Rock Name | Major Minerals | | | | | Minor Minerals | | | | | Remarks / Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Quartz | K-Feldspar | Oligoclase | Biotite | Amphibole | Magnetite | Chlorite | Epidote | Muscovite | Carbonate | |
| 1 | Rock Samples | Foliated Granite | 24 | 18 | 17 | 21 | 1 | 2 | 2 | 6 | 7 | 1 | ASR Potential exists |
| 2 | | Granite | 32 | 26 | 14 | 6 | 3 | 2 | 4 | 1 | 3 | 3 | ASR Potential exists |
| 3 | | Granodiorite | 24 | 11 | 20 | 15 | 16 | 2 | 3 | 5 | 2 | 2 | ASR Potential exists |
| 4 | | Granodiorite | 26 | 12 | 25 | 14 | 11 | 2 | 3 | 3 | 2 | 2 | ASR Potential exists |
| 5 | BH-04 | Granitic Gneiss | 30 | 13 | 28 | 17 | 4 | 1 | 3 | 1 | 2 | 1 | ASR Potential exists |

The petrographic analysis shows that granodiorite and granitic gneiss are the major rock units exposed at the Project Site. Quartz, plagioclase, K-feldspar, amphibole and biotite are the major mineral constituents. Both rocks units show strong quartz grains extinction and are deleterious in nature. Due to this reason, these rock units cannot be used with ordinary portland cement (OPC) as coarse aggregate. It can be used with low alkali cement, slag cement or cement with additives like fly-ash, pozzoloan, and chemical additives like lithium nitrate or silica fume.

Rock samples (Marble) from Passu village area along KKH have been collected and sent to laboratory to conduct petrographic analysis. Result shows that, marble consists of 91.5% calcite, 5% dolomite, with quartz, magnetite and muscovite as minor minerals. The rock has no alkali carbonate nor alkali silica and therefore can be used as coarse aggregate with OPC.

## 5.2 DIRECT SHEAR TEST

One sample from BH-04 has been selected for Direct Shear Tests from depth of 56 to 56.35m. Both normal and shear stress have been applied gradually to observe the strain and displacement rate, under applied stress. The result shows that cohesion “C” has 0.595 MPa with angle of shear resistance “ϕ” is 21.8 deg.



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The direct shear test results show that both values are in safe limit, indicating that rock is moderately strong to strong.

## 5.3 ROCK CORE MODULUS

02 core samples from BH-04 and 3 bulk samples from borrow area have been selected to carry out the Rock Core Modulus including Young's Modulus, and Modulus of Deformation, for which the mode of failure has also been observed and presented in table 5-2

**Table 5-2 Rock Core Modulus Test Results**

| Sr. No. | Bore Hole | Location | Depth (m) | | Test Results (MPa) | | |
|---|---|---|---|---|---|---|---|
| | | | From | To | Young's Modulus | Modulus of Deformation | Mode of Failure |
| 1 | BH-04 | Power Tunnel Alignment | 48.0 | 48.25 | $2.29*10^4$ | $1.15*10^4$ | Axial |
| 2 | | | 61.0 | 61.30 | $1.83*10^4$ | $9.16*10^3$ | Axial |
| 3 | Bulk Samples | Passu Area | - | - | $7.52*10^4$ | $3.76*10^4$ | Diagonal & Axial |
| 4 | | Powerhouse Area | - | - | $4.16*10^4$ | $2.08*10^4$ | Diagonal & Axial |
| 5 | | Slided Mass | - | - | $4.96*10^4$ | $1.88*10^4$ | Diagonal |

Rock samples from BH-04 show "Axial" mode of failure while bulk samples for borrow area of coarse aggregate shows "Diagonal & Axial" mode of failure exists with relative low Poisson's Ratio. The values of Young's Modulus indicate that all the rocks encountered are moderately hard to hard. Result of borrow area shows that the Passu Area rock (Marble) show very high value with diagonal as well as axial mode of failure, this shows that marble is hardest among all samples for borrow area.

## 5.4 POINT LOAD STRENGTH INDEX (PLSI) TEST

A total of 7 samples, 3 from BH-4 and 4 from borrow area have been selected to carry out (PLSI) Test. The main purpose of the (PLSI) Test is to determine/calculate the strength index of rock mass. For this purpose, ASTM standard D 5731-95 has been used to carry out the (PLSI) Test. The values of these tests are given in table below: -

**Table 5-3 Point Load Strength Index Test Results**

| Sr. No. | Bore Hole No. | Location | Depth (m) | | Test Results | | |
|---|---|---|---|---|---|---|---|
| | | | From | To | Is (Mpa) | Is 50 (Mpa) | Failure |
| 1 | BH-04 | Power Tunnel Alignment | 21.00 | 21.15 | 4.04 | 3.93 | Diametrically |
| 2 | | | 31.21 | 31.52 | 5.39 | 5.23 | Diametrically |
| 3 | | | 43.25 | 43.55 | 3.14 | 3.05 | Diametrically |
| 4 | Bulk Samples | TP-08 | - | - | 1.81 | 1.66 | Diametrically |
| 5 | | Passu Area | - | - | 4.11 | 4.30 | Diametrically |
| 6 | | Powerhouse Area | - | - | 3.97 | 4.15 | Diametrically |
| 7 | | Slided Mass | - | - | 5.68 | 5.94 | Diametrically |

Point Load Index value is an index of strength but not a strength value. The above table shows that all the values except 1.66 MPa (TP-08) is relatively low while all others have reasonably good values which proves that rock strength is moderately high and durable.



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## 5.5 UNIAXIAL COMPRESSIVE STRENGTH (UCS) TEST

A total of 9 samples, 3 samples from BH-04, 3 samples from test pits, and 3 bulk samples from different borrow areas have been selected to carry out the (UCS) Test. The main purpose of the (UCS) Test is to determine the compressive strength under uniaxial load in an unconfined state. The strength is determined by using ASTM standard D-2938. The values are given in table below: -

**Table 5-4 Uniaxial Compressive Strength Test Results**

| Sr. No. | Bore Hole / Test Pits | Location | Depth (m) | | Test Results | |
|---|---|---|---|---|---|---|
| | | | From | To | UCS (MPa) | Failure Mode |
| 1 | BH-04 | Power Tunnel Alignment | 38.14 | 38.43 | 49.2 | Diagonal |
| 2 | | | 56.00 | 56.39 | 45.2 | Diagonal |
| 3 | | | 68.00 | 68.23 | 38.5 | Diagonal |
| 4 | TP-7 | Slided Mass (Left side) | - | - | 52.40 | Diagonal |
| 5 | TP-8 | Slided Mass (Right side) | - | - | 71.91 | Diagonal |
| 6 | TP-9 | Slided Mass (Right side) | - | - | 34.63 | Diagonal |
| 7 | - | Passu Area | - | - | 47 | Diagonal |
| 8 | - | P/H Area | - | - | 88 | Diagonal & Axial |
| 9 | - | Slided Mass | - | - | 59 | Diagonal & Axial |

The rock strength given in table shows that the rock has medium strength and moderately hard.

## 5.6 INDIRECT TENSILE STRENGTH (ITS) TEST

(ITS) Test has been carried out on core sample collected from BH-04, at depth from 43.25 to 43.55m. A cylindrical specimen is loaded diametrically and tensile deformation perpendicular to the loading direction yields a tensile failure. ASTM standard D-3967 has been used to carry out the indirect tensile strength.

The (ITS) Test is mostly estimated as 10 to 15% of Uniaxial Compressive Strength (UCS). The lab test value is 6.46 MPa which indicates that rock is moderately hard.

## 5.7 HOEK TRIAXIAL COMPRESSIVE STRENGTH (HTCS) TEST

(HTCS)Test has been carried out on 2 rock core samples collected from different depths from BH-04. (HTCS) Test is used to determine the shear strength of rock samples. The test can determine that how applied stress is related to deformation experienced by rock samples as well as to determine the angle of internal friction and cohesion of the rock samples. ASTM standard D-2664 has been used to carry out the (HTCS) Test. The values are given in table below: -



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**Table 5-5 Hoek Triaxial Compressive Strength Test Results**

| Sr. No. | Borehole No. | Depth | | Cohesion "C" MPa | Angle (Ø) deg. |
|---|---|---|---|---|---|
| | | From | To | | |
| 1 | BH-04 | 52.60 | 53.00 | 2.18 | 27.749 |
| 2 | | 63.00 | 63.35 | 0.60 | 15.543 |

The values of cohesion "C" and angle of internal friction "**Ø**" calculated by (HTCS)Test, given in table indicates that the shear strength of the rock core samples is low to moderate.

## 5.8 PROPERTY INDEX

A total of 6 rock core samples from BH-04 at different depths have been sent to CMTL, Lahore. Property index tests were conducted under ISRM standard to determine the properties of rock. The table below shows results of test on rock core samples

**Table 5-6 Property Index Test (Core) Results**

| Sr No. | Sample | Depth | | NMC (%) | Sp. Gravity | Porosity | Dry Density | Water Abs. (%) |
|---|---|---|---|---|---|---|---|---|
| | | From | To | | | | | |
| 1 | BH-04 | 38.14 | 38.43 | 0.12 | 2.73 | 1.58 | 2.69 | 0.59 |
| 2 | | 43.25 | 43.55 | 0.21 | 2.76 | 1.17 | 2.72 | 0.43 |
| 3 | | 52.60 | 53.00 | 0.04 | 2.77 | 0.69 | 2.75 | 0.25 |
| 4 | | 56.00 | 56.39 | 0.27 | 2.77 | 1.25 | 2.73 | 0.46 |
| 5 | | 63.00 | 63.35 | 0.07 | 2.76 | 0.81 | 2.73 | 0.30 |
| 6 | | 68.00 | 68.23 | 0.09 | 2.77 | 0.72 | 2.75 | 0.26 |

**Table 5-7 Property Index Test (Test Pits) Results**

| Sr No. | Sample | Material | Sp. Gravity | Org. Impurities | Water Abs. (%) |
|---|---|---|---|---|---|
| 1 | TP-1 | Fine | 2.68 | NIL | 1.11 |
| 2 | TP-2 | Coarse | 2.71 | - | - |
| 3 | | Fine | 2.65 | NIL | 1.20 |
| 4 | TP-3 | Fine | 2.17 | NIL | - |
| 5 | TP-4 | Fine (0.0-1.5m) | 2.30 | NIL | - |
| 6 | | Fine (1.5-3.0m) | 2.27 | - | - |
| 7 | TP-5 | Fine | 2.36 | NIL | - |
| 8 | TP-6 | Coarse | 2.67 | - | - |
| 9 | | Fine | 2.70 | - | 1.04 |
| 10 | TP-8 | Coarse | 2.72 | - | - |
| 11 | | Fine | 2.69 | - | 1.12 |
| 12 | Block (TP-3) | Fine | 2.36 | - | - |
| 13 | Block A (TP-10) | Fine | 2.38 | - | - |
| 14 | Block B (TP-10) | Fine | 2.30 | - | - |
| 15 | Passu | Coarse | 2.84 | - | 0.37 |
| 16 | P/H Area | Coarse | 2.78 | - | 0.27 |
| 17 | Slided mass | Coarse | 2.75 | - | 0.33 |



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The values given in table 5.7 (A&B) shows that all the values of fine and coarse aggregate fall in permissible limits besides water absorption test which shows some relative higher values with no organic impurities.

## 5.9 LOS ANGELES ABRASION (LAA) TEST

A total of 4 samples, from test pits, of different borrow areas have been selected to carry out the (LAA) Test. The main purpose of this test is to indicate aggregate toughness and abrasion characteristics. Aggregate abrasion characteristics are important because the constituent coarse aggregate must resist crushing, degradation and disintegration. ASTM standard C-131 is used to perform this test for 500 revolutions. The values are given in table below

**Table 5-8 Los Angeles Abrasion Test Results**

| Sr. No. | Test Pits | Location | Test Results | |
|---|---|---|---|---|
| | | | Percentage (%) Wear | Uniformity of wear |
| 1 | TP-7 | Slided Mass (Left side) | 48 | 0.41 |
| 2 | - | Passu Area (marble) | 27 | 0.20 |
| 3 | - | Power House Area | 18 | 0.21 |
| 4 | - | Slided Mass | 56 | 0.34 |

(LAA) Test results indicate that, samples of Passu Area (marble) and powerhouse area show minimum wearing ability and values ranges within the permissible limits while TP-7 and samples from slided mass show high percentage of wearing.

## 5.10 SULPHATE SOUNDNESS TEST

A total of 03 samples, from different borrow areas have been selected to carry out the Sulphate Soundness Test. The main purpose of this test is to determine the aggregate resistance to change of volume due to change of physical condition and weathering. These physical conditions include freezing and thawing, temperature change, alternative change of drying and wetting in normal condition and alternative change of drying and wetting in salt water for 5 No. of cycles. ASTM standard C-88 is used to perform this test. The values are given in table below: -

**Table 5-9 Sulphate Soundness Test Results**

| Sr. No. | Location | Test Results | | |
|---|---|---|---|---|
| | | % Passing Designated Sieve after Test | Weighted Percent Loss | Total |
| 1 | Passu Area | 0.96 | 0.89 | 0.89 |
| 2 | Power house | 0.85 | 0.81 | 0.81 |
| 3 | Slided Mass | 1.88 & 1.78 | 1.69 & 0.18 | 1.87 |

Sulphate Soundness Test results indicates that, samples of Passu Area (marble) and powerhouse area show minimum loss while slided mass material shows relatively double values. Therefore, both can be used as an aggregate with concrete.



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## 5.11 CRUSHING VALUE OF AGGREGATE

A total of 5 samples, 2 samples from test pits and 3 samples from different borrow areas have been selected to carry out crushing value of aggregate. The main purpose of this test is to determine the aggregate resistance to wear and tear. BS-812 (1990) Part 110 is used for performing this test with fraction used (3/4"-1/2"). The values are given in table below: -

**Table 5-10 Crushing Value of Aggregate Test Results**

| Sr. No | Location | Depth | Crushing Value |
|---|---|---|---|
| 1 | TP-6 | 0.0-3.0 | 43 |
| 2 | TP-8 | 0.0-3.0 | NP |
| 3 | Passu Area | - | 24 |
| 4 | Powerhouse Area | - | 27 |
| 5 | Slided Mass | - | 22 |

Table 5-10 shows that, samples of Passu area (marble), powerhouse area and slided mass fall in permissible limits while TP-6 shows relatively high value.

## 5.12 FLAKINESS/ELONGATION INDEX

A total of 5 samples, 2 samples from test pits and 3 samples from different borrow areas have been selected to carry out the particle shape of the aggregate specimen and each particle shape being preferred under specific condition. For cement concrete types and base coarse construction and bituminous-construction, the presentence of flaky and elongated aggregate particles are considered undesirable as they may cause inherent weakness with possibility of breaking down under heavy loads. BS-812 Part 105.1 & 105.2 is used for performing this test. The values are given in table below: -

**Table 5-11 Flakiness/Elongation Index Test Results**

| Sr. No. | Location | Depth | Flakiness Index |
|---|---|---|---|
| 1 | TP-8 | 0.0-3.0 | 13 |
| 2 | TP-9 | 0.0-3.0 | 04 |
| 3 | Passu Area | - | 22 |
| 4 | Powerhouse Area | - | 23 |
| 5 | Slided Mass | - | 21 |

Table 5-11 shows that, all samples fall in permissible limits.

## 5.13 CONSOLIDATION TEST

A total of 3 samples undisturbed box samples, from different test pits have been selected to carry out consolidation tests. The main purpose of this test is to determine the magnitude and rate of consolidation of soil when it is restrained laterally and drained axially while subjected to incremental applied controlled stress loading. ASTM Standard D-2435 is used to perform this test. The values are given in table below: -



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**Table 5-12 Consolidation Test Results**

| Sr. No | Block Sample | Moisture Contents | | Bulk Density mg/cm | | Dry Density mg/cm | | Void Ratio "e" | | Saturation (%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Initial | Final | Initial | Final | Initial | Final | Initial | Final | Initial | Final |
| **1** | TP-10 (A) | 9.8 | 27.0 | 1.66 | 1.97 | 1.51 | 1.55 | 0.775 | 0.725 | 33.8 | 99.8 |
| **2** | TP-10 (B) | 4.2 | 29.0 | 1.52 | 1.94 | 1.46 | 1.51 | 0.837 | 0.778 | 13.4 | 99.8 |
| **3** | TP-3 | 6.9 | 27.7 | 1.54 | 1.96 | 1.44 | 1.54 | 0.866 | 0.744 | 21.5 | 99.7 |

Consolidation plays an important role in stability analysis for the embankment, footings or a column constructed on clayey soils. The settlement behavior of these structures and the pore pressure needs to be investigated for construction on these soils. Table 5-12 shows that, the clayey silt fall in permissible limits and therefore may be considered as impervious blanketing material.

## 5.14 SWELLING POTENTIAL, UNIT WEIGHT AND NMC

A total of 7 soil (clayey silt) samples, i.e. 3 undisturbed block samples, 4 disturbed samples from different test pits have been selected to investigate swelling potential of soil. The main purpose of this test is to determine the swelling potential when come in contact with water. The values are given in table below: -

**Table 5-13 Swell Potential, Unit Weight and NMC**

| Sr. No | Location | Depth | Swell Potential (KPa) | Unit Weight mg/m$^3$ | NMC (%) |
|---|---|---|---|---|---|
| 1 | TP-2 | 2.0-3.0 | 39.5 | - | - |
| 2 | TP-3 | 0.0-3.0 | 30.0 | - | - |
| 3 | TP-4 | 1.5-3.0 | 12.5 | - | - |
| 4 | TP-5 | 1.5-3.0 | 31.5 | - | - |
| 5 | Block (TP-3) | 1.0 | 22.5 | 1.683 | 3.88 |
| 6 | Block (TP-10) A | 0.5 | 23.0 | 1.688 | 3.72 |
| 7 | Block (TP-10) B | 1.5 | 25.0 | 1.691 | 3.18 |

All the samples of clayey silt show high swelling potential irrespective of TP-4, having moderate swelling potential and needs proper attention prior to their use as fine aggregate or for the foundation while unit weight and NMC fall in permissible limits.

## 5.15 MODIFIED PROCTOR TEST

A total of 5 of samples, from different test pits of borrow areas have been selected to carry out Modified Proctor test. The main purpose of this test is to determine the maximum compaction at corresponding moisture content of different types of soil and the relationship between dry density and moisture content. ASTM standard D-1557 is used to carry out this test. The values are given in table below:



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**Table 5-14 Modified Proctor Test Results**

| Sr. No | Location | Depth | Max. Dry Density (mg/m$^3$) | O.M.C (%) |
|---|---|---|---|---|
| 1 | TP-2 | 2.0-3.0 | 1.893 | 13.30 |
| 2 | TP-3 | 0.0-3.0 | 1.887 | 13.05 |
| 3 | TP-4 | 0.0-1.5 | 1.783 | 10.54 |
| 4 | Block TP-3 | 1.0 | 1.881 | 12.87 |
| 5 | Block TP-10 | 0.5 | 1.878 | 12.80 |

Table 5-14 shows that, all the values fall in permissible limits.

## 5.16 ACCELERATED MORTAR BAR TEST

A total of 5 samples; 2 samples from test pits and 3 bulk samples from different borrow areas have been selected to carry out Accelerated Mortar Bar Test. The main purpose of this test is to determine the changes in volume / expansion of material, either fine or coarse when mixed with ordinary Portland Cement (OPC) and reading for 28 days. ASTM Standard C-1260 is used to conduct this test. The values are given in table below: -

**Table 5-15 Accelerated Mortar Bar Test Results**

| Sr. No | Location | Depth | Material | Average Change (28 days) | Average Expansion (28 days) |
|---|---|---|---|---|---|
| 1 | TP-1 | 0.0-1.3 | Fine aggregate | 0.099 | 0.039 |
| 2 | TP-2 | 0.0-2.0 | Fine aggregate | 0.106 | 0.042 |
| 3 | Passu Area | - | Coarse aggregate | 0.235 | 0.093 |
| 4 | P/H Area | - | Coarse aggregate | 0.251 | 0.099 |
| 5 | Slided mass | - | Coarse aggregate | 0.246 | 0.097 |

All values of coarse as well as fine aggregate fall under permissible limits and can be used as concrete aggregate with OPC.

## 5.17 GRAIN SIZE ANALYSIS

A total of 15 of samples, from each test pits at different depth have been selected to carry out Grain Size Analysis. The main purpose of this test is to determine the different grain sizes contained within a soil. The mechanical or sieve analysis is performed to determine the distribution of the coarser, larger-sized particles, and the hydrometer method is used to determine the distribution of the finer particles. ASTM standard D-422 is used to carry out this test. The values are given in table below:



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**Table 5-16 Grain Size Analysis Results**

| Sr. No. | Test Pit | Depth (m) | Boulder % | Gravel % | Cobbles % | Sand % | Passing # 200 | Silt % | Clay % |
|---|---|---|---|---|---|---|---|---|---|
| 1 | TP-1 | 0.0-1.3 | | 0 | | 99 | 1 | | |
| 2 | TP-2 | 0.0-2.0 | | 0 | | 76 | 24 | | |
| 3 | | 2.0-3.0 | | 0 | | 0 | | 55 | 45 |
| 4 | TP-3 | 0.0-3.0 | | 0 | | 0 | | 58 | 42 |
| 5 | TP-4 | 0.0-1.5 | | 0 | | 51 | | 39 | 10 |
| 6 | | 1.5-3.0 | | 0 | | 24 | | 66 | 10 |
| 7 | TP-5 | 0.0-1.5 | | 0 | | 48 | 52 | | |
| 8 | | 1.5-3.0 | | 0 | | 0 | | 65 | 35 |
| 9 | TP-6 | 0.0-3.0 | 0 | 56 | 11 | 12 | 21 | | |
| 10 | TP-7 | 0.0-3.0 | 0 | 62 | 11 | 22 | 5 | | |
| 11 | TP-8 | 0.0-3.0 | | 0 | | 72 | 28 | | |
| 12 | TP-9 | 0.0-3.0 | | 0 | | 63 | 37 | | |
| 13 | Block (TP-3) | 1.0 | | 0 | | 1 | | 59 | 40 |
| 14 | Block (A) TP-10 | 0.5 | | 0 | | 0 | | 60 | 40 |
| 15 | Block (B) TP-10 | 1.5 | | 0 | | 0 | | 56 | 44 |

## 5.18 ATTERBERG LIMITS

A total of 8 samples, from different depth of test pits have been selected to carry out Atterberg Limits. The main purpose of this test is to determine the critical water contents of a fine-grained soil, its shrinkage limit, plastic limit, and liquid limit. The Atterberg limits can be used to determine the response of soil to change in moisture content exhibiting the consistency from hard and soft to rigid and pliable, termed as plasticity. ASTM standard D-422 is used to carry out this test. The values are given in table below: -

**Table 5-17 Atterberg Limits Results**

| Sr. No. | Test Pit No. | Depth (m) | L.L % | P.L % | P.I % | Shrinkage. Limit % |
|---|---|---|---|---|---|---|
| 1 | TP-2 | 2.0-3.0 | 43 | 31 | 12 | 25.2 |
| 2 | TP-3 | 0.0-3.0 | 40 | 29 | 11 | 23.8 |
| 3 | TP-4 | 0.0-1.5 | NP | - | - | - |
| 4 | | 1.5-3.0 | NP | - | - | - |
| 5 | TP-5 | 1.5-3.0 | 39 | 31 | 8 | 26.1 |
| 6 | Block (TP-3) | 1.0 | 43 | 33 | 10 | 27.8 |
| 7 | Block (A) TP-10 | 0.5 | 45 | 34 | 11 | 29.1 |
| 8 | Block (B) TP-10 | 1.5 | 46 | 34 | 12 | 28.9 |



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# 6 GEOLOGY AND FOUNDATION EVALUATION

## 6.1 GENERAL

The rocks exposed in Project Area consists of granodiorite and granitic gneiss (ganitoide) intruded by pegmatite dykes belong to Karakorum Batholith. Most of the structures i.e. weir with overtopping spillway, sediment flushing channel, pedestals of penstock and powerhouse lie on overburden material. About 2.1 km long power tunnel is proposed at left side and will be excavated through granodiorite and granitic gneiss.

On the basis of surface geological mapping, geological x-sections, borehole logs, test pits excavation and laboratory test results, the foundation evaluation of various engineering structures proposed for Attabad Lake Hydropower Project (ALHP) have been made and describe in the following sections: -

## 6.2 WEIR SITE

### 6.2.1 Surface Geological Mapping

The surface geological mapping of the main weir area has been carried out at a scale of 1:1000 with the help of Total Station, Plane Table and Brunton Compass and presented at 1:2000 scale. A geological X-section along line AA` has been developed and presented as drawing **(DWG No: AFS-GE-313).** The main purpose to develop geological x-section is to estimate condition prevailing in subsurface i.e. overburden thickness, extension / alignment of faults, extension / trend of rock units in the subsurface.

**Photo 6-1 A View of Weir Site.**

An overtopping concrete weir founded on slided mass is proposed after foundation treatment. Geological rock units with which weir has to be abut, includes granodiorite, intruded by pegmatite veins at right side. On left side, weir has to be abut with ABGM formed by slided mass **(DWG No: AFS-GE-297 & 298).** Some treatment / engineering solution have to be implemented for stability of the weir **(Photo 6-1)**.



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### 6.2.2 Boreholes Drilling at Weir Site

A borehole BH-01, has been drilled at left side slope to investigate the subsurface geological conditions. The location of the boreholes is presented on drawing **(DWG No: AFS-GE-316).** No rock has been encountered in this borehole up to 90 m. The core recovery CR (%) and permeability test results are given in **Table 6-1**, and graphically presented in **Figure 6-1**. The permeability tests were conducted after every 3 m. In most of tests, head could not be maintained due to cavities/ open works encountered in subsurface. The borehole has been stabilized with cement.

**Table 6-1 Summary of BH-01 (Weir Site Left Abutment)**

| ATTABAD LAKE HPP | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| BH-01 | | | | | | | | | | | |
| Depth (m) | | CR (%) | K-Value (cm/sec) | Depth (m) | | CR (%) | K-Value (cm/sec) | Depth (m) | | CR (%) | K-Value (cm/sec) |
| From | To | | | From | To | | | From | To | | |
| 0.5 | 1 | 0 | | 31 | 32 | 62 | | 61 | 62 | 54 | |
| 1 | 2 | 0 | | 32 | 33 | 88 | | 62 | 63 | 44 | Head Failure |
| 2 | 3 | 40 | | 33 | 34 | 83 | Head Failure | 63 | 64 | 55 | |
| 3 | 4 | 39 | 0.046178 | 34 | 35 | 100 | | 64 | 65 | 31 | |
| 4 | 5 | 78 | | 35 | 36 | 70 | | 65 | 66 | 32 | Head Failure |
| 5 | 6 | 60 | | 36 | 37 | 78 | Head Failure | 66 | 67 | 44 | |
| 6 | 7 | 17 | Head Failure | 37 | 38 | 58 | | 67 | 68 | 45 | |
| 7 | 8 | 40 | | 38 | 39 | 69 | | 68 | 69 | 88 | |
| 8 | 9 | 29 | | 39 | 40 | 45 | | 69 | 70 | 61 | Head Failure |
| 9 | 10 | 31 | Head Failure | 40 | 41 | 46 | Head Failure | 70 | 71 | 56 | |
| 10 | 11 | 30 | | 41 | 42 | 45 | | 71 | 72 | 53 | |
| 11 | 12 | 32 | | 42 | 43 | 53 | | 72 | 73 | 65 | Head Failure |
| 12 | 13 | 12 | Head Failure | 43 | 44 | 68 | Head Failure | 73 | 74 | 65 | |
| 13 | 14 | 42 | | 44 | 45 | 81 | | 74 | 75 | 77 | |
| 14 | 15 | 90 | | 45 | 46 | 56 | | 75 | 76 | 87 | Head Failure |
| 15 | 16 | 49 | 0.002858 | 46 | 47 | 89 | Head Failure | 76 | 78 | 87 | |
| 16 | 17 | 43 | | 47 | 48 | 65 | | 78 | 79 | 64 | Head Failure |
| 17 | 18 | 16 | | 48 | 49 | 58 | | 79 | 80 | 37 | |
| 18 | 19 | 96 | 0.012294 | 49 | 50 | 63 | Head Failure | 80 | 81 | 89 | |
| 19 | 20 | 100 | | 50 | 51 | 66 | | 81 | 82 | 57 | Head Failure |
| 20 | 22 | 90 | | 51 | 52 | 33 | | 82 | 83 | 32 | |
| 22 | 23 | 65 | | 52 | 53 | 28 | Head Failure | 83 | 84 | 45 | |
| 23 | 25 | 98 | Head Failure | 53 | 54 | 58 | | 84 | 85 | 38 | Head Failure |
| 25 | 26 | 33 | | 54 | 55 | 56 | | 85 | 86 | 56 | |
| 26 | 27 | 45 | | 55 | 56 | 100 | | 86 | 87 | 66 | |
| 27 | 28 | 35 | Head Failure | 56 | 57 | 47 | Head Failure | 87 | 88 | 59 | |
| 28 | 29 | 55 | | 57 | 58 | 50 | | 88 | 89 | 55 | Head Failure |
| 29 | 30 | 99 | | 58 | 59 | 23 | | 89 | 90 | 59 | |
| 30 | 31 | 100 | Head Failure | 59 | 60 | 53 | Head Failure | **End of Borehole.** | | | |



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| PERMEABILITY TEST IN OVERBURDEN | |
|---|---|
| K (cm/sec) $<10^{-6}$ | Impervious |
| K (cm/sec) $10^{-6}$ to $10^{-4}$ | Semi-pervious |
| K (cm/sec) $>10^{-4}$ | Pervious |

| PERMEABILITY TEST (Lugeon) IN ROCK | |
|---|---|
| 0 to 5 | Low Permeable |
| 5 to 15 | Slightly Permeable |
| 15 to 25 | Permeable |
| >25 | High Permeable |

On the basis of drilling borehole log, a graph is developed between CR (%) Vs Depth (m), and is presented as **Figure 6-1.**

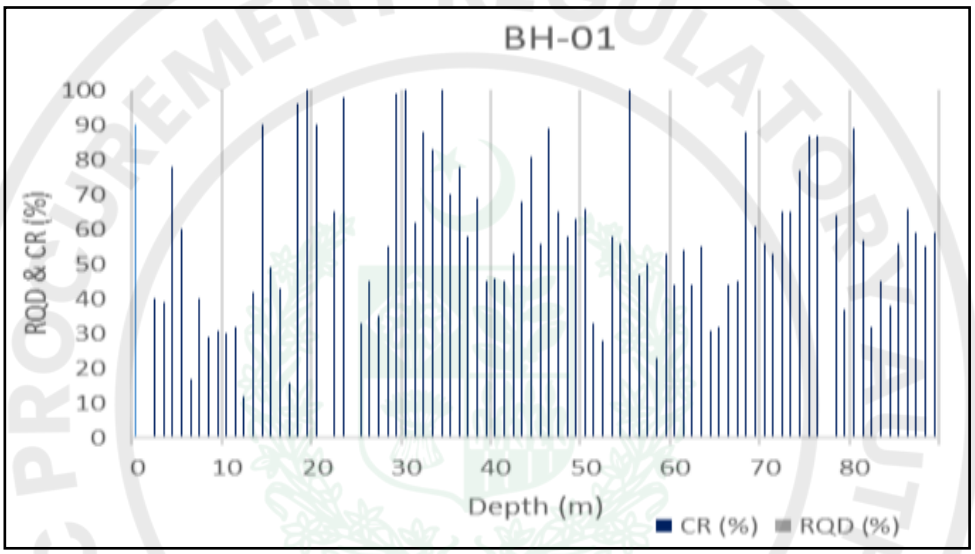


**Figure 6-1 Graphical Representation of CR Vs Depth of BH-01.**

It is noticed that head could not be maintained throughout the drilling of borehole. 100 % water loss has been observed. It indicates that slide mass is highly permeable with large cavities and open works which required cementing for stabilization of bore holes during drilling.

## 6.3 INTAKE AREA

The surface geological mapping of the intake area has been carried out at a scale of 1:1000. and presented at 1:2000 scale. A geological X-section along line BB` has been developed and presented as drawing **(DWG No: AFS-GE-313).** The main purpose to develop geological x-section is to estimate condition prevailing in subsurface i.e. overburden thickness, extension/alignment of faults, extension/trend of rock units in the subsurface.

The intake area is proposed at the left side of the Hunza River. Granodiorite rock is exposed at steep angle where it is hard, massive, strong to moderately strong with Schmidt hammer values ranges from 40 to 58 MPa **(DWG No: AFS-GE-295 & 298).** The rock is foliated where platy minerals are aligned in specific orientation with trending at N42°W and plunging at 52°NE. Different joint sets measured at the outcrop is given below



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| | | |
|---|---|---|
| **N20°W/50°NE** | **N62°E/64°NW** | **N24°W/49°SW** |
| **N25°W/61°NE** | **N85°W/82°SW** | **N06°E/88°SE** |
| **N58°E/88°NW** | **N85°W/67°NE** | **N75°E/74°SE** |

**Photo 6-2 Proposed Intake Area for Power Tunnel**

Granodiorite rock is hard, strong to moderately strong, and sparsely to moderately jointed **(Photo 6-2)**. But at higher elevation, the rock is highly jointed and sheared, having vertical open joints which must be treated for stability and safety.

## 6.4 POWER TUNNEL

### 6.4.1 Surface Geological Mapping

The surface geological mapping of the power tunnel alignment has been carried out at a scale of 1:1000. and presented at 1:2000.

**Photo 6-3 Rolling down of Scree along Active Slide**



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It is observed during surface geological mapping that a fault is running obliquely across the alignment of power tunnel alignment **(DWG No: AFS-GE-296,297,300,303,304 & 307).** A geological X-Section CC` has been developed to estimate the subsurface conditions and presented as **(DWG No: AFS-GE-303).** The power tunnel has to be excavated mostly through the granodiorite with subordinate granitic gneiss at the left side slope of Hunza River. The strength of rock reduces downstream and near the termination point of slided mass, brecciated/ gaugic rock is present/exposed **(DWG No: AFS-GE-303).** Rolling down of large boulders are quite common at this point **(Photo 6-3).** The rock units are quite crushed, sheared and brecciated forming active slides throughout its alignment.

A borehole BH-04 has been drilled to estimate the rock conditions in the subsurface. The brief description of CR and RQD is given in table 6-2 below.

**Table 6-2 Summary of Borehole BH-04**

| Depth (m) | | CR(%) | RQD(%) | Lugeon | Depth (m) | | CR(%) | RQD(%) | Lugeon |
|---|---|---|---|---|---|---|---|---|---|
| From | To | | | | From | To | | | |
| 0 | 1 | | | | 35 | 38 | 94 | 91 | |
| 1 | 2 | 14 | | | 38 | 40 | 97 | 94 | 2.60 |
| 2 | 3 | 12 | | | 40 | 43 | 98 | 98 | |
| 3 | 4 | 12 | | | 43 | 45 | 98 | 97 | 3.77 |
| 4 | 5 | 18 | | | 45 | 47.6 | 98 | 97 | |
| 5 | 6 | 15 | | | 47.6 | 50 | 98 | 98 | 0.42 |
| 6 | 8 | 91 | 41 | | 50 | 52 | 100 | 100 | |
| 8 | 10 | 85 | 70 | | 52 | 53 | 100 | 100 | |
| 10 | 13 | 97 | 97 | | 53 | 54 | 100 | 100 | |
| 13 | 15 | 97 | 92 | 2.48 | 54 | 55 | 100 | 100 | 0.12 |
| 15 | 16 | 92 | 58 | | 55 | 56 | 99 | 99 | |
| 16 | 17 | 93 | 63 | | 56 | 57 | 98 | 96 | |
| 17 | 19 | 98 | 95 | | 57 | 60 | 99 | 99 | 0.00 |
| 19 | 20 | 91 | 90 | 1.22 | 60 | 63 | 99 | 99 | |
| 20 | 23 | 97 | 89 | | 63 | 65 | 99 | 99 | |
| 23 | 24 | 92 | 60 | | 65 | 68 | 100 | 100 | |
| 24 | 25 | 98 | 98 | 1.45 | 68 | 70 | 100 | 100 | |
| 25 | 27 | 96 | 94 | | 70 | 73 | 99 | 99 | |
| 27 | 30 | 96 | 91 | 1.68 | 73 | 75 | 100 | 100 | |
| 30 | 32.5 | 95 | 76 | | 75 | 78 | 100 | 100 | |
| 32.5 | 35 | 96 | 83 | 0.64 | 78 | 80 | 100 | 100 | |

Lugeon test has been conducted in the field to check the permeability condition of the rock mass at every 5 m interval.

On the basis of data collected during borehole logging, a graph has been developed between depth Vs RQD and CR and presented as Figure 6.2.



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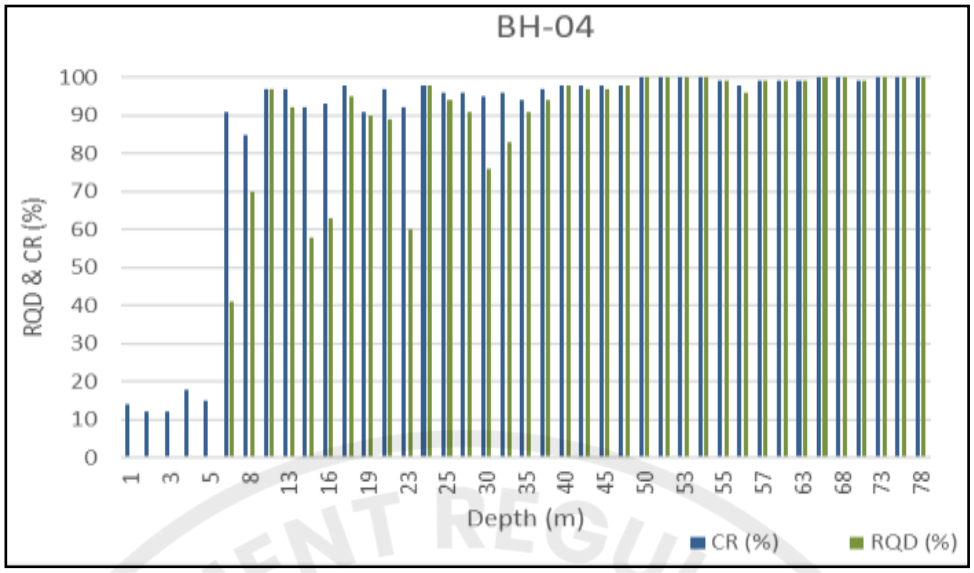


**Figure 6-2 Graphical Representation of RQD&CR Vs. Depth of BH-04**

During drilling works, it is estimated that the RQD values in upper 23 m is fair after that the value tends to excellent to good and good. The lugeon values calculated after every 5 m interval indicate that rock is low permeable. It shows that rock in sparsely jointed in subsurface. The lab test results indicate that in spite of the fact that RQD is quite high in lower portion but the strength index is moderate. The value of all tests indicate that the rock in BH-04 is moderately hard and moderately strong with low cohesion “C” and low angle of internal friction “Ø”. While excavating through this portion, some treatment is required to enhance for stability of structure.

## 6.5 SEDIMENT FLUSHING CHANNEL

### 6.5.1 Surface Geological Mapping

The surface geological mapping of the power tunnel alignment has been prepared at a scale of 1:1000 in field and presented at 1:2000 scale. It is proposed on the left side of Hunza River **(Photo 6.4)**. It is observed during surface geological mapping that the sediment flushing channel has to be excavated through ABGM of slided mass **(DWG No: AFS-GE-297 & 298).**.

Slided mass covers an area of about 1 km and consist of huge volume of ABGM. One of the difficult and critical task is to stabilize the both side slopes along the sediment flushing channel. The large boulders of more than 25 m in length are present in slided mass. Benching is one of the best solution for such type of slope to stabilize. At some place, mashing or gabion may be helpful for slope stabilization.



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**Photo 6-4 Intake Area of Sediment Flushing Channel**.

### 6.5.2 Borehole Drilling

To investigate the nature of material exposed at left side slope, two borehole BH-02 and BH-03 have been drilled at outlet and intake of sediment flushing channel respectively. The summary of these boreholes is given in table 6.3 and 6.4.

**Table 6-3 Summary of Borehole BH-02**

| ATTABAD LAKE HPP | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| BH-02 | | | | | | | | | | | |
| Depth (m) | | CR | K-Value | Depth (m) | | CR | K-Value | Depth (m) | | CR | K-Value |
| From | To | (%) | cm/s | From | To | (%) | cm/s | From | To | (%) | cm/s |
| 0 | 1 | 0 | Head could not be maintained | 21 | 22 | 42 | Head could not be maintained | 41 | 42 | 30 | Head could not be maintained |
| 1 | 2 | 10 | | 22 | 23 | 60 | | 42 | 43 | 28 | |
| 2 | 3 | 13 | | 23 | 24 | 23 | | 43 | 44 | 37 | |
| 3 | 4 | 16 | | 24 | 25 | 9 | | 44 | 45 | 27 | |
| 4 | 5 | 18 | | 25 | 26 | 16 | | 45 | 46 | 25 | |
| 5 | 6 | 16 | | 26 | 27 | 15 | | 46 | 47 | 41 | |
| 6 | 7 | 19 | | 27 | 28 | 32 | | 47 | 48 | 27 | |
| 7 | 8 | 21 | | 28 | 29 | 22 | | 48 | 49 | 24 | |
| 8 | 9 | 29 | | 29 | 30 | 22 | | 49 | 50 | 25 | |
| 9 | 10 | 55 | | 30 | 31 | 34 | | 50 | 51 | 29 | |
| 10 | 11 | 47 | | 31 | 32 | 28 | | 51 | 52 | 36 | |
| 11 | 12 | 29 | | 32 | 33 | 33 | | 52 | 53 | 21 | |
| 12 | 13 | 24 | | 33 | 34 | 23 | | 53 | 54 | 25 | |
| 13 | 14 | 42 | | 34 | 35 | 27 | | 54 | 55 | 36 | |
| 14 | 15 | 29 | | 35 | 36 | 21 | | 55 | 56 | 22 | |
| 15 | 16 | 39 | | 36 | 37 | 24 | | 56 | 57 | 27 | |
| 16 | 17 | 25 | | 37 | 38 | 25 | | 57 | 58 | 27 | |
| 17 | 19 | 65 | | 38 | 39 | 12 | | 58 | 59 | 39 | |
| 19 | 20 | 27 | | 39 | 40 | 15 | | 59 | 60 | 24 | |
| 20 | 21 | 36 | | 40 | 41 | 44 | | **End of Borehole.** | | | |



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On the basis of data collected during borehole logging, a graph has been developed between depth Vs CR and presented as **Figure 6.3**. Permeability tests were performed at every 3 m interval. It is noticed that throughout the borehole drilling, head could not be maintained and 100% water loss is observed during drilling.

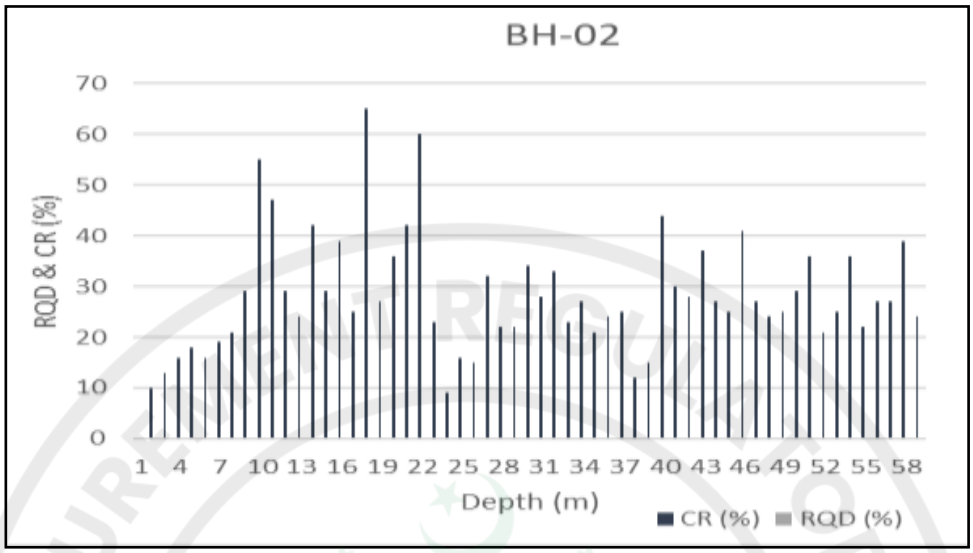


**Figure 6-3 Graphical Representation of CR Vs Depth .**

**Table 6-4 Summary of Borehole BH-03**

| ATTABAD LAKE HPP | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| BH-03 | | | | | | | | | | | |
| Depth (m) | | | K-Value | Depth (m) | | CR | | Depth (m) | | | K-Value |
| From | To | CR (%) | cm/s | From | To | (%) | K-Value cm/s | From | To | CR (%) | cm/s |
| 0 | 1 | 33 | | 20 | 21 | 77 | Head Failure | 40 | 41 | 66 | |
| 1 | 2 | 70 | | 21 | 22 | 41 | | 41 | 42 | 31 | 0.00281 |
| 2 | 3 | 32 | | 22 | 23 | 48 | Head Failure | 42 | 43 | 27 | |
| 3 | 4 | 24 | | 23 | 24 | 29 | | 43 | 44 | 34 | |
| 4 | 5 | 34 | | 24 | 25 | 60 | Head Failure | 44 | 45 | 30 | |
| 5 | 6 | 83 | | 25 | 26 | 73 | | 45 | 46 | 25 | 0.00183 |
| 6 | 7 | 51 | | 26 | 27 | 36 | | 46 | 47 | 27 | |
| 7 | 8 | 25 | | 27 | 28 | 34 | 0.001226 | 47 | 48 | 41 | |
| 8 | 9 | 23 | | 28 | 29 | 75 | | 48 | 49 | 37 | 0.00262 |
| 9 | 10 | 27 | | 29 | 30 | 30 | | 49 | 50 | 23 | |
| 10 | 11 | 20 | | 30 | 31 | 20 | | 50 | 51 | 24 | |
| 11 | 12 | 62 | | 31 | 32 | 30 | 0.00704 | 51 | 52 | 66 | 0.00108 |
| 12 | 13 | 59 | | 32 | 33 | 12 | | 52 | 53 | 75 | |
| 13 | 14 | 46 | | 33 | 34 | 40 | | 53 | 54 | 45 | |
| 14 | 15 | 37 | | 34 | 35 | 54 | | 54 | 55 | 78 | |
| 15 | 16 | 35 | | 35 | 36 | 29 | | 55 | 56 | 56 | 0.00144 |
| 16 | 17 | 15 | | 36 | 37 | 20 | 0.003243 | 56 | 57 | 49 | |
| 17 | 18 | 37 | | 37 | 38 | 45 | | 57 | 58 | 68 | |
| 18 | 19 | 96 | | 38 | 39 | 100 | | 58 | 59 | 68 | 0.00072 |
| 19 | 20 | 79 | | 39 | 40 | 98 | | 59 | 60 | 59 | |
| | | | | | | | | 60 | 61 | 23 | |



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On the basis of data collected during borehole logging, a graph has been developed between depth Vs CR and presented as **Figure 6.4**.

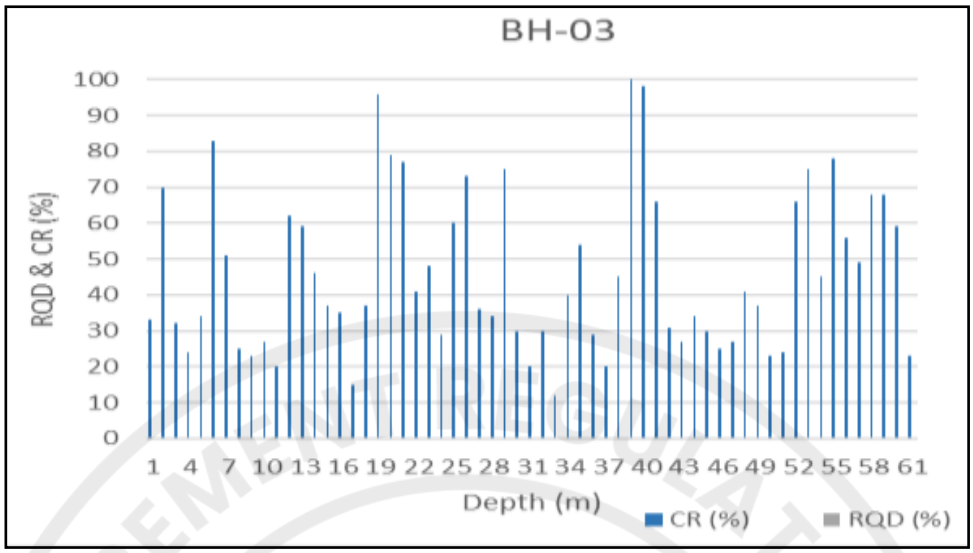


**Figure 6-4 Graphical Representation of CR Vs Depth of BH-03.**

Permeability tests have been performed at every 3 m interval. These values indicate that the material is pervious.

It is clear from the drilling logs that rock is not encountered upto 60 m in both boreholes. The drilling data and lab test results show that the boulders of overburden material (ABGM) are hard and moderatly strong. The slope can be stablized by benching. The permeability values in BH-02 are quite high as head cannot be maintained throughout drilling while in BH-03 the permeability values show that strata is pervious.

### 6.5.3 TEST PITS

Two test pits TP-5 and TP-6 have been excavated along sediment flushing channel at inlet and outlet area. In TP-5, it is observed that from 0-1.5 m, ABGM and RBGM is embedded into clayey silt while further from 3 m, fine to very fine grained, moist clayey silt is present. In TP-06 and 07, large boulders with subordinate fine material is present, which was originated from slided mass. During excavation of these test pits, large gaps have been found between these boulders.

## 6.6 SURGE TANK AND PENSTOCK ALIGNMENT

The surface geological mapping of the surge tank and penstock alignment have been carried out at a scale of 1:1000 in the field and presented at 1:2000 scale. It is proposed on the left side of Hunza River **(Photo 6-5)**. It is observed during surface geological mapping that the granodiorite rock with granitic gneiss is exposed in surge tank area. It is moderately hard, sheared and highly jointed **(DWG No: AFS-GE-307).**



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**Photo 6-5 Proposed Area for Surge Tank.**

From surge tank 450 m long penstock with diameter of 3.6 m is proposed up to powerhouse. Piers will support penstock alignment. The foundation of piers will be laid on overburden material **(DWG No: AFS-GE-306 & 309).** The presence of clayey silt may create problem and might be excavated prior to establish foundation for piers **(Photo 6-6)**.

**Photo 6-6 Proposed Alignment of Penstock.**

## 6.7 POWER HOUSE

The surface geological mapping of the power tunnel alignment has been carried out at a scale of 1:1000 in the field and presented at 1:2000 scale. It is proposed on the left side of Hunza River on a flat area **(Photo 6-7)**.



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**Photo 6-7 Proposed Power House Area.**

It is observed during surface geological mapping that thick clayey silt has been deposited having depth of about 30 m as confirmed by drilling (**BH-5 & BH-6**). It is interbedded in upper layers by RBGM while pure clayey silt found in depth. It is deposited due to choking of Hunza River when Salmanabad slide occurred **(DWG No: AFS-GE-309)..** A geological X-section DD` has been established to estimate the sub surface conditions and presented as **(DWG No: AFS-GE-315).**

### 6.7.1 Borehole Drilling

To explore the nature of foundation of power house material two boreholes, BH-05 and BH-06 with drilled depth of 50 m and 60 m respectively, have been drilled at powerhouse area. The summary of these boreholes is given in table 6-5 and 6-6 respectively.

**Table 6-5 Summary of Borehole BH-05**

| ATTABAD LAKE HPP | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| BH-05 | | | | | | | | | | | |
| Depth (m) | | CR | K-Value | Depth | | CR | K-Value | Depth | | CR | K-Value |
| From | To | (%) | cm/s | From | To | (%) | cm/s | From | To | (%) | cm/s |
| 1 | 2 | 10 | | 17 | 18 | 0 | | 34 | 35 | 40 | |
| 2 | 3 | 9 | | 18 | 19 | 0 | | 35 | 36 | 49 | |
| 3 | 4 | 9 | | 19 | 20 | 0 | 0.00945 | 36 | 37 | 47 | |
| 4 | 5 | 0 | | 20 | 21 | 0 | | 37 | 38 | 41 | |
| 5 | 6 | 0 | | 21 | 22 | 0 | | 38 | 39 | 90 | |
| 6 | 7 | 0 | | 22 | 23 | 0 | 0.00685 | 39 | 40 | 94 | |
| 7 | 8 | 0 | | 23 | 24 | 0 | | 40 | 41 | 94 | |
| 8 | 9 | 0 | | 24 | 25 | 0 | | 41 | 42 | 92 | |
| 9 | 10 | 0 | | 25 | 26 | 0 | 0.00635 | 42 | 43 | 83 | |
| 10 | 11 | 0 | | 26 | 27 | 0 | | 43 | 44 | 50 | |
| 11 | 12 | 0 | | 27 | 28 | 0 | | 44 | 45 | 11 | |
| 12 | 13 | 0 | | 28 | 29 | 0 | 0.00496 | 45 | 46 | 0 | |
| 13 | 14 | 0 | | 29 | 30 | 0 | | 46 | 47 | 0 | |
| 14 | 15 | 0 | 0.0277 | 30 | 31 | 44 | | 47 | 48 | 80 | |
| 15 | 16 | 0 | | 31 | 32 | 93 | | 48 | 49 | 13 | |
| 16 | 17 | 0 | | 32 | 33 | 36 | | 49 | 50 | 7 | |
| 17 | 18 | 0 | | 33 | 34 | 43 | | End of Borehole | | | |



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On the basis of data collected during borehole logging, a graph has been developed between depth Vs CR and presented as **Figure 6-5**. Permeability tests have been performed at every 3m interval.

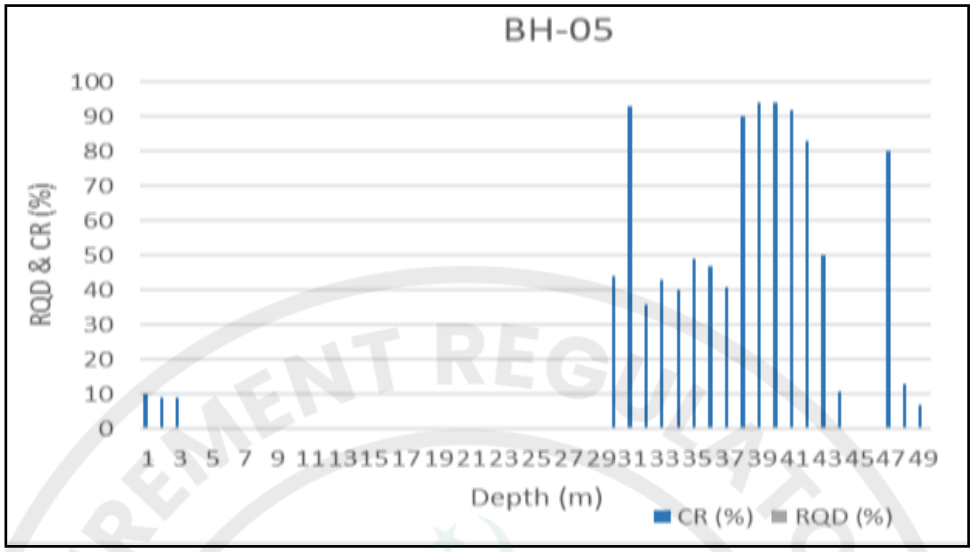


**Figure 6-5 Graphical Representation of CR Vs Depth.**

**Table 6-6 Summary of Borehole BH-06**

| ATTABAD LAKE HPP | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| BH-06 | | | | | | | | | | | |
| Depth (m) | | CR | K-Value | Depth (m) | | CR | K-Value | Depth (m) | | CR | K-Value |
| From | To | (%) | cm/s | From | To | (%) | (cm/s) | From | To | (%) | (cm/s) |
| 0 | 1 | 0 | | 21 | 22 | 67 | | 41 | 42 | 61 | |
| 1 | 2 | 0 | | 22 | 23 | 41 | | 42 | 43 | 29 | |
| 2 | 3 | 0 | | 23 | 24 | 81 | 0.00392 | 43 | 44 | 68 | |
| 3 | 4 | 0 | | 24 | 25 | 62 | | 44 | 45 | 43 | |
| 4 | 5 | 0 | | 25 | 26 | 37 | | 45 | 46 | 47 | |
| 5 | 6 | 0 | | 26 | 27 | 68 | 0.00286 | 46 | 47 | 39 | |
| 6 | 7 | 0 | | 27 | 28 | 77 | | 47 | 48 | 42 | |
| 7 | 8 | 0 | | 28 | 29 | 77 | | 48 | 49 | 92 | |
| 8 | 9 | 0 | | 29 | 30 | 94 | Head Failure | 49 | 50 | 93 | |
| 9 | 10 | 0 | | 30 | 31 | 19 | | 50 | 51 | 6 | |
| 10 | 11 | 0 | | 31 | 32 | 13 | 0.00338 | 51 | 52 | 19 | |
| 11 | 12 | 0 | | 32 | 33 | 23 | | 52 | 53 | 22 | 0.000781 |
| 12 | 13 | 0 | | 33 | 34 | 24 | | 53 | 54 | 0 | |
| 13 | 14 | 0 | | 34 | 35 | 69 | Head Failure | 54 | 55 | 17 | |
| 14 | 15 | 0 | | 35 | 36 | 40 | | 55 | 56 | 80 | 0.00298 |
| 15 | 16 | 27 | | 36 | 37 | 34 | | 56 | 57 | 52 | |
| 16 | 17 | 77 | 0.00241 | 37 | 38 | 86 | | 57 | 58 | 59 | |
| 17 | 18 | 71 | | 38 | 39 | 83 | 0.00279 | 58 | 59 | 100 | |
| 18.4 | 20 | 74 | | 39 | 40 | 68 | | 59 | 60 | 100 | |
| 20 | 21 | 60 | 0.00289 | 40 | 41 | 16 | | End of Borehole. | | | |



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On the basis of data collected during borehole logging, a graph has been developed between depth Vs CR and presented as **Figure 6-6**. Permeability tests were performed at every 3 m interval.

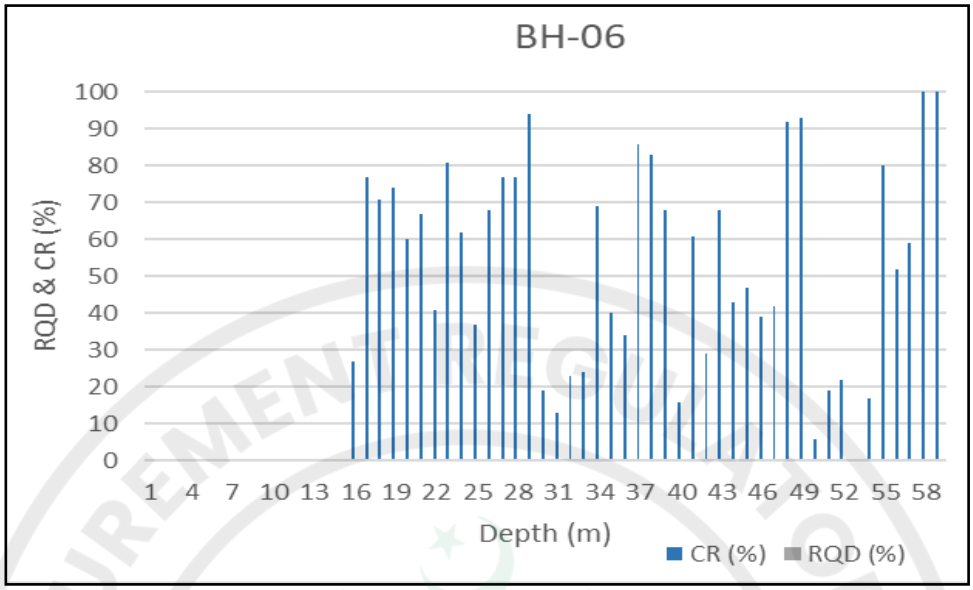


**Figure 6-6 Graphical Representation of CR Vs Depth**

It is clear from the drilling data that about 15 m clayey silt in BH-06 and about 30 m in BH-05 has been encountered during drilling. SPT has been conducted in the clayey silt for 18 inches penetration in these boreholes. It is estimated from this data that firm to stiff clayey silt is present. The permeability tests conducted in this strata show that they have relatively high hydraulic conductivity. The lab test results indicate that the clayey silt has swelling potential.

Foundation of the powerhouse will be lying on overburden material. The whole thickness of clayey silt layer has to be removed/excavated prior to establish the foundation of powerhouse.

## 6.8 TAILRACE CHANNEL

The surface geological mapping of tailrace channel has been carried out at a scale of 1:2000. It is proposed on the left side of Hunza River. It is observed during surface geological mapping that the whole channel has to be excavated through the overburden material **(DWG No: AFS-GE-309).**. Water after generating electricity will again join Hunza River near Sarat village suspension bridge.



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# 7 CONSTRUCTION MATERIAL

## 7.1 GENERAL

Construction material required for various structures of ALHPP is available in ample quantity within/near the Project Area in economic haulage.

The rocks granodiorite and granitic gneiss are exposed in/near the Project Area. Both are acidic rocks and cannot be used as coarse aggregate with Ordinary Portland Cement (OPC) due to alkali silica reaction (ASR). Both rocks show deleterious quartz more than 5%. More over 10 test pits have been excavated for the study of aggregate material and foundation condition. These have been excavated in river bed, slided mass and fine deposits near old Chinese camp in power house area. Samples of marble have been collected from Passu area to conduct laboratory testing in CMTL WAPDA, Lahore.

## 7.2 FINE AGGREGATE

Two types of fine aggregate sand and clayey silt have been selected for testing and proven source for fine aggregate. Samples have been collected from 0 to 3 m depth (by coning and quartering method) for laboratory testing and sent to CMTL, WAPDA, Lahore.

### 7.2.1 Sand Quarry

To fulfil the quantity of sand material during construction of ALHPP, ample quantity of this material is deposited in the tail area of Attabad Lake near Shishkat Bridge **(Photo 7-1)**. A test pit TP-1 has been excavated, and samples have been collected for lab testing. Log of test pit is given in **(Volume 4A)**. Gradation test, indicates that 99% sand with only 1% silt and clay is present **(Table 5-15 & 5-16)**. The results of Accelerated Mortar Bar indicate minimum average expansion (0.039) for 28 days. Specific gravity and water absorption values also fall in permissible limits. The results of lab testing are provided in **Volume 4B.**

**Photo 7-1 Quarry Area Selected for Sand near Shishkat Bridge.**



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The lab. test results show that it can favorably be used as sand quarry site for construction of ALHPP.

### 7.2.2 Silt and Clay Quarry

For fine aggregate (Clayey silt) 3 test pits 3x3x3m have been excavated to analyze the nature of material present in river bed. Two test pits TP-2 & TP-3 in helipad/powerhouse area and TP-10 near Klin area, near Ganesh Bridge, have been excavated to explore the subsurface geological conditions prevailing in the area **(Photo 7-2)**. Both composite as well as block samples from each test pit have been collected for lab testing.

**Photo 7-2 TP-3, Excavated for Clayey Silt in P/H Area.**

Lab test results indicate that the material consists of clayey silt with clay index ranges from (40-45%). Atterberg Limits and Swell Potential show that some treatment may be needed prior to their use. Results of Modified Proctor test on block and composite samples indicate that max dry density 1.7 to 1.8 mg/m$^3$ for clayey silt can be attained in range of 10 to 13% optimum moisture contents (ch. 5, Table 5-14). The laboratory test results can be seen in **Volume 4B**.

Another huge source of borrow area for silt and clay is present at brick kiln area near Ganesh Bridge along KKH. It lies in economic haulage. A test pit TP-10 has been excavated in clayey silt and two block samples were collected from this pit and sent to CMTL to conduct different tests. The log of test pit is presented in volume 4A. The Lab test results have been collected and interpreted in chapter 5.

It indicates from lab test results that, clayey silt is present and can be used ase blanket material to minimize the seepage. The ratio of silt and clay naturally present in 60 and 40% respectively (Table 5-16). It is present in adequate quantity in P/H area and near Ganesh Bridge.



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**Photo 7-3 View of Clayey Silt in P/H Area.**

## 7.3 COARSE AGGREGATE

The rock units exposed in the Project Area are acidic in nature on the basis of silica contents i.e. granodiorite and granitic gneiss. Due to sliding of huge mass downslope, large material is deposited in foothills chocking the Hunza River. For coarse aggregate, three sites have been selected. Samples from slided mass, powerhouse area/river bed and Passu area have been collected and sent to CMTL WAPDA, Lahore to conduct different tests.

### 7.3.1 Passu Area

It is located about 35 km upstream of Attabad Lake along KKH near Passu village **(Photo 7-4)**. Bulk sample have been collected and sent to laboratory for testing. Petrographic analysis shows that marble is exposed. It consists of 97% of calcite, with specific gravity 2.84 and 0.37 water absorption, Los Angeles abrasion has uniformity of wear 0.20, crushing value 24, with flakiness index of 22. Sulphate soundness test result has weight percent loss 0.89.

The laboratory test results indicate that the rock mostly consists of calcite with no alkali silica reaction and no alkali carbonate reaction. This material has no deleterious quartz and tests results fall in permissible limit; therefore, it can be used as coarse aggregate for concrete with Ordinary Portland Cement.



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**Photo 7-4 Exposure of Marble in Passu Village Area.**

### 7.3.2 Power House Area

Large quantity of RBGM is deposited near old Chinese camp along old KKh route. Bulk sample from TP-2 has been collected and sent to lab for different tests **(Photo 7-5)**.

**Photo 7-5 View of RBGM in TP-2 at P/H Area.**

It consists of marble, granite, granitic gneiss, with some slate pieces. As per lab. test results, the material have specific gravity 2.78 with 0.33% water absorption. Los Angeles abrasion value with uniformity of wear is 0.20, crushing value is 27, and flakiness index is 21. Sulphate soundness value is 0.81 and average expansion for 28 days in accelerated mortar bar is 0.099, and point load index is 4.15 MPa (ch-5).

Petrographic analysis indicates that the rock is mostly granitic in composition and has more than 20% deleterious quartz, therefore, it cannot be used with OPC. To minimize the ASR, low alkali cement, slag cement or fly ash, pozzoloan can be used. Some chemical additives like



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lithium nitrate or silica fume can also be used. The finalization of the additive material depends upon the other strength and expansion tests during concrete mix design. Moreover, all the values of other tests fall in permissible limit, therefore, it can be used as coarse aggregate material for concrete but not with OPC.

### 7.3.3 Slided Mass

Sample from TP-7 have been collected to conduct different lab tests. Lab testing program has been framed to check the suitability of this material. The description is given below: -

Petrographic analysis shows that rock is granodiorite and has more than 20% deleterious quartz and cannot be used with OPC. Point load strength is 5.94 with diametrically failure, specific gravity 2.72 and water absorption 1.04%. Los Angeles abrasion test show 0.41 uniformity of wear, crushing value 22 with flakiness index of 21. The value of Sulphate soundness test for this material is 1.87.

**Photo 7-6 View of Slided Mass in TP-6 at Left Side Slope of Hunza River.**

Higher Los Angeles abrasion, Sulphate soundness and presence of deleterious quartz values, show that this rock cannot be favorable for coarse aggregate material as in comparison with other two quarry site. Thus this material is not recommended as coarse aggregate for concrete works with OPC. This material can be used as coarse aggregate with slag cement, low alkali cement and by adding pozzoloan material to counter ASR.

## 7.4 BUILDING STONE

The granodiorite and granitic gneiss rocks are exposed in the project periphery, available for masonry works in sufficient quantities. More over, the large boulders, present in slided material can be used as rip rap material, to control the erosion/ wave action of water. This material has high strength UCS value ranges upto 72 MPa in TP-8. Similarly, the values of property index test, Los Angeles abrasion test fall in permissible limits. The slided mass may, therefore, be used as rip rap material.



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## 7.5 FILL MATERIAL

For protection works along slopes and structures, shoulder fill, construction of coffer dams, fill material of heterogeneous nature e.g. silty sand, sandy silt, gravelly sand etc. are available in river bed as well as in slided mass. These materials are present in ample quantities in the economic haulage of the Project Area.

**Photo 7-7 Fill Material (Boulder and Gravels) in Slided Mass.**

The test pits excavated in the powerhouse area / river beds show that large quantities of gravels and cobbles with subordinate sands are present. This materials satisfy the lab test program, therefore it might be used as fill material.

## 7.6 CEMENT AND STEEL

Cement and steel are required in adequate quantity for the construction of ALHPP. The cement should be supplied from nearby cement factory. The most nearer unit of cement is situated in Haripur/WAH areas includes Askari Cement, Wah cantt unit with capacity of 3500 ton/day and Fauji cement near Fateh Jang has two units; one with 3500 ton/day and other with 6700 ton/day.

These options can be considered for the supply of cement. The steel has to be transported from Rawalpindi to fulfill the requirement of the project. It is suggested that laboratory tests on representative samples should be carried out to determine the engineering characteristic of cement and steel prior to their use / procurement.



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# 8 NEOTECTONICS AND SEISMIC HAZARD ANALYSIS

## 8.1 GENERAL

A large slided mass moved down and chocked the Hunza River and KKH for more than 2 km in January 2010 from right side near Attabad village. This large slide causes a 25 km long lake to develop upto Khyber village in Gojal. Due to excavation and development of channel through this slided mass, the level of lake decreases down and extension reduces up to Shishkat Bridge. This large mass slided down due to some regional stress operating in this region. To understand these regional forces and their effect and vulnerability of expected slope material to slide, a Neo-tectonic study has been conducted.

During the Feasibility Study, the colossal slide and as a result damping of Hunza River in 2010 has made the Neo-tectonic studies as core point. It is therefore, very important for the development of hydropower project in this area that understanding of Neo-tectonic setting should be explored to know the regional tectonic forces. Regional tectonic forces responsible for the massive slide are affecting Project Area severely as indicated by diverse features.

## 8.2 OBJECTIVES

Main objectives are:

- Evaluation of the regional tectonic setting of the area and recognition of fault (regional or local) which may act as a seismic source.
- Detailed investigation of the fault geometry, alignment, and structural deformations associated with these fault. These may include shear zones, fault bend folds, active slides and fault breccia.
- Recognition of active fault zones and their distinction from older, dormant fault zones.
- Assessment of the vulnerability of Neo-tectonic activity along the fault/slides around the Project Area so that the movement along the affected area may be predicted.
- Identification of deformation/displacement in recent deposits to evaluate the activity of area.

## 8.3 METHODOLOGY

An array of activities including literature review,image analysis,field studies and datacompilation are involved in Neo tectonic evaluation as per standard practices in Industry. These include:

- Collection of previous research on regional as well as on local geology, geomorphology and tectonics of Project Area.
- In-depth studies on satellite image analysis using GIS techniques by applying various image-enhancing techniques e.g. Digital Elevation Model (DEM) have been studied, the lineaments and faults on regional as well as on local scale have been recognized.



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- Detailed geological map of the Project Site, regional and local faults within the vicinity covering the upstream and downstream of the Project Area have been marked on GT sheets at scale of 1:50000 in the field area to understand the trend of regional tectonic forces.
- During field visit keen concentration has been given to characterize the kinematics of fault where possible e.g. sense of fault (Strike and Dip), alignment and type of fault, throw and heave, dip direction and other associated characteristics.
- Development of fault-source map indicating various regional scale faults that may contribute seismic affect in the Project Area.
- The relationship of older tectonic features to the recent ones.
- Field evidences of Neo-tectonic features have been captured in photographs including active slides, tiltness in recent deposits, folding, faulting, step fault, fault associated folding in recent deposits, topographic features including drainage pattern at slopes and abrupt shifting of river/stream course.

## 8.4 FIELD OBSERVATIONS

This study covers the 40 km upstream and 50 km downstream of the Project Site along both banks of the Hunza River. Different features related to Neo-tectonics activity have been observed during site visit. In this study the focus has been given to the recent deposits, at the both bank of river.

The main objective of the Neo-tectonic study has been to identify/observe the feature of active tectonic events occurred in recent past about 0.1 Million years ago. There are many field observations regarding the Neo-tectonic activity. Some of the Neo-tectonics features/observations are as under: -

- The tiltness in recent deposition, i.e. to study the slopes of gravels, clays, and sand layers w.r.t slope of the stream beds.
- Intersection of faults in recent deposits i.e. lacustrine deposits, terraces/ alluvial deposits or in any cultural features (houses, roads). The amount of displacement, Heave as well as Throw measurement, dip and strike of the fault.
- The presence of active slide zones.
- The displacement /uplift in fluvial as well as lacustrine deposits on each side of the lake/stream and magnitude of its displacement.
- Identify the zones of brittle as well as ductile deformation.
- To observe the movements along slicken sides / fault / joints blocks.
- The presence of hanging valley along the main streams.
- The presence of escarpment slope along the plain area.
- The presence of hanging valleys /cirques along main stream, in series and presence of waterfalls along it.



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- Folding/bending in the recent deposits (alluvium, morainic, lacustrine).

The Neo-tectonic features at the right as well as left bank of Hunza River in different villages from upstream to downstream **(DRW No: AFS-GE-318 to 320)** are described below: -

### 8.4.1 Passu Village:

Passu is one of the largest village in Gojal valley situated at the right bank of Hunza River along KKH about 35 km from Attabad Site. The great Passu Glacier, 56 km in length is present near the village. Many deformational evidences have been observed in recent deposits along the road.

- 2-3 km upstream of Passu village

N 4038610.325 m

E 489292.583 m

El. 2470.03 m.a.s.l

The coordinates measured by mobile topographer application.

A large deposit of RBGM material is present along the right side slope of the river along KKH. This material consists mostly of gravel, cobble, and pebbles with subordinate sandy material. Some inclinations in these deposits have been observed along roof and sole beds. This inclination varies from 15° to 35° layer-by-layer **(Photo 8-1).**

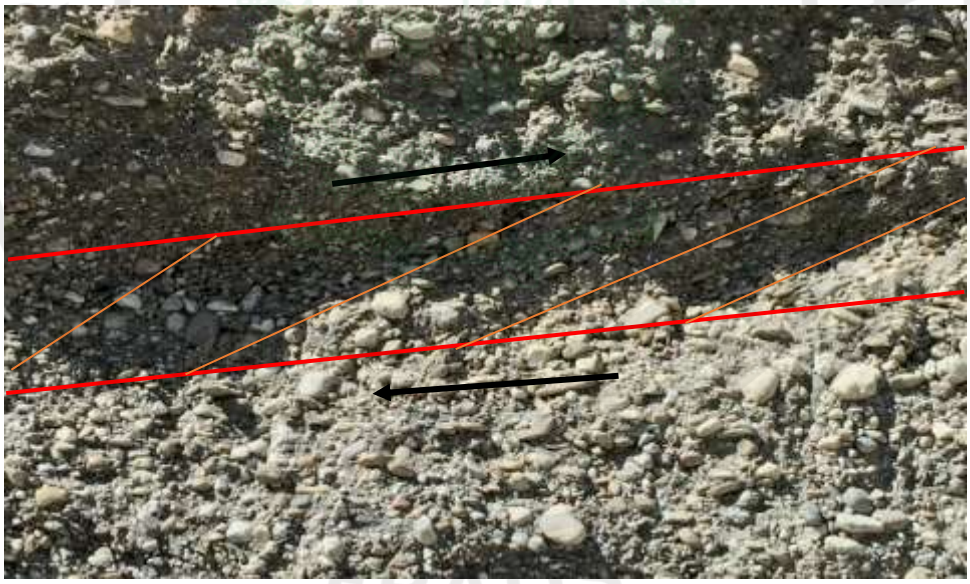

**Photo 8-1 Inclined Gravel Layers under Effect of Shearing**

Some shearing effects have been chronicled along these planes in numeral layers. This shows that the area is tectonically active.

The clay deposits are overlain by morainic material of Batura Glacier. The clay deposits are tilted upward at an angle ranging from 10° - 15°. The area has undergone compressional regime, which uplifted the clay beds **(Photo 8-2)**.



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**Photo 8-2 Recumbent Fold Strata with Crenulation in Limbs in Clay Strata.**

The clayey strata is folded with straight horizontal limbs and horizontal hingline. This shows that the horizontal compressional stress is applied on this material that turned this unit into folded strata **(Photo 8-3).** Many micro folds (crenulations) in both limbs of fold are present. The Hinge area toward outer layers point out, that intense compressional stress is applied to the strata.

**Photo 8-3 Stylolite/Pressure Solutions in Clay Strata.**

The strata shows some stylolite structures that are formed by expulsion of water through pressure solutioning. Alignment of wavelength and geometry of hinge area indicates that the compressional stress is applied horizontally **(Photo 8-4)**. This shows that the recent stresses are functioning in this area.

Many joints are developed in the clay beds showing that there are relative movement in blocks along the plane, which might be acted as micro faults **(Photo 8-5)**.



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The relative movement of hanging wall block moves down relative to the footwall block, signposted the development of normal fault.

**Photo 8-4 Micro Fault in Clay Beds.**

At the same location there are cross cutting faults, dipping towards each other in clay beds. The block between two micro faults moves downward forming Graben structure while the block, that cannot move forming Horst structure **(Photo 8-5)**.

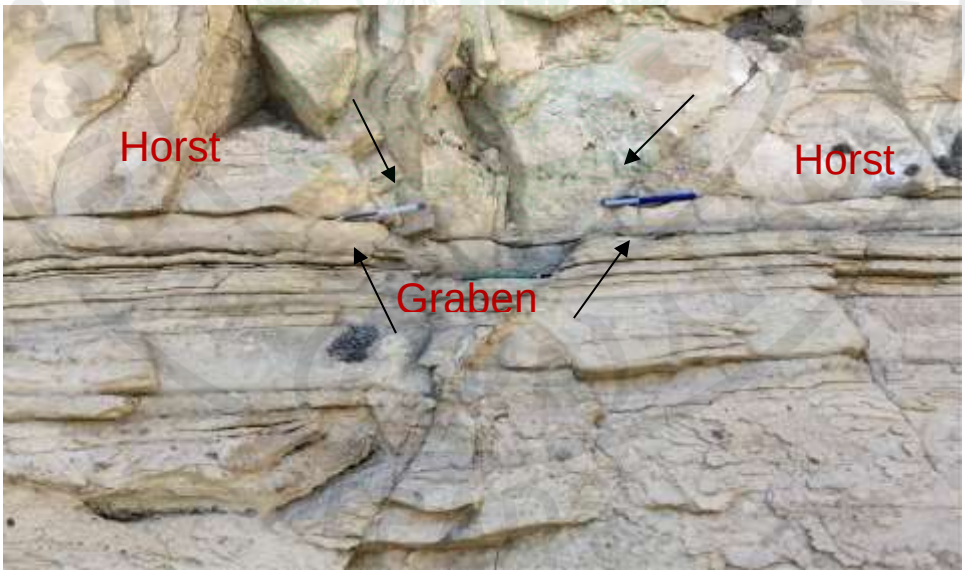


**Photo 8-5 Horst and Graben Structure along Micro Fault in Clay Beds.**

The formation of these structures in clay beds show that there is relative movement along the micro faults in recent deposits.

The development of these normal fault systems in such compressional regime indicates that these deposits are under such environment where two thrust faults dipping toward each other.



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The up thrown block between these two faults undergone extensional regime where normal faults are developed. This indicates that this area is under active tectonics regime.

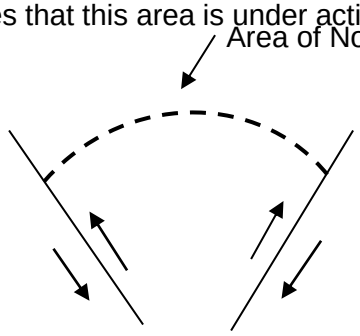


**Figure 8-1 Development of Normal Faults under Compressional Regime.**

### 8.4.2 Road Section from Murradabad to Hussani Village:

Coordinate

| | |
|---|---|
| N | 4033080.557 m |
| E | 489417.275 m |
| El. | 2656.69 m.a.s.l |

Just upstream of Hussaini village a large mass of ABGM and brecciated rock is exposed along the road. It is present in the alignment of thrust fault where crushed marble is in contact with Passu Slates. The faulted contact between slate and marble is well exposed along road **(Photo 8-6)**.

**Photo 8-6 View of Brecciated Rock Upstream of Passu Village.**

In this area two faults are intersecting each other; one is striking N60°E and dipping 40°NW while other is striking NW and dipping NE **(DWG No: AFP-GE-3180)**. Due to these faults discrete hillocks have formed with thin overburden overlain by fault breccia. At few feet away from breccia, a slided material consists of ABGM is present along road. Apparently this material



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seems to be stable but in excavated portion, it is folded. Compressional forces are responsible for this deformation exposed at slope **(Photo 8-7)**.

**Photo 8-7 View of Folded ABGM just Upstream of Passu Village.**

Rock (Passu Slates) is locally folded, some shear joints along which the cleavage plane (originally bedding planes) across shear joint has different dip values. The overall strike of slates is NW and dipping in NE but along this shear joint some movement took place and the value of dip changes from SW to NE **(Photo 8-8)**. Change of sense of dip along the shear joint shows that some shear forces are active in the area. The developments of such joints indicate the brittle deformational style.

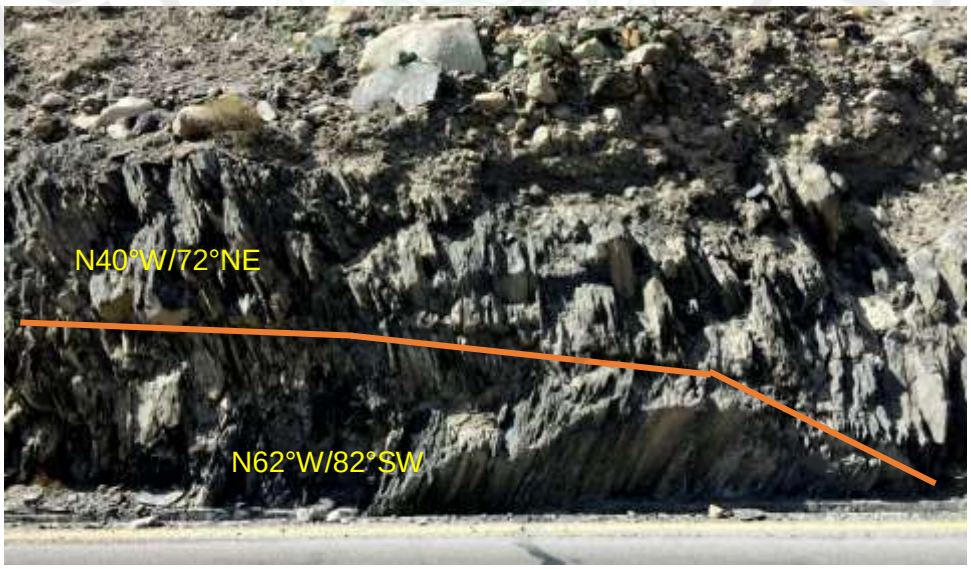


**Photo 8-8 Change of Dip along Shear joint.**

### 8.4.3 At Sarat Village:

Coordinates:

N 4018254.850 m



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E 481549.816 m
El. 2371.35 m.a.s.l

Due to Salmanabad slide in 1858, a large lake developed in upstream reaches. The depositional clayey silt can be seen on both bank of Hunza River. Due to operational neo-tectonic forces, deformation including folding, jointing, micro faulting have been developed in these deposits.

Both vertical and oblique joints can be seen in clayey silt at right side near Sarat Suspension Bridge. The strike and dip values of vertical and oblique joints are N38°W/87°NE and N32°E/63°SE respectively **(Photo 8-9)**.

**Photo 8-9 View of Vertical and Oblique Joints in Clayey Silt at Sarat Village.**

Clayey silt beds are striking N 80°E and dipping 18°NW at the left side of road to Sarat Village while at the right side of the road these beds have strike N 32°E and dipping 9°SE **(Photo 8-10 & 8-11)**.

**Photo 8-10 Tiltness in Clayey Silt Beds, Left Side of Road at Sarat Village.**



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The strike of the beds is NE while the dip is in opposite direction, indicating that it forms some sort of antiform. Formation of antiform in recent deposits clearly indicates that lateral shear compressional force are operational in this area.

**Photo 8-11 Tiltness in Clayey Silt Beds, Right Side of Road at Sarat Village.**

Just downstream of Sarat village near the Suspension Bridge, fault breccia is exposed along the river showing the alignment of fault.

**Photo 8-12 Folded and Sheared Clayey Silt at Sarat Village.**



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**Photo 8-13 Sheared and Smeared Clayey Silt at Sarat Village.**

**Photo 8-14 Fault Breccia just D/S of Suspension Bridge at Sarat Village.**

Folding, jointing, smearing and shearing of clayey silt **(Photo 8-12, 8-13, 8-14)** deposits show some lateral stresses are actively operating in this area. The active slides and rolling down of brecciated material from this slope indicate that it is tectonically active area.

### 8.4.4 Inside Tunnel 2

Many cracks/joints are going to develop in the concrete especially in crown area in tunnel-2. The pattern of the cracks indicates stress release and shear oblique joints **(Photo 8-15)**.



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**Photo 8-15 View of Recently Generated Joints Tunnel-2.**

As far as geological condition is concerned, this portion of tunnel in is under influence of two faults **(DWG No: AFP- GE- 319)**. Rock is highly crushed, rolling down of boulders is quite common along these active faults. The active tectonic forces are responsible for the development of fractures in this terrain. The same features can also be noted in concrete area in between tunnel 2 and 3 **(Photo 8-16)**.

**Photo 8-16 View of Recently Generated Joints between Tunnel-2 & 3.**

The concrete slab fractured between tunnel 2 and 3. It is evident that some tectonic forces are recently operative in this area.

### 8.4.5 Power House Area

In powerhouse area near helipad along old KKH, clayey silt is present where Chinese Camp was established. The clayey silt has been deposited after river choking due to Salmanabad



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slide. Due to operational compressional stresses, some deformations including faulting, shearing, folding, and tiltness in clayey silt have been observed.

**Photo 8-17 Micro Thrust Fault in Clayey Silt Beds near Helipad.**

The relative movement of both blocks against fault plane indicates compressional environment, moved the hanging wall block upward **(Photo 8-17)**.

**Photo 8-18 Inclination of Clayey Silt near Helipad.**

The clayey silt beds are well exposed at the left side of Hunza River near Sarat Bridge. The clayey silt beds are well jointed and tilted upward at an angle ranging from 10° to 15° **(Photo 8-18)**. The inclinations of the beds in recent soil are active tectonic features.

Near old Chinese Camp, at powerhouse area, the clayey silt is folded **(Photo 8-19)**. Folding in recently deposited clayey silt may be the result of slipping along fault plane under regional compressional shear forces.



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**Photo 8-19 Folding in Clayey Silt near Helipad/Powerhouse Area.**

Near the SCO building, along old KKH, near tunnel-1, some cracks are going to develop in recently deposited material. The development of joints is mostly parallel in nature but occasional cross cutting joints also present **(Photo 8-20)**.

**Photo 8-20 Development of Parallel Joints near SCO Building.**

### 8.4.6 At Murtazabad- Shahyar Road:

Coordinates:

| | |
|---|---|
| N | 4016299.113 m |
| E | 465418.47 m |
| El. | 2095 m.a.s.l |

Just crossing the Murtazabad to Shahyar Bridge, a thick alluvial deposit consists of gravels, cobbles, pebbles interbedded with silty sand is exposed. This material moved upward against fault plane and formed fault bend fold **(Photo 8-21)**.



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**Photo 8-21 Inclination in Clay Silt and Gravels.**

The beds are tilted at an angle of 22° to 30°. Many micro fault in sand beds have been observed in hinge area of the fold. The ramp and flat geometry have NE striking and dip SE **(Photo 8-22)**.

**Photo 8-22 Ramp and Flat Geometry along Fault.**

Some micro faults have been observed in this alluvium. Step faulting on micro level is well preserved in sandy material **(Photo 8-23)**. This alluvium is overlain by morainic material. Same joint pattern is going to be develop in it. Some open joints ranging from 10 cm to 150 cm have been observed there. All these features indicate that the tectonic forces are active in this area.



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**Photo 8-23 Development of Micro Faults in Sand.**

### 8.4.7 In Tashot Village:

Coordinates: N 4012830.531m
E 462157.244m
El. 2111.0 m a s l

After crossing suspension bridge near Tishot Bridge, a thick deposit of RBGM and clayey silt are exposed along the road toward Phakhar village. Due to some recent activity, clayey silt has displaced and smeared along micro fault.

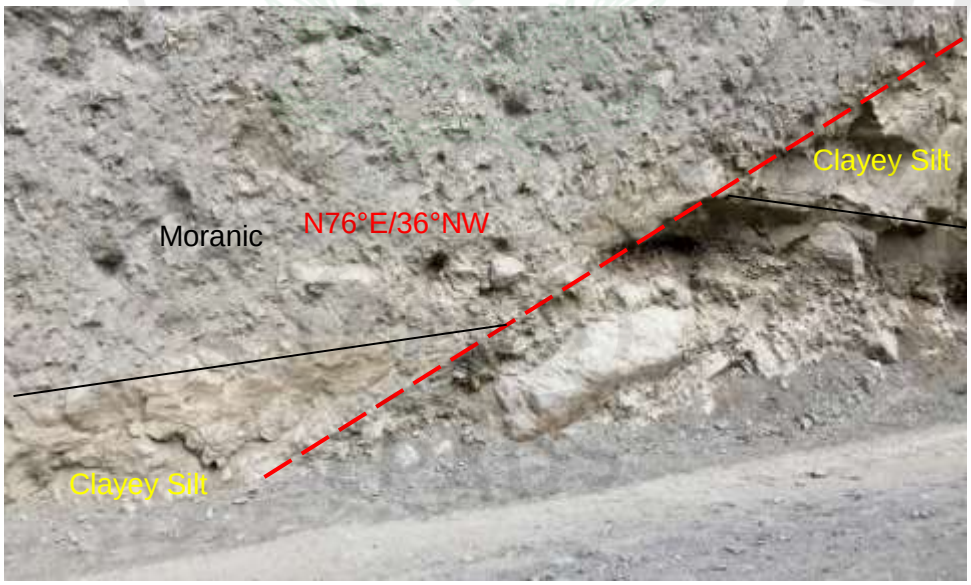


**Photo 8-24 Development of Micro Faults in Clayey Silt.**

Upward inclination of 6°in recent RBGM in measured along the road **(Photo 8-24, 8-25)**.



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**Photo 8-25 Inclination in RBGM in Tashot Village along Road.**

## 8.5 SEISMIC HAZARD ANALYSIS

The quantitative and qualitative seismic hazard analyses presented in this study preceded by a detailed appraisal of the structure, geodynamics and neotectonics, to characterize the on-site and regional tectonic scenario to assist in proposing a suitable earthquake resistant design. This study has used the seismic source characterization deduced in the accompanying Neo-tectonic studies and calculated the earthquake potential hazard and related ground motions as presented in this report.

### 8.5.1 PROBABILISTIC HAZARD ANALYSIS

Both PSHA and DSHA were carried out using EZ-FRISK software Version 7.65 developed by Risk Engineering Inc. USA. The latest version of R-CRISIS Software version 21.1.1 developed by PEER, USA has also been used during the current study. The purpose of using both software has to cross check the validation comparing the quality of the seismic hazard analysis of the two software for the project. During the study it has been found that Ez-Frisk software is more standardized as compared to R-CRISIS software in quality of analysis as well as the smart outputs of the analyzed results. Therefore, Ez-Frisk software has been preferred and used in the in the final analysis.

Important input parameters for different seismic zones used in probabilistic approach are presented in **Table 8-1**. It is assumed that weir foundation will be placed on gravelly soil (alluvium), therefore, the site condition has taken as gravelly soil with average shear wave velocity at 30 meters depth ($V_{s30}$) of 450 m/sec for soil site (alluvium) and 760 m/s for rock sites. The mean total hazard curve obtained by giving equal weighting to all the Five NGA W2 Ground Motion Prediction Equations.

The total hazard curve obtained for the Project Area is shown as **Figure 8-2** and the total mean Hazard Spectra showing combination of all used Ground Motion Prediction Equations for ALHPP is presented as **Figure 8-3**.



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**Table 8-1 Seismic Source Parameters for Probabilistic Analysis**

| Source Zone | Seismic Source Zone | Min. Magnitude Mw | Activity Rate / Year | β | Max. Magnitude Mw |
|---|---|---|---|---|---|
| 1 | Karakorum | 4.0 | 1.929 | 1.120 | 7.3 |
| 2 | Nanga Parbat | 4.2 | 1.112 | 1.101 | 7.0 |
| 3 | Western Himayan | 4.1 | 5.339 | 1.44 | 7.0 |
| 4 | Hindukush | 4.2 | 59.107 | 1.20 | 8.0 |
| 5 | Kashmir Himalaya | 4.2 | 7.143 | 1.13 | 7.8 |
| 6 | Kohistan | 4.1 | 10.500 | 1.07 | 7.5 |

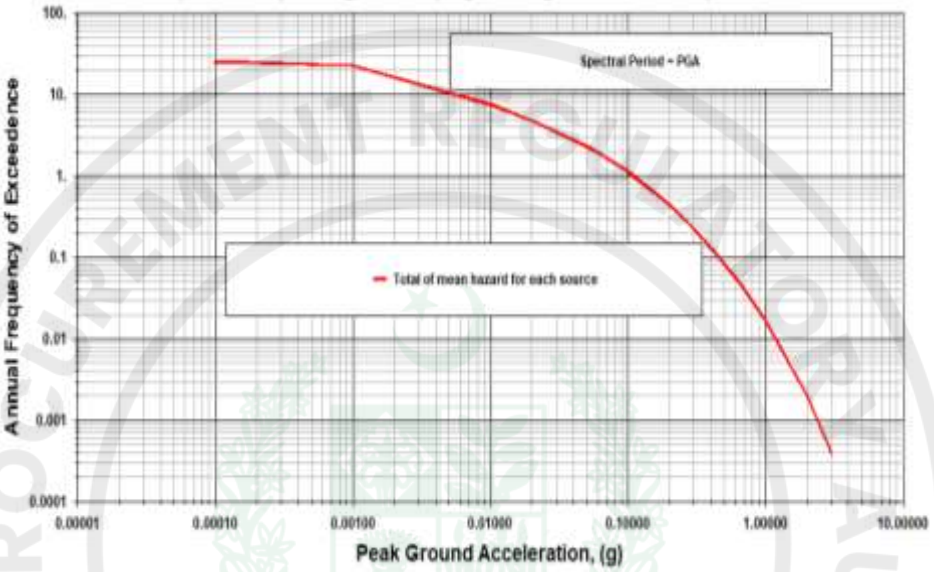


**Figure 8-2 Total Hazard Curve for ALHPP**.

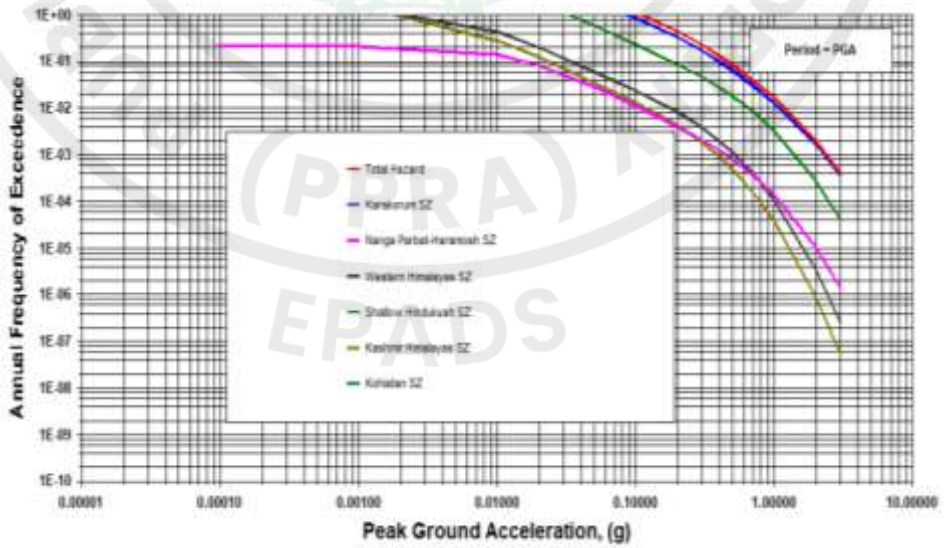


**Figure 8-3 Earthquake Hazard by Seismic Sources, Showing Spectral Response**.



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## 8.6 DETERMINISTIC SEISMIC HAZARD ANALYSIS (DSHA)

The capability of the faults to generate earthquakes is ascertained by means of analysis of historical and instrumental seismic data and geological criteria such as rupture length – magnitude relationship or fault movement – magnitude relationship.

The main tectonic features around the Project Site within a radius of 200 km which could be controlling the maximum earthquake hazard are as follows:

- Hunza Fault
- Main Karakoram Thrust (MKT)
- Main Mantle Thrust (MMT)

Empirical correlations have been developed between maximum potential of a fault and key fault parameters like rupture length, fault area, fault displacement and slip rate. Out of these fault parameters, only fault lengths are known with sufficient accuracy. For the faults around the ALHPP site, the half rupture length of the faults has been taken for determination of maximum potential magnitude. The maximum earthquake magnitude (in moment magnitude $M_W$) of each of the fault calculated using Wells & Coppersmith (1994) relationship between fault rupture length and magnitude and the input data given in **Table 8-2** has been used for deterministic approach.

**Table 8-2 The Controlling Faults with Quantitative Features (input values of DSHA)**

| Controlling Faults | Fault Type | Fault Rupture Length (km) | Distance (km) | Maximum magnitude potential | |
|---|---|---|---|---|---|
| | | | | Catalogue data | Conservatively Assigned |
| Hunza Fault | Thrust | 5 inferred | 1.4 | 6.1 | 6.7 |
| MKT | Thrust | 200 | 32 | 7.0 | 7.6 |
| MMT | Thrust | 260 | 71.69 | 6.9 | 7.6 |

Ground motion prediction equations developed under the Next Generation Attenuation (NGA) West 2 Project of PEER (Pacific Earthquake Engineering Research Center, University of California at Berkeley, USA) are used to obtain the median and median plus-one percentile levels of Peak Horizontal Ground Acceleration (PGA) in deterministic approach.

The NGA equations are developed using a large worldwide database of strong motion recording of earthquakes of magnitude 4-8 and distances ranging from 0-200 km in accordance with ICOLD Guidelines. The NGA equations are preferable over the older equations for the evaluation of seismic hazard particularly in the near field as these are based on a broad spectrum of data recorded in the near field. The same attenuation equations were used for the PSHA approach too.

For all the seismic sources, thrust rupture mechanism has been considered. It is assumed that dam foundation will mainly be placed on gravelly soil therefore the site condition for weir has been taken as gravelly soil with average shear wave velocity for top 30 meters ($V_{s30}$) of 760 m/sec. The depth to basement rocks ($Z_{25}$) is taken as 5 km. The PGA g values have been calculated using the latest 5 sets of NGA West 2 Ground Motion Prediction Equations (GMPEs).



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Input values in Deterministic Seismic Hazard Analysis (DSHA) are given in **Table 8-2**. The analyzed results obtained through DSHA are presented in figures.

## 8.7 DETERMINISTIC RESPONSE SPECTRA

Deterministic Response Spectra for Safety Evaluation Earthquake (SEE) at 50$^{th}$ percentile and 84th percentile levels over the Five NGA West 2 equations are shown in **Figure 8-4 & 8-5** respectively.

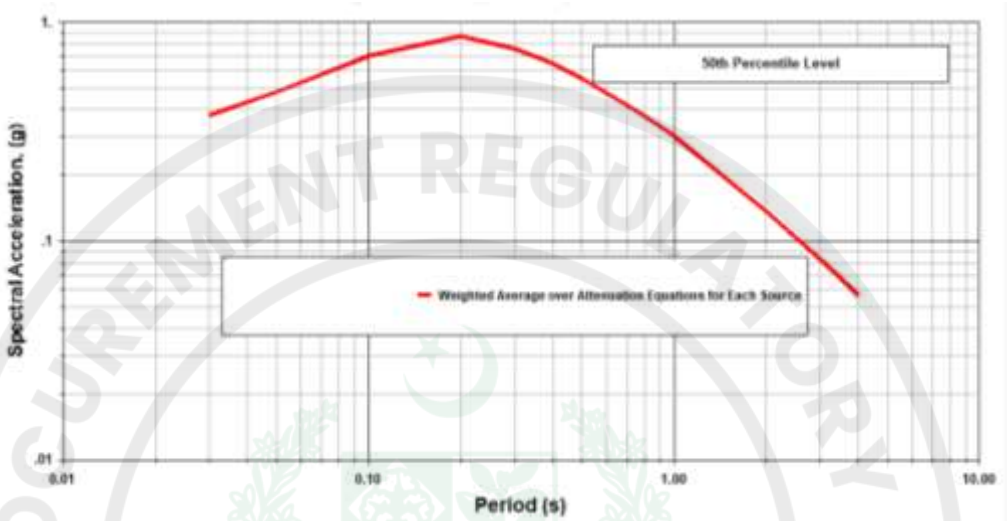


**Figure 8-4 Deterministic Spectra at 50$^{th}$ Percentile Level Weighted Average**

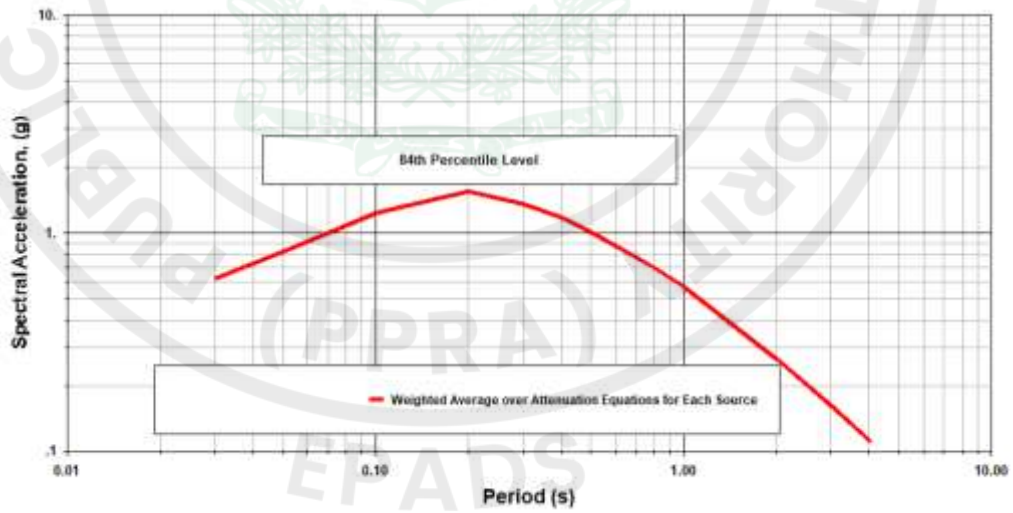


**Figure 8-5 Deterministic Spectra at 84$^{th}$ Percentile**

### 8.7.1 Deterministic Pseudo Spectral Acceleration (PSA)

Pseudo spectral acceleration has been worked out using the latest version of R-CRISIS software. Pseudo spectral acceleration Vs time is given in **Figure 8-6**.



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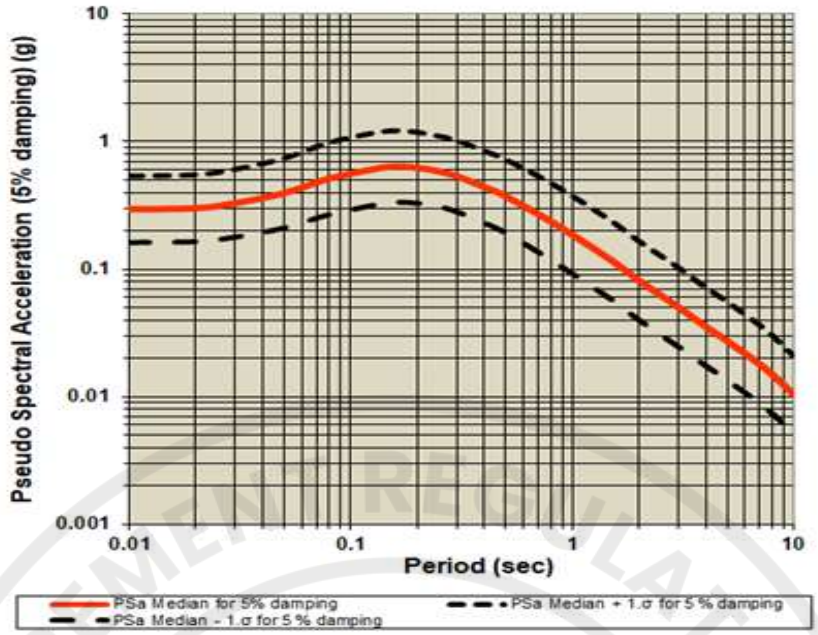


**Figure 8-6 Deterministic pseudo Spectral Acceleration (g) at 5% Damping.**

## 8.8 SELECTION OF SEISMIC DESIGN PARAMETERS

### 8.8.1 Safety Evaluation Earthquake (SEE)

As per ICOLD guidelines (2016) the Safety Evaluation Earthquake (SEE) will produce the maximum level of ground motion for which the dam should be designed or analyzed. For dams whose failure would present a great social hazard, the SEE will normally be characterized by a level of motion equal to that expected at the dam site from the occurrence of deterministically evaluated MCE or of the probabilistically-evaluated SEE earthquake ground motion with a very long return period, for example 10,000 years for high consequence large dams. Depending on the circumstances e.g. the importance of the dam, the consequences of a dam failure, it is recommended to design safety-critical elements such as the bottom outlet and/or spillway gates for the SEE. It will be required at least that there is no uncontrolled release of water when the dam is subjected to the seismic load imposed by the SEE.

As per the latest ICOLD Guidelines, for medium consequence dams, median value ($50^{th}$ percentile level) is recommended whereas for high consequence dams, the SEE ground motion parameters should be estimated at median plus one ($84^{th}$ percentile level) if developed by a deterministic approach and need not have a mean annual exceedance probability (AEP) smaller than 1/10,000 if developed by a probabilistic approach. For a particular project of importance such as hydropower project, optimum percentile level may be any optimum percentile level between $50^{th}$ percentile level to $95^{th}$ percentile level. For ALHPP, $66^{th}$ percentile level has been worked out and the same is recommended.



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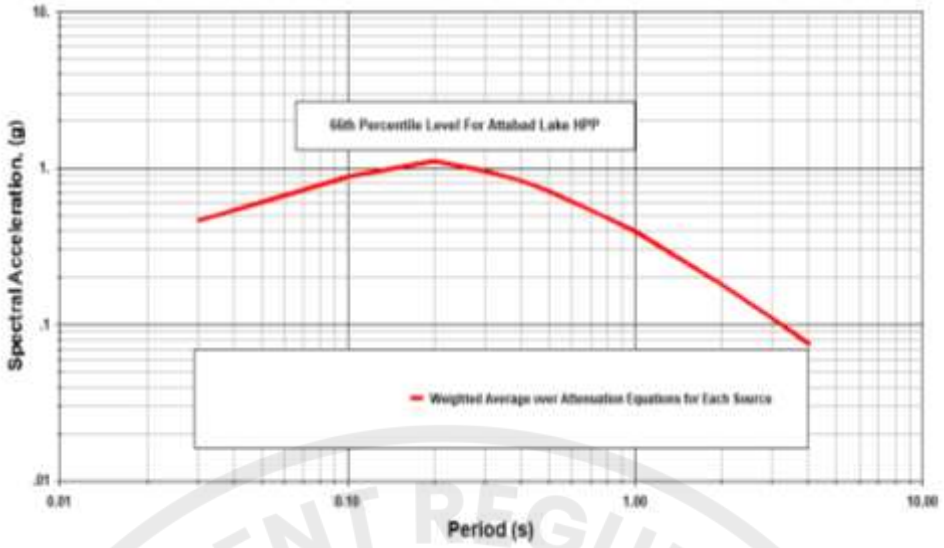


**Figure 8-7 Deterministic Spectra at 66th Percentile Level of SEE.**

### 8.8.2 Operating Basis Earthquake (OBE)

The Operating Basis Earthquake (OBE) represents the level of ground motion at the dam site at which only minor damage is acceptable. In theory the OBE can be determined from an economic analysis, but this is not always feasible and, in many cases, it will be appropriate to choose a return period of about 145 years (i.e. a 50 % probability of not being exceeded in 100 years). The dam, appurtenant structures and equipment should remain functional and damage easily repairable, from the occurrence of earthquake shaking not exceeding the OBE.

Since the consequences of exceeding the OBE are normally economic, the circumstances in a particular case may justify use of a more severe or less severe event for the OBE. The resulting return period depends on prevailing conditions.

Because of the above definition, the OBE is the best determined by using probabilistic procedure. OBE ground motions are significantly lower than those for SEE.

### 8.8.3 Uniform Hazard Spectra (UHS)

Uniform hazard spectra for ALHPP for OBE (145 year return period), DBE (475 year and 2475 years return period) and SEE (10,000-years return period) are presented as **Figure 8-8.**



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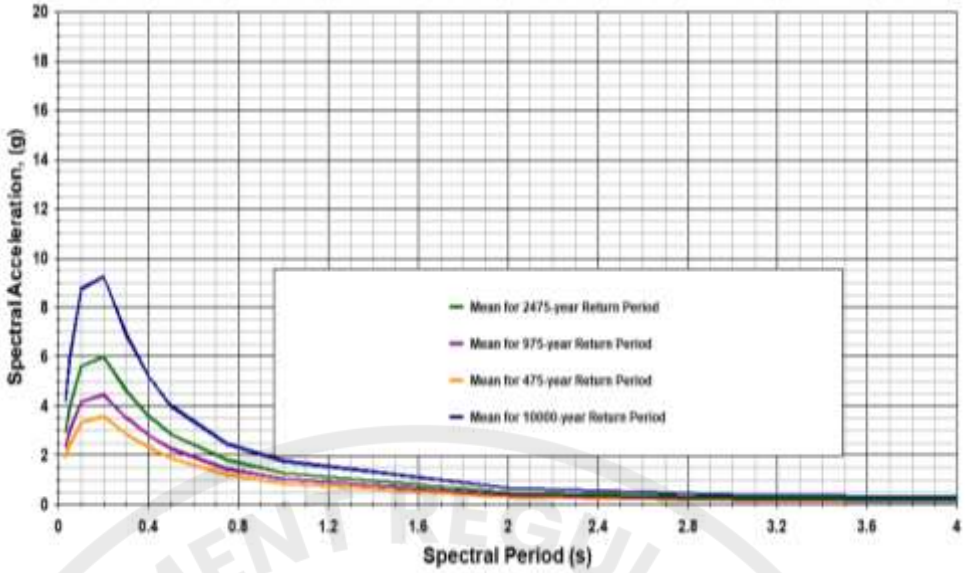


**Figure 8-8 Uniform Hazard Spectra (UHS) showing mean hazard for various return periods.**

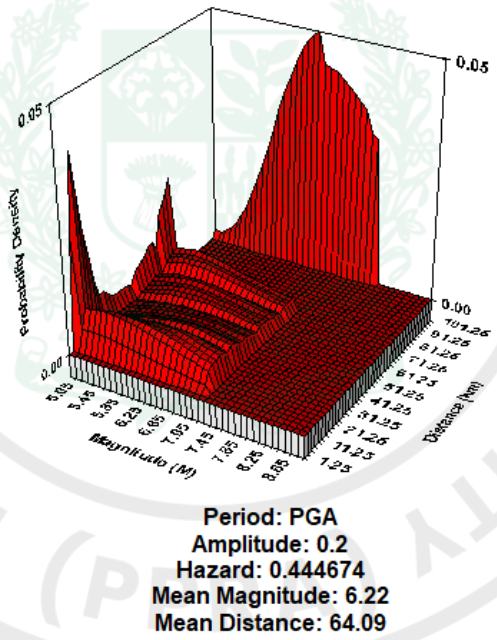


**Figure 8-9 Deaggregation of Mean Hazard, Mean Magnitude and Mean Distance.**

## 8.9 CONCLUSION AND RECOMMENDATIONS

Based on the analysis results, the following earthquakes design parameters are concluded and recommended for ALHPP.

**<u>Operation Basis Earthquakes (OBE):</u>**

OBE at return period of 145 years is recommended as follows:

OBE Horizontal = 0.24 g

OBE Vertical = 0.17 g



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**Safety Evaluation Earthquakes (SEE):**

For the design of dam / weir, the following PGA 'g' values for SEE (Safety Evaluation Earthquakes) are recommended:

SEE Horizontal = 0.44g

SEE Vertical = 0.29g

For the design of appurtinent structures including spillway, the following PGA 'g' values for SEE (Safety Evaluation Earthquakes) are recommended:

SEE Horizontal = 0.38g

SEE Vertical = 0.26g

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# 9 CONCLUSIONS

- The Project Area lies in Karakorum Block, where rocks of meta igneous provenance are exposed. The rock units represent acidic igneous rocks including Granodiorite and Granitic Gneiss.
- The Project Area lies in the vicinity of collisional tectonic belt, bounded by Main Karakoram Thrust (MKT) in south and Karakorum Fault (strike slip) in northeastern margin. Many local as well as regional faults are present in Project Area.
- Different surface and subsurface investigations including surface geological mapping, drilling, neo-tectonic studies and seismic hazard analysis have been carried out during Feasibility Study. It is observed that overall the area is tectonically disturbed, many deformational features are illustrious of recent operative compressional forces in recently deposited material.
- Different laboratory tests regarding geotechnical parameters for design and foundation evaluation have carried out in the field and in laboratory. The rock core samples as well as soil samples (from UDS and SPT) from different test pits regarding different structures and borrow area have been carried out in Central Material Testing Laboratory (CMTL) Lahore.
- The geotechnical investigations carried out during Feasibility Study indicates that weir is founded at overburden material consist of slided mass. High permeability values encountered during drilling in all borehole is indicative of gaps/cavities in subsurface. One of the major task is to control the seepage through slided mass for the stability of weir and other appurtenant structures. Slope stability at both abutments of weir and sediment flushing channel is very important and crucial task in this regard.
- All the appurtenant structures i.e. sediment flushing channel, power tunnel, surge shaft, penstock and power house are proposed on left side of Hunza River.
- During the Neo-tectonic studies it is observed during field work that there are many active surface geological features regarding the recent tectonic activities operating in the vicinity of the Project Area. These features have been incorporated as parameters in calculation of Peak Ground Acceleration (PGA) “g” value in Seismic Hazard Analysis.
- Both fine and coarse aggregates for construction of overtopping concrete weir and other associated structures are present in the vicinity of Project Area in ample quantities. Clayey silt for blanketing/impervious material, coarse aggregate and rip rap have been investigated and proposed as barrow area while sand and fill materials are proposed to be excavated from river bed.


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# 10 RECOMMENDATIONS

- As active tectonic forces are operative in this area, it is quite important that all the structures should designed according to peak ground acceleration “g” value calculated by seismic hazard analysis.
- The active tectonic forces are responsible for the rolling down of Attabad Slide. Some additional investigations should be carried out at right side slope. At different locations installation of inclinometers and fixation of telltales (Glass strips)/movement pins should be carried out during DED to observe the ground motion.
- Clay blanketing/grout curtain may be required to control the seepage especially through the foundation of weir and sediment flushing channel.
- Special attention should be given for the stabilization of slided mass at both banks of Hunza River, especially along sediment flushing channel and weir area.
- Ample quantity of Angular Boulder Gravels (ABG) present in slided material falls in permissible limits as perceived by laboratory testing. It can be used as rip-rap material to stabilize the slope in upstream area.



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# PAKISTAN

## WATER AND POWER DEVELOPMENT AUTHORITY

# ATTABAD LAKE HYDROPOWER PROJECT

# FEASIBILITY STUDY

# VOLUME 4

# NEOTECTONIC STUDIES & SEISMIC HAZARD ANALYSIS

**June 2021**

## HYDRO PLANNING ORGANIZATION

WAPDA, SUNNY VIEW ESTATE, LAHORE ☎ 99202717 🖷 99202722 ✉ gmhydroplanning@gmail.com

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# ATTABAD LAKE HYDROPOWER PROJECT
# LIST OF VOLUMES

VOLUME – 1 MAIN REPORT

VOLUME – 2 DRAWINGS

VOLUME – 3 GEOLOGICAL AND GEOTECHNICAL STUDIES

**VOLUME – 4 NEOTECTONIC STUDIES & SESIMIC HAZARD ANALYSIS**

VOLUME – 5 BOREHOLE LOGS AND LABORTORY TESTING

VOLUME – 6 ENVIRONOMENTAL AND SOCIAL IMPACT ASSESSMENT

VOLUME – 7 APPENDICES

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# LIST OF ABBREVIATION

| | |
|---|---|
| **A** | |
| ADB | Asian Development Bank |
| AKCSP | Aga Khan Cultural Service Pakistan |
| AKDN | Aga Khan Development Net Work |
| AKF | Aga Khan Foundation |
| AKHS | Aga Khan Health Service |
| AKRSP | Aga Khan Rural Support Program |
| **C** | ` |
| CBM | Confidence-Building Measure |
| CBOs- | Community-based organizations |
| CPEC | China Pakistan Economic Corridor |
| DLP | Defect Liability Period |
| **E** | |
| EIA | Environmental Impact Assessment |
| EL | Elevation Level |
| EMMP | Environment Monitoring Management Plan |
| EOT | Electric Overhead Bridge Type Traveling |
| EPA | Environment Protection Agency |
| EIA | Environmental Impact Assessment |
| **G** | |
| GB | GilgitBaltistan |
| GEF | Global Environment Facility |
| GHG | Green House Gases |
| GLOF | Glacial Lake Outburst Floods |
| GSP | Geological Survey of Pakistan |
| **H** | |
| ha | Hectare |
| HPO- | Hydro Planning Organization |
| HPP | Hydropower Project |
| **I** | |
| ICT- | Information and Communication Technologies |
| IEE | Initial Environmental Examination |
| IRS | Indus River System |
| IUCN | International Union for Conservation of Nature |
| **K** | |
| KKH | Karakoram Highway |
| KNP- | Khunjerab National Park |



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## LIST OF ABBREVIATION

| | |
|---|---|
| KPK- | Khyber Pakhtunkhwa |
| **L** | |
| LAA | Land Acquisition Act |
| LGO | Local Government Ordinance |
| **M** | |
| MASL | Meters Above Sea Level |
| MBT | Main Boundary Thrust |
| MKT | Main Karakoram Thrust |
| MMM | Mitigation Management Matrix |
| MMT | Main Mantle Thrust |
| MW | Mega Watt |
| **N** | |
| NA | Northern Areas |
| NCS | National Conservation Strategy |
| NEQS | National Environment Quality Standards |
| NGO | Non- Governmental Organizations |
| NOC | No Objection Certificate |
| **P** | |
| PAP | Project Implementation and Resettlement of the Affected Persons |
| PEPA | Pakistan Environmental Protection Act |
| PEPC | Pakistan Environmental Protection Council |
| PMAC | Program for Mountain Areas Conservation |
| PPC | Pakistan Penal Code |
| **R** | |
| RAP | Resettlement Action Plan |
| RNR | Renewable Natural Resources |
| **S** | |
| SC | Supervisory Consultants |
| SWHP | Surface Water Hydrology Project |
| **T** | |
| TOR | Terms of Reference |
| **U** | |
| UNDP | United Nations Development Program |
| **V** | |
| VO | Village Organizations |
| **W** | |
| WAPDA | Water and Power Development Authority |



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## LIST OF ABBREVIATION

| | |
|---|---|
| WCSDO | Wildlife Conservation and Social Development Organizations |
| WCS | Wildlife Conservation Society |
| WHO | World Health Organization |
| WUO | Water Users' Organizations |
| WWF | World Wide Fund |

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## UNITS: CONVERSION FACTORS: SI TO FPS

| Length | To convert from | to | Multiply by |
|---|---|---|---|
| | M | ft | 3.281 |
| | Cm | ft | 0.0328 |
| | Km | ft | 3,280.84 |
| | M | mi | 0.0006214 |
| | Km | mi | 0.6214 |
| **Area** | $m^2$ | $ft^2$ | 10.764 |
| | $km^2$ | $mi^2$ | 0.3861 |
| | $m^2$ | acre | 0.0002471 |
| | $km^2$ | acre | 247.105 |
| | Hectare | acre | 2.471 |
| **Volume** | $m^3$ | $ft^3$ | 35.315 |
| | $m^3$ | US gal | 264.172 |
| | $m^3$ | UK gal | 219.969 |
| | L | $ft^3$ | 0.035315 |
| | $m^3$ | Acre Feet | 0.000810714 |
| **Velocity** | m/s | ft/s | 3.281 |
| | cm/s | ft/s | 0.03281 |
| | m/s | mi/h | 2.237 |
| | km/h | mi/h | 0.622 |
| **Acceleration** | $m/s^2$ | $ft/s^2$ | 3.281 |
| **Mass** | Kg | $lb_m$ | 2.205 |
| | Kg | ton | 0.00110 |
| **Pressure and Stress** | Pa or $N/m^2$ | psi | 0.000145 |
| **Discharge** | $m^3/s$ | $ft^3/s$ | 35.315 |
| | L/s | $ft^3/s$ | 0.035315 |
| | $m^3/s$ | US gal/min | 15850.3 |
| | $m^3/s$ | UK gal/min | 13198.2 |
| | L/s | US gal/min | 15.850 |
| | L/s | UK gal/min | 13.198 |



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# TABLE OF CONTENTS

**1 INTRODUCTION ..... 1-1**

1.1 GENERAL ..... 1-1
1.2 SCOPE OF WORK ..... 1-2
1.3 OBJECTIVES ..... 1-2
1.4 METHODOLOGY ..... 1-2

**2 REGIONAL GEOLOGY ..... 2-1**

2.1 GENERAL ..... 2-1
2.2 STRATIGRAPHIC SEQUENCE ..... 2-1
2.2.1 Misgar Unit ..... 2-2
2.2.2 Sost Unit: ..... 2-2
2.2.3 Gojal Unit: ..... 2-2
2.2.4 Karakorum Axial Batholith (KAB): ..... 2-3
2.2.5 Ganesh Formation: ..... 2-3
2.2.6 Hassanabad Granite: ..... 2-3
2.2.7 Chalt Formation: ..... 2-3
2.3 REGIONAL TECTONICS ..... 2-3
2.4 REGIONAL FAULTS ..... 2-5
2.4.1 Karakorum Fault (KF) ..... 2-5
2.4.2 Upper Hunza Fault (UHF) ..... 2-6
2.4.3 Main Karakorum Thrust (MKT) ..... 2-6
2.4.4 Main Mantle Thrust (MMT) ..... 2-6

**3 SITE GEOLOGY ..... 3-1**

3.1 GENERAL ..... 3-1
3.2 TECTONOSTRATIGRAPHIC MAP ..... 3-1
3.2.1 Lithological Units: ..... 3-1
3.3 GEOLOGICAL STRUCTURES ..... 3-4
3.3.1 Faults ..... 3-4

**4 NEOTECTONICS STUDIES ..... 4-1**

4.1 GENERAL ..... 4-1
4.2 RIGHT BANK OF HUNZA RIVER: ..... 4-2
4.2.1 Passu Village: ..... 4-2



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4.2.2 Murradabad/Barut Village: ....4-6
4.2.3 Road Section from Murradabad to Hussaini Village: ....4-8
4.2.4 At Hussaini Village: ....4-9
4.2.5 Way From Hussaini to Borith Lake: ....4-12
4.2.6 At Borith Lake: ....4-13
4.2.7 Just Downstream of Gulkin Glacier: ....4-18
4.2.8 At Attabad Village: ....4-20
4.2.9 At Sarat Village: ....4-22
4.2.10 At Salmanabad Village: ....4-25
4.2.11 At Hassanabad Nullah: ....4-27
4.2.12 At the Murtazabad- Shahyar Bridge: ....4-28
4.3 LEFT BANK OF HUNZA RIVER ....4-29
4.3.1 At confluence of Shamshal Nullah with Hunza River: ....4-29
4.3.2 In front of Gulmit and Gulkin Glacier: ....4-31
4.3.3 In Perennial Nullah at the End of Tunnel 4: ....4-32
4.3.4 Inside Tunnel 2: ....4-33
4.3.5 In Between Tunnel 1 and 2: ....4-34
4.3.6 Power House Area: ....4-35
4.3.7 In front of Salmanabad and Ahmadabad Village: ....4-36
4.3.8 Upstream of Ganesh Bridge: ....4-39
4.3.9 Near Kiln Upstream of Ganesh Bridge: ....4-40
4.3.10 At Ganesh Bridge: ....4-41
4.3.11 Just Downstream of Ganesh bridge: ....4-42
4.3.12 In Hispar Valley: ....4-44
4.3.13 At Nagar Valley: ....4-47
4.3.14 At Murtazabad- Shahyar Road: ....4-47
4.3.15 In Tashot Village: ....4-49
4.3.16 In Maichar Village: ....4-50
**5 CONCLUSIONS FOR NEOTECTONICS STUDY ....5-1**
**6 SEISMIC HAZARD ASSESSMENT ....6-1**
6.1 INTRODUCTION ....6-1
6.2 TECTONIC SETTING ....6-3
6.2.1 General ....6-3
6.3 Regional and Local Tectonic Features ....6-4



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6.3.1 General ..... 6-4
6.3.2 HUNZA Fault (HF) ..... 6-6
6.3.3 MAIN KARAKORAM THRUST (MKT) ..... 6-6
6.3.4 MAIN MANTLE THRUST (MMT) ..... 6-7
6.3.5 MAIN CENTRAL THRUST (MCT) ..... 6-7
6.3.6 PANJAL THRUST (PT) ..... 6-7
6.3.7 NATHIA GALI THRUST (NGT) ..... 6-7
6.3.8 MAIN BOUNDARY THRUST (MBT) ..... 6-7
6.3.9 KASHMIR BOUNDARY THRUST / HIMALAYAN FRONTAL THRUST (KBT/HFT) ..... 6-8
6.3.10 SALT RANGE THRUST (SRT) ..... 6-8
6.4 SEISMICITY OF PROJECT AREA ..... 6-10
6.4.1 General ..... 6-10
6.4.2 STUDY AND ANALYSIS OF EARTHQUAKES DATA ..... 6-11
6.4.3 Historical (Pre-Instrumental) Seismicity ..... 6-12
6.4.4 Analysis of Historical (Pre-Instrumental) Seismicity ..... 6-12
6.4.5 Instrumental Seismicity ..... 6-13
6.4.6 Analysis of Instrumental Seismicity ..... 6-14
6.4.1 Conversion of Magnitudes and Standard Deviation ..... 6-17
6.4.2 Kashmir Earthquake of October 08, 2005 and the New Scenario 6-19
6.5 INDENTIFICATION OF SEISMIC SOURCES ..... 6-21
6.5.1 HUNZA FAULT (HF) ..... 6-21
6.5.2 MAIN KARAKORUM THRUST (MKT) ..... 6-22
6.5.3 MAIN MANTLE THRUST (MMT) ..... 6-22
6.6 SEISMOTECTONICS ..... 6-22
6.7 PROBABILISTIC SEISMIC HAZARD ASSESSMENT (PSHA) ..... 6-23
6.7.1 PSHA Methodology ..... 6-23
6.7.2 Earthquake Recurrence Model ..... 6-24
6.7.3 Activity Rate of Seismic Sources ..... 6-26
6.7.4 Maximum Magnitude ..... 6-27
6.7.5 Ground Motion Prediction Equations ..... 6-27
6.7.6 Seismic Sources Modeling ..... 6-27
6.8 RESULTS OF PROBABILISTIC HAZARD ANALYSIS ..... 6-28
6.9 DETERMINISTIC SEISMIC HAZARD ANALYSIS (DSHA) ..... 6-30
6.9.1 DETERMINISTIC RESPONSE SPECTRA ..... 6-31



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6.9.2 Deterministic Pseudo Spectral Acceleration (PSA) ..... 6-32
6.10 SELECTION OF SEISMIC DESIGN PARAMETERS..... 6-33
6.10.1 Safety Evaluation Earthquake (SEE)..... 6-33
6.10.2 Operating Basis Earthquake (OBE)..... 6-34
6.10.3 Uniform Hazard Spectra (UHS)..... 6-34
**7 CONCLUSION AND RECOMMENDATIONS..... 7-1**
7.1 Operation Basis Earthquakes (OBE): ..... 7-1
7.2 Safety Evaluation Earthquakes (SEE): ..... 7-1
**8 REFERENCES..... 8-1**



e-Pak Acquisition and Disposal System (EPADS) generated document | © 2026

# LIST OF FIGURES

Figure 4:1 Development of Normal Faults under Compressional Regime.....4-5
Figure 6-1 Composite Map Showing Location of ALHPP Site. .....6-2
Figure 6-2 Geological Map of Northern Pakistan (Pecheretal. 2008) & Geological Map of Hunza. .....6-2
Figure 6-3 General Tectonic Setting of Pakistan, .....6-4
Figure 6-4 Major Tectonic Faults of Pakistan, Pink Circle Shows the Project Area. .....6-5
Figure 6-5Tectonic Map of Northwestern Himalayas (Northern Pakistan.....6-5
Figure 6-6Geological Map of Northern Pakistan. .....6-6
Figure 6 -7 Faults Map of Northern Pakistan Marked on ]Satellite Map .....6-8
Figure 6-8 Geological Map of Northern Pakistan and Geological Map of Hunza Area.....6-9
Figure 6-9 Composite Map Showing Site Geology and Seismicity with Preliminary Project Layouts. .....6-10
Figure 6-10 Region Selected for Acquiring Tele-seismic Earthquakes Catalogue .....6-11
Figure 6-11 Pie Chart of Historical Sources for Compilation of Composite Earthquake Catalogue. .....6-12
Figure 6-12 Historical Earthquakes Map around ALHPP and Adjoining Areas in Ez-Frisk Software. .....6-13
Figure 6 -13 Pie Chart of Instrumental Sources Contributing to the Composite Earthquake Catalogue...6-14
Figure 6 14 Temporal Distribution of the Earthquakes Events with Magnitudes of the Past 100 Years ...6-15
Figure 6-15 Distribution of Earthquake Magnitudes of the Project Area. .....6-15
Figure 6-16 Composite Map Showing Seismic Basins of Pakistan and Hunza Area .....6-16
Figure 6-17 Earthquakes Focal Depth Contour Map of ALHPP Area.. .....6-17
Figure 6-18 Seismic Map Showing Events with Magnitudes of the Past 1255 Years (765 A.D. to 2020). 6-17
Figure 6-19 Standard Deviations (б) Vs Moment Magnitudes (Mw). .....6-19
Figure 6-20 Earthquake Epicenter of Kashmir Earthquake of October 8, 2005. .....6-20
Figure 6-21 Seismo-Tectonic Map of the Project Area. y Rectangle Shows the Project Area. .....6-23
Figure 6-22 Seismo-Tectonic Map of Northern Pakistan Showing Project Area. .....6-23
Figure 6-23 Magnitude-Frequency Curves of Seismic Sources. .....6-26
Figure 6-24 Activity Rate by Seismic Sources for ALHPP Area. .....6-27
Figure 6-25 Total Hazard Curve for ALHPP.....6-29
Figure 6-26 Total Hazard Spectra for ALHPP. .....6-29
Figure 6-27 Hazard by Seismic Sources Contribution, Spectral Response @ 5% Damping.. .....6-30
Figure 6-28 Deterministic Spectra at 50th Percentile Level.....6-31
Figure 6-29 Deterministic Spectra at 84th Percentile Level. .....6-32
Figure 6-30 Deterministic Pseudo Spectral Acceleration (g) at 5% Damping. .....6-32
Figure 6 -31 Deterministic Spectra at 66th Percentile Level of SEE.....6-34
Figure 6-32 Uniform Hazard Spectra (UHS) for ALHPP. .....6-35
Figure 6-33 Deaggregation of Mean Hazard, Magnitude and Distance for SEE by PSHA for ALHPP .....6-35



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# LIST OF PHOTOS

Photo 4-1 Inclined Gravel Layer Under Effect of Shearing ..... 4-2
Photo 4-2 Overall View of Clay Deposits and Inclination in Beds. ..... 4-3
Photo 4-3 Recumbant Fold Strata with Crenulation in Limbs in Clay Strata. ..... 4-3
Photo 4-4 Stylolite/Pressure Solutions in Clay Strata. ..... 4-4
Photo 4-5 Micro Faults in Clay Beds. ..... 4-4
Photo 4-6 Horst and Graben Structure along Micro Fault in Clay Beds. ..... 4-5
Photo 4-7 View of Active Slides in Passu Village. ..... 4-6
Photo 4-8 View of Bedding Joints along Shear Zone Passu Village. ..... 4-6
Photo 4-9 View of Bedding Joints along Shear Zone Murradabad Village. ..... 4-7
Photo 4-10 View of Micro Folding in Clay Beds near Murradabad Village. ..... 4-7
Photo 4-11 View of Brecciated Rock Upstream of Hussaini Village. ..... 4-8
Photo 4-12 View of Folded ABGM Just Upstream of Passu Village. ..... 4-9
Photo 4-13 Change of Dip along Shear Joint. ..... 4-9
Photo 4-14 Inclination in Sand Beds in RBGM. ..... 4-10
Photo 4-15 Inclination in RBGM. ..... 4-10
Photo 4-16 Micro Fault in Clay Deposit Overlain by RBGM. ..... 4-11
Photo 4-17 Micro Folding and Inclination in Clay Deposit Overlain by RBGM. ..... 4-11
Photo 4-18 Contact of Granitic Gneiss and Passu Slates. ..... 4-12
Photo 4-19 Micro Faults in Clay Beds. ..... 4-12
Photo 4-20 Fold in Clayey Silt along Trace to Borith Lake. ..... 4-13
Photo 4-21 Highly Deformed Sand and RBGM. ..... 4-14
Photo 4-22 Inclination of RBGM and Sand Beds. ..... 4-14
Photo 4-23 Inward Inclination(curvature) of RBGM and Sand Beds. ..... 4-15
Photo 4-24 X-bedding and Pinching of Sand Beds. ..... 4-15
Photo 4-25 Folding in RBGM and Sand Beds. ..... 4-16
Photo 4-26 Folding in RBGM and Sand Beds. ..... 4-16
Photo 4-27 Folding in RBGM and Sand Beds. ..... 4-17
Photo 4-28 Micro Faulting in RBGM and Sand Beds. ..... 4-17
Photo 4-29 Fault Breccia of Marble at High Elevation. ..... 4-18
Photo 4-30 Micro Fault in Alluviul Gritty Sand. ..... 4-19
Photo 4-31 X-bedding in Sand. ..... 4-19
Photo 4-32 Folding in Clayey Silt with Pointed Hinge. ..... 4-20
Photo 4-33 View of Fault Alignment Crossing Hunza River near Attabad. ..... 4-21
Photo 4-34 View of Attabad Slide. ..... 4-22
Photo 4-35 View of Vertical and Oblique Joints in Clayey Silt at Sarat Village. ..... 4-23
Photo 4-36 Tiltness in Clayey Silt Beds, Left Side of Road at Sarat Village. ..... 4-23
Photo 4-37 Tiltness in Clayey Silt Beds, Right Side of Road at Sarat Village. ..... 4-24
Photo 4-38 Folded and Sheared Clayey Silt at Sarat Village. ..... 4-24
Photo 4-39 Sheared and Smeared Clayey Silt at Sarat Village. ..... 4-25
Photo 4-40 Fault Breccia just D/S of Suspension Bridge at Sarat Village. ..... 4-25
Photo 4-41 Fault Breccia along Road at Salmanabad Village. ..... 4-26
Photo 4-42 Faulted Contact of Breccia with Alluvium at Salmanabad Village. ..... 4-26
Photo 4-43 Fault Breccia beneath Salmanabad Village along Hunza River. ..... 4-27
Photo 4-44 Active Slides at Right Side Slope of Hassanabad Nullah. ..... 4-27
Photo 4-45 Fault Breccia/Gauge along Road Just D/S of Murtazabad Village. ..... 4-28
Photo 4-46 Inward Tiltness in Clayey Silt Just D/S of Murtazabad Village. ..... 4-28



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Photo 4-47 Hummocky X-bedding in Clayey Silt near Murtazaba Village. ..... 4-29
Photo 4-48 Jointing in Morainic Material, near Confluence of Shamshal Nullah with Hunza River. ..... 4-30
Photo 4-49 View of Active Slides in Shamshal Nullah. ..... 4-30
Photo 4-50 View Of Folding, Crushed Rocks and Active Slides in Shamshal Nullah. ..... 4-31
Photo 4-51 View of Inclined Gravel Bed Near Confluence of Hunza River and Shamshal Nullah. ..... 4-31
Photo 4-52 View Of Active Slides along Left Bank of Hunza River. ..... 4-32
Photo 4-53 View Of Fault Breccia in Perennial Nullah. ..... 4-33
Photo 4-54 View of Recently Generated Joints in Tunnel-2. ..... 4-33
Photo 4-55 View of Recently Generated Joints between Tunnel-2 & 3. ..... 4-34
Photo 4-56 View of Fault Breccia between Tunnel-2 & 3. ..... 4-34
Photo 4-57 Micro Thrust Fault in Clayey Silt Beds near Helipad. ..... 4-35
Photo 4-58 Inclination in Clayey Silt near Sarat Village Bridge. ..... 4-35
Photo 4-59 Folding in Clayey Silt near Helipad/Power House Area. ..... 4-36
Photo 4-60 Development of Parallel Joints Near SCO Building. ..... 4-36
Photo 4-61 View of Active Slides Infront of Salmanabad. ..... 4-37
Photo 4-62 View of Stable Slide infront of Ahmadabad. ..... 4-37
Photo 4-63 Panoramic View of Slope infront of Salmanabad and Ahmadabad Villages ..... 4-38
Photo 4-64 View of Shear Zone and Folding in Clayey Silt. ..... 4-39
Photo 4-65 View of Micro Fault and Displacement of Blocks. ..... 4-40
Photo 4-66 Inclination in Gravel Bed near Kiln ..... 4-40
Photo 4-67 Inclination in ABGM and Clayey Silt Bed along KKH. ..... 4-41
Photo 4-68 Development of Jointing in ABGM Underlain by Rock along KKH. ..... 4-41
Photo 4-69 Development of Longitudinal Joints in Rock along KKH. ..... 4-42
Photo 4-70 Inclination in RBGM at Left Bank of Hispar River. ..... 4-43
Photo 4-71 Folding in RBGM along Hispar River. ..... 4-43
Photo 4-72 Inclined Isoclinal Fold In RBGM along Hispar River. ..... 4-44
Photo 4-73 Inclination in Gravel Beds Tilted Upstream along Hispar River. ..... 4-44
Photo 4-74 Inclination in Gravel Bed Tilted Upstream along Hispar River. ..... 4-45
Photo 4-75 Inclination in Gravel Beds Tilted Upstream along Hispar River. ..... 4-45
Photo 4-76 Fault Breccia at Tukurkhai Village at Left Bank of Hispar River. ..... 4-46
Photo 4-77 Fault Breccia near Hakuchar Village with Active Slides. ..... 4-47
Photo 4-78 Inclination in Clayey Silt and Gravels. ..... 4-48
Photo 4-79 Ramp and Flat Geometry along Fault. ..... 4-48
Photo 4-80 Development of Micro Faults in Sand. ..... 4-49
Photo 4-81 Development of Micro Faults in Clayey Silt. ..... 4-49
Photo 4-82 Inclination in RBGM in Tashot Village along Road. ..... 4-50
Photo 4-83 Highly Crushed Rock in Maicher Village along Road. ..... 4-50
Photo 4-84 Panoramic View of Crushed Rock and Drainage Pattern at Miachar Village. ..... 4-51



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# LIST OF TABLES

Table 6-1 The Controlling Faults with Quantitative Features (input values of DSHA) .....6-21
Table 6-2 Seismic Source Zones Parameters for Probabilistic Analysis .....6-28

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# 1 INTRODUCTION

## 1.1 GENERAL

Attabad Lake Hydropower Power Project (ALHPP) is proposed on Hunza River, a left tributary of Gilgit River. A large slide occurred on January 4, 2010 from right side slope of Attabad, chocked the Hunza River. The total height of the slide as estimated by GSP (Geological Survey of Pakistan) was about 100 m and the blocked length of river was about 2 km that destroyed 1.3 km of Karakorum Highway (KKH) (ISSMGE Bulletin: Volume 4, Issue 3 Page 21). Due to development of lake, WAPDA Authority planned to utilize this potential for Hydropower Development. Firstly, GB local consultants conducted feasibility study. The study was lacking in many aspects including geotechnical investigations, laboratory testing, layout planning, pros and cons of sliding, Neo-tectonic study and environmental issues. The Feasibility study has been submitted to Hydro Planning, WAPDA for comments and updating.

The Hydro Planning WAPDA entrusted to carry out the feasibility study of Attabad Lake HPP. During the detailed analysis and investigations, it is estimated that lake potential of 0.1MAF (125$Mm^3$), can be utilized to generate about 54 MW. The coordinates of weir site are 484036.834m E and 4018143.837m N with bed elevation 2368 m a s l from river bed**(DRW No: AFS- WR - 403)**

The proposed weir site is located about 20 km upstream of Aliabad (Central Hunza), near Attabad village, District Hunza. The site is accessible by metaled road from Gilgit city, the capital of Gilgit-Baltistan. From Islamabad, the site is reachable through Karakorum Highway (KKH) by covering about 750 km. It is also accessible through PIA air plane from Islamabad to Gilgit and thereon to Hunza via Karakorum Highway **(DRW No: AFS- GN- 102).**

Geologically site is located in Karakorum Block (KB) further North of Main Karakorum Thrust (MKT). The KB consists of Sedimentary, Metasedimentary, Igneous as well as Metamorphic Rock, throughout its extension from Karakorum Fault in the East, Chaman and Herat Fault in West (Zanchi 1993) ranging in age from Precambrian to Cretaceous. The overburden material, consist mainly of Angular Boulder Gravel with Sand and appreciable amount of fines (ABGM) and Rounded Boulder Gravels with Sand and appreciable amount of fines (RBGM). The talus deposits are main constituents of ABGM and well developed mostly in Shamshal valley and along Hunza River in upstream reaches. There are many evidences (the deposition of clayey silt along both banks of Hunza River) along the road indicate that the river might be chocked many time in recent past. Prior to Attabad slide, the slope failure occured at Salmanabad in 1958 and chocked the Hunza River.

The topography and geological conditions present in this valley indicate that it is glacial originated valley modified later on by river system. There are many glaciers that feed the Hunza River, from South to North i.e. Hassanabad, Gulmit , Gulkin , Passu and Batura Glaciers, from right side and Shamshal Valley Glacier from left side. Morphologically the valley is lithological as well as structurally controlled. Weak lithology i.e. slates as well as fault system attributed for the development of present shape of the Hunza valley in upper reaches and near MKT.



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This Report is mainly based on the annotations observed during field visit at both banks along Hunza River and its tributaries mainly originated from glaciers. During this visit the main concentration was to observe the deformation in recent deposits mostly in rounded boulders gravel with sand and appreciable amount of fines (RBGM), sand, clay and silt etc. Due to chocking of river and development of lake, sedimentation took place at both banks of the river. As a result, of collision between Indian & Eurasian Plates, a continuous application of stress resulted in deformation of variegated levels.

## 1.2 SCOPE OF WORK

During the Feasibility Study, the colossal slide and as a result damping of Hunza River in 2010 has made the Neo-tectonic studies as core point. It is therefore, very important for the development of hydropower project in this area that understanding of Neo-tectonic setting should be explored to know the regional tectonic forces. Regional tectonic forces responsible for the massive slide, affecting Project Area severely as indicated by diverse features.

The area under study has covered by the two Nos of GT sheets 42 L/15 and 42 L/11 by Survey of Pakistan (SoP) at a scale of 1:50,000, covering the area upstream and downstream of slide mass.

## 1.3 OBJECTIVES

Main objectives are:

- Evaluation of the regional tectonic setting of the area and recognition of fault (regional or local) which may acted as a seismic source.
- Detailed investigation of the fault geometry, alignment, and structural deformations associated with these faults. These may include shear zones, fault bend folds, active slides and fault breccia.
- Recognition of active fault zones and their distinction from older, dormant fault zones.
- Assessment of the vulnerability of neo-tectonic activity along the faults/slides around the Project Area so that the movement along the affected area may be predicted.
- Identification of deformation/displacement in recent deposits to evaluate the activity commenced in the area.

## 1.4 METHODOLOGY

An array of activities including literature review, image analysis, field studies and data compilation are involved in Neo tectonic evaluation as per standard practices in Industry. These include:

- Collection of previous research on regional as well as on local geology, geomorphology and tectonics of Project Area.
- In-depth studies on satellite image analysis using GIS techniques by applying various image-enhancing techniques e.g. Digital Elevation Model (DEM) have been studied; the lineaments and faults on regional as well as on local scale have been recognized.



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- Detailed geological map of the Project Site, regional and local faults within the vicinity covering the upstream and downstream of the Project Area have been marked on GT sheets at a scale of 1:15000 in the field to understand the trend of regional tectonic forces.
- During field visit keen concentration has been given to characterize the kinematics of faults where possible e.g. sense of faults (Strike and Dip), alignment and type of fault, throw and heave, dip direction and other associated characteristics.
- Development of fault-source map indicating various regional scale faults that may contribute seismic affect in the Project Area.
- The relationship of older tectonic features to the recent ones.
- Field evidences of Neo-tectonic features have been captured in Photos including active slides, tiltness in recent deposits, folding, faulting, step fault, fault associated folds in recent deposits, topographic features including drainage pattern at slopes and abrupt shifting of river/stream course.



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# 2 REGIONAL GEOLOGY

## 2.1 GENERAL

Information and data relating to Regional Geology of Project Area is taken from already published literature and research papers. The catchment area lies in KB where snow covered peaks are quite common. The geological features in 40 km upstream and 50 km downstream of the Project Area have been studied in detail. In the Project Area many neo-tectonic features have been observed/recorded in the recent deposits which indicate that the regional tectonic forces are operating there.

The Project Area lies in the KB bounded in north by Central Pamir through Rushan Pshart Suture, in east by Karakorum Fault, in the west by Herat Fault and in south by Kohistan Island Arc (KIA) through MKT (Pashkov & Shvol'man, 1979 & 1981). The KB have classified as a part of Gondwana land in pre-collision history. The rocks of KB have stratigraphic association with rocks of Indian Plate as indicated by Paleozoic to Mesozoic sequence of both plates. It is likely to be considered that Karakorum Micro Plate and Indian Plate were united till Mesozoic Era.

The stratigraphic sequences of the Karakorum Plate are metamorphic equivalent of sedimentary rock in Indian Plate shows that both plates have pre-collision similarities. Also the Karakorum Plate consists of Sedimentary (well exposed in Chitral Area along Mastuj River), Ignoeus Rocks (Karakorum Batholith) and Metamorphic Rock (slates, schist and marbles).

The rocks of KB include a thick sedimentary cover, which is mainly Paleozoic in the western termination and Permian to Cretaceous in the central and eastern area. In the Hunza valley, the cover consists of a thick pile of Permian-Cretaceous sediments cropping out north of the Karakorum Axial Batholith (KAB). It separates the sedimentary cover to the north, named North Karakorum terrain by Searl (1991), from high to low grade metamorphic present south of the KAB just north of the MKT.

## 2.2 STRATIGRAPHIC SEQUENCE

The area under study mostly includes part of the Northern Karakorum Terrain, which comprises intensively folded and thrusted sedimentary rocks with a very low metamorphic imprint, locally reaching low grade conditions (Zanchi,1993). The Lower Permian to Upper Cretaceous succession of the North Karakorum represents one of the few terrains which escaped strong metamorphism during the Indian-Eurasian collision, thus permitted a detailed reconstruction of its stratigraphic framework **(DWG No: AFS-GE-291)**. Plutonic bodies mainly of mid-Cretaceous age intruded the sedimentary cover forming a discontinuous granitic belt developed about 100 km north of the KAB. Four main tectonic units have recognized in the Project Area (Gaetani et all., 1990). These include;

- Misgar Unit
- Sost Unit



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- Gojal Unit
- Karakorum Axial Batholith (KAB)

The brief descriptions of these units are given below;

### 2.2.1 Misgar Unit

This unit consists mostly of slates, with few intercalations of metacarbonate quartzite and black terrigenous slates, mostly exposed at the Northern part of the Project Area. In some areas, its thickness increases up to thousand meter. It is strongly folded with intensive development of slaty cleavage. The fold axes generally trend E-W up to the Khunjerab Pass, where they turn to NNW-SSE. The unit has low grade metamorphism indicated by chlorite, biotite, and muscovite. This unit is intruded by granitoide pluton in northern and eastern terrain having western extension up to Sost. This unit belongs to different stratigraphic formations of Paleozoic age.

The southern boundary of Misgar Unit is faulted with south vergent thrust plane, the northern fault stacking the Misgar Slate over Jurassic limestone and sandstones of Sost belt (Gaetani et al. 1990). Large recumbent folds present along the northern flank of the Chapursan valley suggest southward movement of Misgar Unit.

### 2.2.2 Sost Unit:

It consists of grey to dark grey slates, meta-limestone, and quartzite. At places, it has dolomitic patches (Gojal Formation). Some sandstone beds with slate intercalations overlain by argillaceous limestone (Gircha Formation) with some sandstone, siltstone, limestone and dolomites of Lupghar Formation, Panjshah Formation, Lashkargaz Formation, ranging in age from Middle to Late Permian.

It comprises of thick pile of folded and thrusted sheets forming in the whole antiformal stack, later disrupted by strike-slip faults. The unit is bounded by two major faults, the Upper Hunza Fault (Desio, 1979) to the south-east and the Northern Fault to the north. Complexity of the tectonic pattern often prevented the reconstruction of continuous stratigraphic successions, as in the Middle Late Jurassic sediments. Fold axes and fault striations along the main thrust surface generally indicate a N-S compression. The well-developed schistosity is defined by sericite, muscovite and fine grained biotite with occasional occurrence of epidote and chloritoid. This suggests that low grade condition of metamorphism with an important increase of temperature with respect to other thrust sheets of the Sost Unit. These shear zones are still poorly understood and may possibly be related to the eastward prosecution of Hunza Fault juxtaposing the Gircha Slates of Gojal Unit to analogues metasediments of Sost Unit. The stratigraphic succession present in the Sost Unit spans from Permian to Late Cretaceous.

### 2.2.3 Gojal Unit:

This tectonostratigraphic unit was defined by Gaetani et al. (1990) and includes the sediments lying between the KAB and UHF. It is composed of two units, a terrigenous unit (Passu Slates) below and a calcareous-dolomitic unit above. In the lower Shamshal valley, dolomitic marbles terminate along a subvertical NS trending fault while southward this unit is intruded by KAB.



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Contact metapelites generally undeformed or poorly deformed intrusive that grades into biotite, muscovite, and andalusite. folds within the unit trend from NW-SE to NNW-SSE and are generally NE-facing. Thrust planes show the same trends and are NE-vergent, as in case of (UHF).

### 2.2.4 Karakorum Axial Batholith (KAB):

The KAB crops out along the southern part of the studied area, where two major plutonic complexes were recognized, the Hunza and Batura Units (Debon et al., 1987). The Hunza Unit consists in a huge plutonic unit extending for more than 250 km, made up of medium grained granodioritic in composition, locally recrystallized. They represent a calc-alkaline association. mafic enclaves of various sizes are abundant and a conspicuous network of Cenozoic leucocratic dykes is locally present.

The Batura Unit intrusive, spanning in age from Paleocene to Eocene, is mostly new, as well as the findings of plutonic bodies belonging to this unit in Upper Chapursan Valley. The Batura Unit includes two main intrusive; The Kuk and Sarbzea Pluton.

The Kuk Pluton consists of pinkish, undeformed and unfoliated granitoides of various grain sizes, locally with porphyritic, microgranular and rapakivi textures. The Sarbzea Pluton mainly differs from the Kuk Pluton by its very coarse to medium grained rocks, which were deformed at places.

### 2.2.5 Ganesh Formation:

This Formation consists of pelite-psammite turbidite unit and overlying calc-pelite marble unit and are intercalated with each other. These units are metamorphosed up to upper amphibolite facies and therefore have well developed sheets of amphibolite. The Formation has well developed ruby and spinal. Different mines are also established in this Unit as can be observed along road near Ganesh Bridge.

### 2.2.6 Hassanabad Granite:

It is well exposed in the Lower Hunza valley and consists mainly of lower s-type granitoid-migmatite complex with metasedimentary enclaves. These garnet-tourmaline bearing two mica granitoids and migmatites are well exposed in Hasanabad Nullah and in Hunza valley along Hunza River.

### 2.2.7 Chalt Formation:

It consists of dark grey quartz biotite schist with subordinate quartz, marble and conglomerate. It is exposed along overturned anticline and faulted against Dumordo Formation. Permo-Carboniferous age is assigned to this Formation.

## 2.3 REGIONAL TECTONICS

Before the Northward flight of the Indian Plate, small continental pieces (Cimmerids, i,e. Karakorum Block, Helmad Block, Hasha Block etc) were broken up from the Northern edge of



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Gondwana Land and welded with the southern edge of Eurasian Plate, consuming the old Tethey and opening the Neo Tethey, (Tapponnier, 1975, 1977; Molnar, 1977a).

In general, due to the subduction of the oceanic part of the Indian Plate beneath the Eurasian Plate, the Island Arc emerged in Middle Cretaceous age. The Arc Complex consists of calc-alkaline plutonic rocks mainly mafic in nature. The presence of blue schist metamorphism in Swat and Shangla Area indicates the trench environment.

The collision of the Indian and Asian Plates has been described as a “head on” north-south collision (Shackleton and Ries, 1984). This is generally accepted by many workers to have occurred in Eocene times (55-40Ma) (Powell, 1979; Klootwijk et al, 1979; Dewery et al, 1988; Treloar and Coward, 1991; Serrle et al, 1987, 1988). The terminal collision between Indian and Asian Plates is suggested to have occurred between 45-40 Ma (Molnar and Tapponnier, 1975; Klootwijk et al, 1985). It is generally agreed, however, that by 55 Ma, the Kohistan Island Arc was already sutured to the Asian Plate, probably since the Late Cretaceous, forming the MKT zone. This is confirmed by the presence of 85-80 Ma thermal event at this time (Treloar and Rex, 1990).

The rocks of Shyok Suture Zone (SSZ) are interpreted to represent the tectonised remainder of a marginal basin. The closure of the marginal basin occurred at the Eocene-Oligocene time boundary, and crustal shortening was responsible for generation of Neogene 2-mica granites of the KAB and regional metamorphism of the Pangong Tso Group (V.C Thakur, D.K. Misra, 2007).

The collision between the Indian Plate and Kohistan Island Arc is recognized as when the Tethyan Ocean disappeared and the continental masses docked. Following features recognize the main arguments for the Eocene age of collision: -

- Sediments deposited on the northern margin of the Indian Plate being of Eocene age.
- Subduction of the oceanic crust stopping, as recognized by the end of calc-alkaline magnetism north of the Indus Suture.
- The Blue schist facies are not developed along MKT zone showing the collisional belt.
- Slowing down of the Indian Plate motion, as recognized by magnetic anomalies.
- After collision, continued suturing occurred, associated with a 35˚ anticlockwise rotation of the Indian Plate relative to Eurasia. As a result of collision, mighty mountain ranges of Himalayas were developed having Island Arc Sequence in the north.

There are some topographic observations about the Himalayas that were immediately noticeable:

- The general curvature of the mountain chain.
- The mass of high land behind the mountain belt (Tibetan Plateau)
- The lineament of the high peaks confined in a rather smaller area.

This seemingly simplified chain becomes very disturbed, with a complete loss of these features in the Northern Himalaya. The general curving of the Higher Himalayan peaks and the suture



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around angles of some 180˚ is related to the structural anomalies that are present in Northwestern Himalaya: i.e. the syntaxes (Nanga Parbat Syntaxis, Hazara-Kashmir Syntaxis etc). These are absent in Central Himalaya. This shows that the collision between two plates is not a simpler phenomenon but there was a much greater extent of deformation to which the collision was accommodated. The accommodation was not constant, but suggested to be partitioned with different mechanisms occurring in different places of the orogenic belt.

Anticlock wise rotation of Mega Lhasa followed the Late Triassic docking of the Iranian Spur, using the later as pivot. The rotation was completed during the Middle Jurassic, when SE Pamir, Shaksgam and Karakorum joined the Qiangtang, more closely assembling Mega Lhasa as it approached the Asian margin (Maurizio, Gaetani, 2007). The Karakorum Block (KB) bounded in the east by Karakorum Fault, in the north by Rushan- Pshart Suture, in the west by Herat Fault and in south by MKT.

Structurally the KB is characterized by broad asymmetrical to tight, isoclinal folds which are commonly imbricated. A number of large regional scale thrust faults, e.g. the Tirchmir Fault, Reshun Fault, Baltit Fault, Upper Hunza Fault, Chapursan Fault and the MKT extends for a distance up to 100 km or more. The KB has undergone multiple deformation since the Cambrian. Parts of the KB have undergone at least four more deformations since the Kohistan-Karakorum collision from Paleocene to Pliocene.

After the collision, due to further Northward subduction of the Indian Plate, still active 4cm/yr, the stresses were accommodated by the imbricate thrust faults from North to South (Treloar et al, 1989). The collisional history along with metamorphic events trapped many clues between these fault systems. These are very useful to delineate the historic events and to unrivaled the movement of Indian Plate, collisional environment and modern deformational style.

## 2.4 REGIONAL FAULTS

The major regional faults of the region include, from north to south, the Main Karakorum Thrust (MKT), Main Mantle Thrust (MMT), Panjal Thrust (PT), Main Central Thrust (MCT), Main Boundary Thrust (MBT), Kashmir Boundary Thrust (KBT)/ Himalayan Frontal Thrust (HFT) and Salt Range Thrust (SRT) **(DWG No: AFS-GE-292)**.

Along with these regional faults, many local faults were developed to accommodate the regional stresses, these may be thrust fault or strike slip fault in nature. In most of the area many small scale strike slip faults are associated with the thrust faults to accommodate the deformation.

The general trend of these faults excluding MKT is predominantly east-west with change in trend due to syntaxial bends. The general description of these major faults is as follows: -

### 2.4.1 Karakorum Fault (KF)

Dextral Strike Slip fault of about 800 km long bounds western Tibet. The KF represents a much younger terrane boundary, juxtaposing rocks of the Ladakh and Saltoro Blocks to those of Karakorum terrane. U-Pb zircon age of leuco-granites intrusion shows that it must therefore be



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younger than 15 Ma old. Movement on the fault displaces the sequence approximately 200-250 km to South Eastern Tibet where the regional rock sequence can be regained (Burtman et al. 1963, Srimal 1983). It merges at the confluence defining a triple point and three blocks; the Ladakh Block to the south, Saltoro Block to the northwest, and the K KB to the northeast.

A number of teleseismic events have occurred along the fault. Interpretation of seismic data from 1975 Kinnaur earthquake confirms right-lateral strike slip motion on this fault. Three events were recorded from K KF Zone at the head of the Nubra Valley, since 1980, recorded by portable seismic stations, established by International Karakorum Project (IKP). It is seismically an active fault.

### 2.4.2 Upper Hunza Fault (UHF)

It is east west trending thrust fault that runs along the depression formed by the Chapursan and Upper Yarkhun Valleys (Zanchi 1973, Kazmi 1979b, Gaetani ey al. 1995). In this region it runs parallel to the northern margin of the KAB. Southeast of morkun (Upper Hunza) three teleseismic events of magnitude 5-7 and focal depth of less than 50 km have been recorded. These epicenters form a cluster very close to the mapped trace of the UHF. It means that the northern and western margin of the KAB is characterized by active zone of faulting along upper Hunza-Reshun Fault zone.

### 2.4.3 Main Karakorum Thrust (MKT)

The MKT is a low angle mega-shear with strike slip component, which on eastern side passes through Machlu in Hushe Valley, Shigar Valley, Zuhri Brook in Shyok Valley and Chalt in Hunza Valley extends westward through Ishkuman, Yasin and Shishi Valleys **(DWG No: AFS-GE-292)**. Its general trend swings between E and E-NE at low to medium dips towards the north. It is believed that this fault is seismically active.

### 2.4.4 Main Mantle Thrust (MMT)

The MMT, which is aligned with the Nanga Parbat-Haramosh tectonic line on east, span an area of about 400 km through Diamir, Kohistan, Swat, Dir and Banjaur, before entering Afghanistan **(DWG No: AFS-GE-292).** The general trend of MMT is NE-SW. It is located along the contact of the mafic/calc-alkaline meta-igneous rocks and the meta-sediments belonging to the Indo-Pakistan Continental Mass. Along this megashear near Jijal Village on Indus River (right bank), the igneous rocks have overthrusted the meta-sediments to the south over a 10-15 km wide zone. The thrust also manifests as the broad high topography of Kohistan relative to the Hazara adjacent to the south. In addition, numerous auxiliary fractures are developed and across the thrust frequent brecciation and mylonitization are also present along the contact. It is seismically active fault.



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# 3 SITE GEOLOGY

## 3.1 GENERAL

The Project Area lies in KB north of MKT. It is V-shape valley, originated by glacier and modified later on by Hunza River. It is stratigraphically as well as structurally controlled. The 2nd highest peak of the World K-2 lies in this range. The rock units comprise granitoides with pellite and psammite sequence ranging in age from Paleozoic to Cretaceous.

## 3.2 TECTONOSTRATIGRAPHIC MAP

The Neo-tectonic studies are carried out on enlarged SoP GT sheets at a scale of 1:15000 during site visit. Different tectonostratigraphic units have identified and marked on these sheets and presented as drawing **(DWG No: AFS-GE-318 to 320)** at a scale of 1:40,000. Different stratigraphic/geological units pragmatic have been marked and summarized below: -

### 3.2.1 Lithological Units

#### 3.2.1.1 Soil Units

The recent deposits are the most widely spread soil units overlies the bed rocks. The slopes are covered with overburden having variable thickness. Terrace deposits comprise mixtures of clay, sandy silt, boulders and gravel in various proportions. These units are mostly present in Aliabad, Karimabad, Nagar and Gojal Areas.

The soil units present in the Project Area are described below: -

##### 3.2.1.1.1 Angular Boulder Gravels with Sand and Appreciable Amount of Fines (ABGM)

Most of the slopes are covered by material comprise ABGM. This is colluvial material broken from the rock units, rolled down slope and settled at the foothill or along the slopes.

These deposits are mainly associated with crushed/brecciated rock units, originated/caused by brittle deformation due to faulting/shearing at both sides. It has been modified by erosion/weathering and accumulated as ABGM at foothills, forming active slides, at both side slopes.

##### 3.2.1.1.2 Rounded Boulder Gravels with Sand and Appreciable Amount of Fines (RBGM)

River bed is mainly occupied by RBGM. Some exposure is also present at powerhouse site near old Chinese Camp, Helipad Area. Due to formation of lake, the bed of the river is mostly covered with silt and sand extends up to Shishkat Bridge.

##### 3.2.1.1.3 Terrace Deposits

Terrace Deposits consist mainly of mixture of clay, silt, sand and gravels with occasional boulders. These are mostly developed in loose material (RBGM, ABGM, Morainic and Breccia) **(DWG No: AFS-GE-302,305 & 309)** in all villages, depending upon the availability of water.



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The irrigation channels were built in such a way that the irrigation demands are meted out by glaciers. In Central Hunza (Hyderabad, Aliabad and Karimabad) water is mainly fed from Ultar and Hassanabad Glaciers. Similarly, from Gulmit and Passu Glaciers, the channels were constructed to fulfill requirement of irrigation water.

#### 3.2.1.1.4 Morainic Deposits

It consists mainly of material ranging in size from large boulders to clay size particles, angular to sub-angular, elongated and have flat surface **(DWG No: AFS-GE-299 & 302)**. The direction of elongation indicates the route of advancement of glacier. These are well exposed throughout the valley.

### 3.2.1.2 Rock Units

The main rock units exposed in Project Area explored during neo-tectonic study are as follows:

- Granitic Gneiss
- Granodiorite
- Passu Slates
- Marbles

It is 70 to 120 km wide and 1400 km long structural zone comprises the Karakorum Crustal Plate(KCP) which is one of the fragment of Cimmerian Collage derived from Gondwana Land and accerated to Eurasia. The stratigraphic history of the Karakorum is similar as that of Himalaya up to Cretaceous. The Project Site mostly present in the KAB consists of Igneous and Metamorphic rocks.

The brief description of the rock units are given below;

#### 3.2.1.2.1 Granitic Gneiss

It is light grey to grey in color on fresh surface and weathers to light brown, coarse to very coarse grained, moderately to highly jointed, highly sheared up to higher elevation due to faulting, sparsely to moderately weathered, moderately hard to hard. It has well developed foliation with trending value N61ºW and plunging value 79ºNE. It is exposed at the right as well as at the left bank of the Hunza River. Some shear zones are also present within the Unit **(DWG No: AFS-GE-293 & 312)**.

On the basis of petrographic analysis, it is evident that the major constituents' minerals present in Granitic Gneiss are quartz, oligoclase, biotite while amphibole, chlorite, muscovite, epidote, and tourmaline are present as minor constituent minerals. The high percentage of Quartz grains show strong strain extinction, indicating that this unit has Alkali Silica Reaction (ASR) potential. The rock may therefore not be used as a coarse aggregate with Ordinary Portland Cement (OPC) or High Alkali Cement. It may be used with low alkali cement, slag cement or cement with additives likes fly ash, pozzolan. Some chemical additives like lithium nitrate or silica fume can also be used to control this reaction. The Schmidt Hammer values ranges from



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**35** to **45 MPa** indicating that rock is moderately strong to very strong. But in some shear zone where rock is tectonized locally, this value reduces up to **18-20 MPa**.

#### 3.2.1.2.2 Granodiorite

It is dark grey to blackish grey in color, weathers to brownish grey, medium to coarse grained, moderately weathered, moderately hard to hard, moderately jointed intruded by pegmatite and granitic gneiss. It is foliated with trend and plunge values of N60ºW/79ºNE. Further downstream, it becomes light grey to grey in color, coarse to very coarse grained. It is crushed, mylonized, and sheared at places. It is well exposed at both banks where it is intruded by many pegmatite dykes. Some shear zones are also present in this Unit.

On the basis of petrographic analysis, it is evident that Granodiorite is quite dominate in the Project Area. The major constituent's minerals present in this unit are plagioclase, k-feldspar, quartz, biotite, and amphibole while Iron, muscovite, chlorite, and epidote are minor constituents. The high percentage of quartz grains show strong strain extinction, indicating that this unit has ASR potential. The rock may therefore not be used as an aggregate with OPC or High Alkali Cement or it may be use with low alkali cement, slag cement or cement with additives like fly ash, pozzolan. Some chemical additives like lithium nitrate or silica fume can also be used to control this reaction.

#### 3.2.1.2.3 Passu Slates

It is well exposed at both sides of Hunza River, in upstream reaches of Hussaini village. It has intrusive contact with granitic gneiss/granodiorite. It is dark grey to blackish grey in color and weathers to brownish grey, fine grained, moderately weathered, weak to moderately weak, moderately to highly jointed but sheared at places, caused by different faults passing through this Unit. In or near the area of Borith Lake this Unit is highly crushed and sheared.

It has transitional upper contact with marbles exposed further upstream. In Shamshal Nullah, the slate is highly crushed and disturbed. On the basis of brachiopods and bryozoans, present in this unit, Carboniferous to Permian age is assigned to this Unit.

#### 3.2.1.2.4 Marble

It is well exposed along Hunza River, near Passu village in upstream area. It is massive and crystalline dolomite. It is off white to greyish white in color, weathers to yellowish brown color, fresh, moderately hard to hard, moderately to highly jointed but sheared at places, caused by different faults passing through this Unit. Brecciated marble is well exposed along the KKH before Passu Glacier. In or near the area of Borith Lake this Unit is highly crushed and sheared / brecciated.

The high peaks of well renowned Passu Cones are developed in this unit. It has transitional lower contact with Passu Slates, the transitional lithofacies of marly limestone has well preserved fusulinid assemblage. On the basis of fusilinid present in this Unit, Middle to Late Permian age is assigned to this Unit.


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## 3.3 GEOLOGICAL STRUCTURES

The Project Area tectonically lies in Karakorum Block. These units have undergone Karakorum as well as Himalayan Orogeny. The whole area has undergone/modified by two major fault systems MKT and Karakorum Strike slip fault. The MKT system which accommodated southward thrusting. Karakorum fault 800km long dextral strike-slip fault that bounds western Tibet, extending from the Pamirs to Gar Basin. As the Project Area has undergone multiple episodes of tectonics events, many regional as well as local faults and their splays have formed as discussed below.

### 3.3.1 Faults

Project Area has undergone compressional tectonic, resulted in release of energy forming thrust fault system with regional as well as local faults, bounded by MKT and Karakorum Strike Slip Fault (KSSF)**)**. These include:

- Batura Glacier- Hussaini Fault
- Borith Lake-Shamishal Nullah Fault
- Shishkat- Gulkin Glacier Fault
- Attabad -Hispar Valley Fault
- Central Hunza/Nagar- Chalt Fault
- Hassanabad Nullah Fault
- Hunza River-Nagar Fault

All these faults have been marked on the sheets and presented as **(DWG No: AFS-GE-318 to 320).** The dip and strike values of major faults have been plotted on the drawings.



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# 4 NEOTECTONICS STUDIES

## 4.1 GENERAL

A large mass slided downward from right slope of Hunza River near Attabad village and chocked the River and destroy KKH for more than 2 km in January 2010. Chocking of Hunza River results in formation of a 25 km long lake up to Khyber village in Gojal Valley. Excavation work of channel through slided mass decreases down its level and span reduces upto Shishkat Bridge. Movement of huge mass downward is consequence of stress releases may have accompanied the direction of regional tectonic forces operating in this Region. To understand these regional forces and their effect and vulnerability of expected slope material to slide, Neo-tectonic study has been conducted.

This study covers the 40 km upstream and 50 km downstream of the Project Site along both banks of the Hunza River. Different features related to Neo-tectonics activity have been observed during site visit. In this study, particularly the focus has been to search the mode of deformation in recent deposits, along the both banks of river and its tributaries in nearby area.

The main objective of the Neo-tectonic study was to identify/observe the features of active tectonic events occurred in recent past about 0.1 Million years ago. There are many field observations regarding the Neo-tectonic activity. Some of the Neotectonics features/observation are given as under: -

- The tiltness in recent deposition, i.e. to study the slopes of gravels, clays, and sand layers w.r.t slope of the stream beds.
- Intersection of faults in recent deposits i.e. lacustrine deposits, terraces/ alluvial deposits or in any cultural features (houses, roads). The amount of displacement, Heave as well as Throw measurement, dip and strike of the fault.
- The presence of active slide zones.
- The displacement /uplift in fluvial as well as lacustrine deposits on each side of the lake/stream and magnitude of its displacement.
- Identify the zones of brittle as well as ductile deformation.
- To observe the movements along slicken sides / fault / joints blocks.
- The presence of escarpment slope along the planer area
- The presence of hanging valleys /cirques along main stream, in series and presence of waterfalls along it.
- Folding/bending in the recent deposits (alluvium, morainic, lacustrine).

A brief description of the right and left bank of the Hunza River has been described below: -



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## 4.2 RIGHT BANK OF HUNZA RIVER:

Neo-tectonic features on the right bank of Hunza River in concomitant with different villages from upstream to downstream **(DWG No: AFS-GE-318 to 320)** are discussed below:-

### 4.2.1 Passu Village

Passu is one of the largest village in Gojal valley situated at the right bank of Hunza River along KKH about 35 km from Attabad Site. The great Passu Glacier, 56 km in length is present near the village. Many deformational evidences were observed in recent deposits along the road.

- 2-3 km Upstream of Passu Village

Co - ordinates

N 4038610.325 m

E 489292.583 m

El. 2470.03 m a s l

The coordinates have been measured by mobile topographer application.

A large deposit of RBGM material is present along the right side slope of the river along KKH. This material consists mostly of gravel, cobble, and pebbles with subordinate sandy material. Some inclinations in these deposits have been observed along roof and sole beds. This inclination varies from 15° to 35° layer-by-layer **(Photo 4-1).**

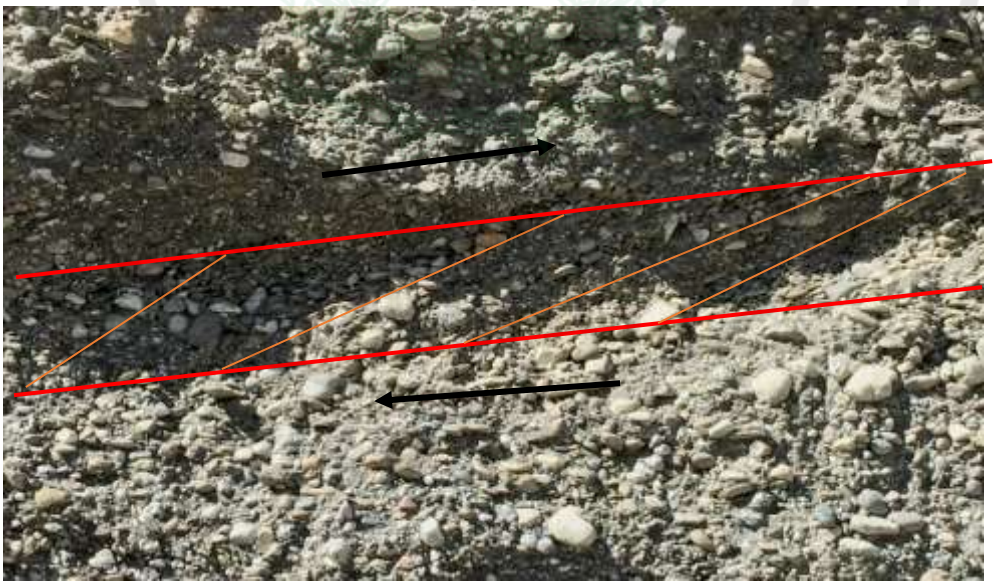

**Photo 4-1 Inclined Gravel Layer Under Effect of Shearing**

Some shearing effects have been chronicled along these planes in numerous layers. This shows that the area is tectonically active.

- In Passu Village

Co-ordinates



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N 4039020.190 m

E 488598.996 m

El. 2521.0 m a s l

Further downstream, from previous station some clay deposits are reputable at right side slope in Passu village. Many Neo-tectonic features have been found in these deposits including jointing in recent clay deposits, folds, faults and associated structures, like tiltness in beddings.

**Photo 4-2 Overall View of Clay Deposits and Inclination in Beds**.

The clay deposit is overlain by morainic material of Batura Glacier. The clay deposits are tilted upward at an angle ranging from 10° - 15°. The area has undergone compressional regime, which uplifted the clay beds **(Photo 4-2)**.

**Photo 4-3 Recumbent Fold Strata with Crenulation in Limbs in Clay Strata.**

The clayey strata are folded with straight horizontal limbs and horizontal hingline. This shows that the horizontal compressional stress is applied on this material that turned this Unit into



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folded strata **(Photo 4-3).** Many micro folds (crenulations) in both limbs of fold are present. The hinge area toward outer layers is pointed out; showing intense compressional stress has been applied to the strata.

**Photo 4-4 Stylolite/Pressure Solutions in Clay Strata.**

The strata show some stylolite structures that are formed by expulsion of water through pressure solutioning. Alignment of wavelength and geometry of hinge area indicates that the compressional stress has been applied horizontally **(Photo 4-4)**. This shows that the recent stresses are functioning in this area.

Many joints are developed in the clay beds showing that there is relative movement in blocks along the plane, which might be acted as micro faults **(Photo 4-5)**. The relative movement of hanging wall block moved down relative to the footwall block, signposted the development of normal fault.

**Photo 4-5 Micro Faults in Clay Beds.**



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At the same location there are cross cutting faults, dipping towards each other in clay beds. The block between two micro faults moved downward forming Graben structure while the block, that could not move formed Horst structure **(Photo 4-6)**.

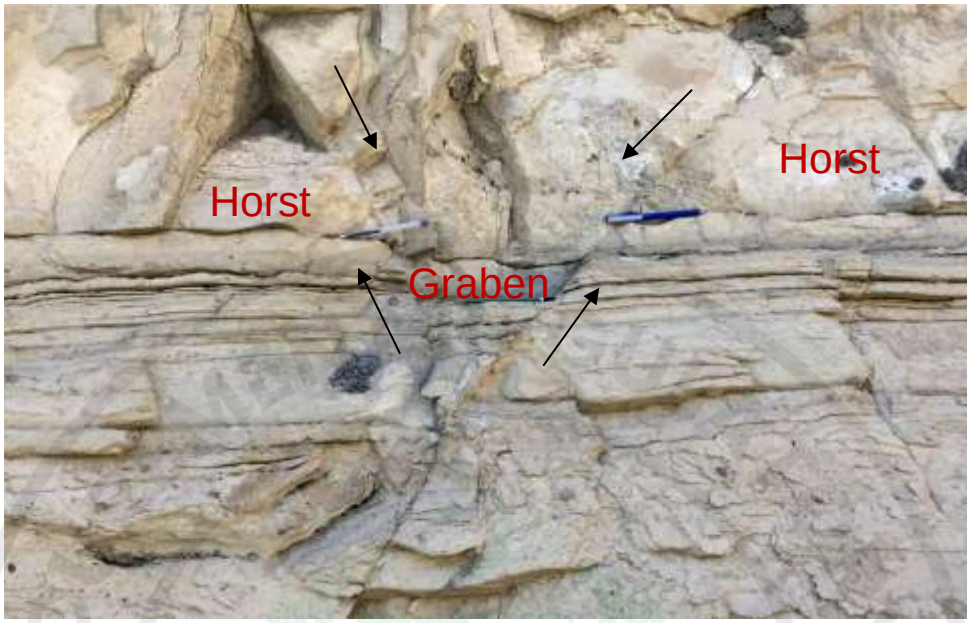


**Photo 4-6 Horst and Graben Structure along Micro Fault in Clay Beds.**

The formation of these structures in clay bed shows that there was relative movement along the micro faults in recent deposits.

The development of these normal faulting systems in such compressional regime indicates that these deposits have been under such environment where two thrust faults dipping toward each other. The up thrown block between these two faults undergone extensional regime where normal faults have been developed. This indicates that this area has been under active tectonics regime.

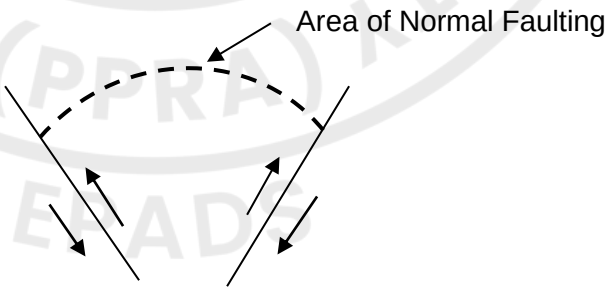


**Figure 4:1 Development of Normal Faults under Compressional Regime.**

Further, downstream, highly sheared marble and graphitic schist is exposed along the KKH. Highly sheared rock is cropped out up to high elevations and are accountable for the rolling down of boulders downward. Many active slides are instigating from this brecciated / sheared rock **(Photo 4-7)**, showing that this area has been under recent tectonic active stress.



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**Photo 4-7 View of Active Slides in Passu Village.**

In Passu village, there is a large shear zone along which the bedding joint have shear movement in marble. The shear zone is tilted inward **(Photo 4-8)**.

**Photo 4-8 View of Bedding Joints along Shear Zone Passu Village.**

This shear zone extends up to active slides and disappears. Highly sheared rock formed due to intersection of different faults are accountable for wide valley section.

### 4.2.2 Murradabad/Barut Village

Coordinates

| | |
|---|---|
| N | 4034396.199 m |
| E | 491392.588 m |
| El. | 2564.02 m a s l |



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The Muradabad village has large cultivated terraces, irrigated by glacier water as well as by River. These terraces are developed on morainic material deposited by Passu Glacier.

In nearby Muradabad village just downstream of Passu village, a large morainic deposits of Passu Glacier is present along road. These morainic deposits are deformed due to release of compressional stress. The original deposited layers of boulder and gravels are allied and tilted up at an angle of 18° **(Photo 4-9)**.

**Photo 4-9 View of Bedding Joints along Shear Zone Muradabad Village.**

In this morainic deposit, folding in some clay layers are pragmatic. These folds are of small scale with minimum amplitude also the material is vertically jointed **(Photo 4-10)**. All these features indicate that the area is under regional compressional active stress.

**Photo 4-10 View of Micro Folding in Clay Beds near Muradabad Village.**



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### 4.2.3 Road section from Muradabad to Hussaini Village:

Co-ordinates

N 4033080.557m

E 489417.275m

El. 2656.69m a s l

Just upstream of Hussaini village a large mass of ABGM and brecciated rock is exposed along the road. It is present in the alignment of thrust fault where crushed marble is in contact with Passu Slates. The faulted contact between slate and marble is well exposed along road **(Photo 4-11)**.

**Photo 4-11 View of Brecciated Rock Upstream of Hussaini Village.**

In this area two faults are intersecting each other, one is striking N60°E and dipping 40°NW while other is striking NW and dipping NE **(DWG No: AFS-GE-318)**. Due to these faults discrete hillocks have formed with thin overburden overlain by fault breccia. At few feet away from breccia, a slided material consists of ABGM is present along road. Apparently this material seems to be stable but in excavated portion, this material is folded. Compressional forces are responsible for this deformation exposed at slope **(Photo 4-12)**.



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**Photo 4-12 View of Folded ABGM Just Upstream of Passu Village.**

Rock (Passu Slates) is locally folded, some shear joints along which the cleavage plane (originally bedding planes) across shear joint has different dip values. The overall strike of slates is NW and dipping in NE. but along this shear joint some movement took place and the value of dip changed from SW to NE **(Photo 4-13)**.

**Photo 4-13 Change of Dip along Shear Joint.**

Change of sense of dip along the shear joint shows that some shear forces have been active in the area. The development of such joints indicate the brittle deformation style.

### 4.2.4 At Hussaini Village

Coordinates

N 4031462.478 m



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E 488964.085 m

El 2413.46 m a s l

At Hussaini village, thick deposit of RBGM is exposed at right bank of river, upon which terraces formed. The sand beds in this material are tilted at an angle of 25° **(Photo 4-14)**. Joints are developed in it shows that this deposit has undergone stress.

**Photo 4-14 Inclination in Sand Beds in RBGM.**

The gravels are compacted and exposed vertically owing to overburden pressure and breaks in blocky form. The gravels beds are tilted up from river at an angle ranges from 6° to 11° but at places it is inclined at an angle of 25° **(Photo 4-15)**.

**Photo 4-15 Inclination in RBGM.**

This inclination in gravel bed indicates the effect of active shear forces operative on recent deposits and responsible for inclination in RBGM.



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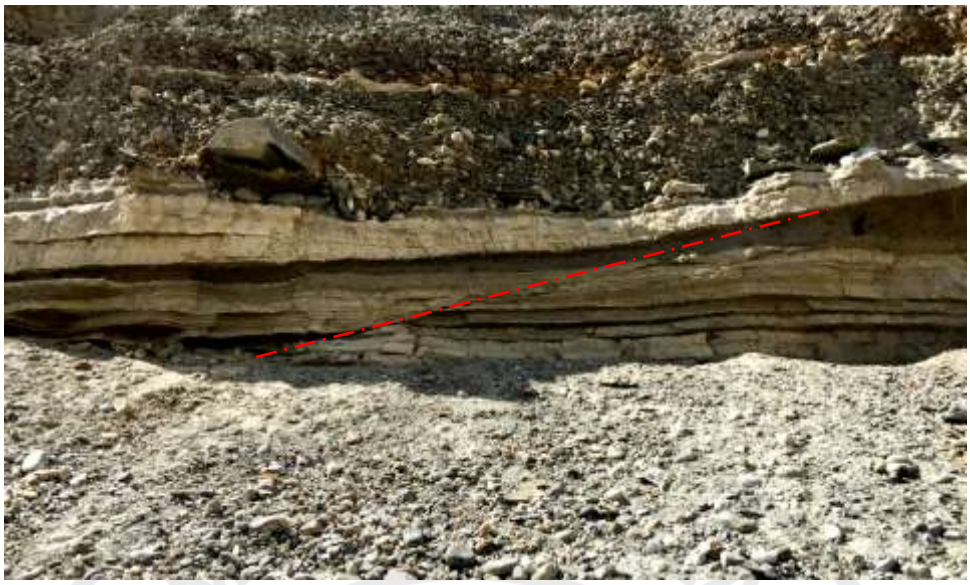

**Photo 4-16 Micro Fault in Clay Deposit Overlain by RBGM.**

A micro fault is observed in the clay deposits that cut the clays, perishes in RBGM, striking at N76°W and dipping 35°SW. The conglomeratic bed have pointed upward gravels, indicative of uplifting of deposit **(Photo 4-16)**.

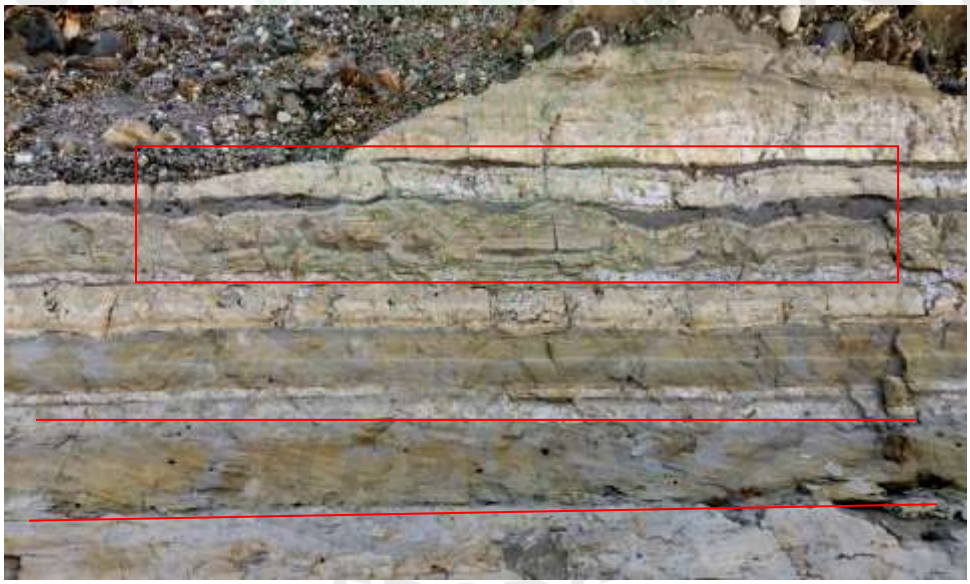

**Photo 4-17 Micro Folding and Inclination in Clay Deposit Overlain by RBGM.**

The highlighted lower portions in **(Photo 4-17)** indicate angularity in beds, tilted upward against the river flow direction. It shows that uplifting took place during deposition of these beds. Some compressional forces have been functioning which are accountable for evolution of micro folding in this strata. This intense deformation might be due to the compressional stresses operational in this area due to presence of active fault **(DWG No: AFS-GE-318)**.



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### 4.2.5 Way from Hussaini to Borith Lake:

Along the track from Hussaini to Borith Lake, sheared slates has intrusive contact with granitic gneiss. Some clay deposits are also present at higher elevations along road toward Borith Lake.

**Photo 4-18 Contact of Granitic Gneiss and Passu Slates**.

The slate is highly sheared/crushed and easily erodible. Micro folding and faulting along with jointing is observed in this deposited. The tiltness in beds is quite common **(Photo 4-18)**. These beds are tilted at an angle of 12° with horizontal surface.

**Photo 4-19 Micro Faults in Clay Beds.**

It is clear in above Photo that the sandy and clayey beds have movement along fracture planes. The hanging wall block move down relative to footwall forming normal faulting **(Photo 4-19)**.



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**Photo 4-20 Fold in Clayey Silt along Trace to Borith Lake.**

The folded strata in ABGM indicate that the area is under compression and stress are active in recent deposits **(Photo 4-20)**.

### 4.2.6 At Borith Lake:

Coordinates

N 4032452.941 m

E 487686.816 m

El. 2682.49 m a s l

At higher elevation from main KKH, a large lake of salty water is present. The alluvium material comprised of RBGM and sand has faulted contact with Passu Slate. Fault may be responsible for alluvium material to move up to the higher elevation. During the detailed study of area, different neo-tectonic features have been observed which are given below,

- Highly deformed sand and gravel beds.
- Tiltness in sand beds having inclination ranges from 15° to 25°.
- Cross bedding in sand beds.
- Folded strata.
- Pinching of sandy beds.
- Half fold.



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**Photo 4-21 Highly Deformed Sand and RBGM.**

The strata are highly disturbed and uplifted to high elevation by fault. Due to tectonic uplift different deformation phases have been observed in this deposit **(Photo 4-21)**. The deformational style shows that multidirectional deformational stresses are operational and responsible for deformation in recent deposits.

Sand beds in this area have tilted at an angle of 15° to 25°. The fault responsible for this is striking and dipping towards NE and NW respectively **(DWG No: AFS-GE-318).**

**Photo 4-22 Inclination of RBGM and Sand Beds.**



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**Photo 4-23 Inward Inclination(curvature) of RBGM and Sand Beds.**

Some sand beds have X-bedding which indicates that the direction of flow of water changes reasonably from time to time which is well preserved in strata at site **(Photo 4-21, 4-22, 4-23)**.

**Photo 4-24 X-bedding and Pinching of Sand Beds.**

Some beds are pinching against bedding planes indicate that the direction of river flow change abruptly due to operational stress **(Photo 4-24)**.



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**Photo 4-25 Folding in RBGM and Sand Beds.**

The above Photo indicates that the clay bed is folded showing the compressional environment. The tiltness of the bed is upward with lateral compression acting on the recently deposited strata.

It is observed during study that the lateral compression is operating in the Borith Lake area. The plastic behavior of clayey silt can be seen in folded strata where clayey silt is accumulated in hinge area of fold with increase in thickness of material (**Photo 4-25, 4-26)**.

**Photo 4-26 Folding in RBGM and Sand Beds.**



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**Photo 4-27 Folding in RBGM and Sand Beds.**

Many micro folds can be seen **(Photo 4-27)** showing that this very coarse grained gritty sand with silt intercalations is folded under lateral compression. The degree of deformation is quite high and the direction of compression changes from time to time as indicated by box fold with two hinge lines with one limb further folded as highlighted in rectangle.

Associated with this folding, some dislocation of silty beds are also observed along fracture surfaces representing compressional regime as hanging wall moves upwards relative to foot wall forming thrust fault **(Photo 4-28)**.

**Photo 4-28 Micro Faulting in RBGM and Sand Beds.**

These dislocations of beds, folding, tiltness, X-bedding indicate that the area is under active compressional stress.



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As moved further from Borith Lake toward Passu Glacier on kacha road, RBGM is present on both sides of the road. The schist present in rear area of Lake is quite sheared and the height of peaks reduces abruptly. Near the edge of Passu Glacier, the schist are in faulted contact with marble. The bedding planes of both blocks along the fault have different sense of dip **(DWG No: AFS-GE-318)**. The bedding of marble is trending N63°W and dipping at 39°NE while the schist is trending at N54°W and dipping at 78°SW.

**Photo 4-29 Fault Breccia of Marble at High Elevation**

Towards western slope of the Borith Lake, crushed marble is present at higher elevation. It is brecciated rock crushed by fault **(Photo 4-29)** and exposed as discrete units about 50 m above the water channel at slope. The coordinates of the breccia is

N 4032085.486m

E 487153.319m

El. 2771.47 m a s l

The depression had been originated by faults resulted to the formation of lake. The alignment of the fault is marked **(DWG No: AFS-GE-318)** along which no rock is present at track towards Hussaini village that confirms the presence of fault.

### 4.2.7 Just Downstream of Gulkin Glacier:

Coordinates

N 4029091.513m

E 488760.419m

El. 2445.0 m a s l

Near the Salvia Restaurant, just downstream of Gulkin Glacier along Hunza River, some alluvium material is present along the KKH. This alluvium is overlain by morainic deposit. Some tectonic features are well preserved showing movement in recent deposits along fractures. **(Photo 4-30)**.



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**Photo 4-30 Micro Fault in Alluvial Gritty Sand.**

Formation of jointing pattern in recent deposits, and movement along these fractures is clear indication of active tectonic stresses.

**Photo 4-31 X-bedding in Sand.**

Along with jointing, there is X-bedding in sand deposits. It indicates that the tectonic uplift might have taken place or the direction of flow change **(Photo 4-31)** responsible for X-cutting of sand beds.



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**Photo 4-32 Folding in Clayey Silt with Pointed Hinge.**

The clay layers in recent deposit are folded under lateral compressional force. The strata are disturbed and evident of Neo-tectonic activity **(Photo 4-32)**.

### 4.2.8 At Attabad Village:

A large slide moved downslope in January 4, 2010 forming a lake of about 25 km unto Khyber village near Batura Glacier. Pre-slided geological features indicate that Attabad village was situated on morainic material. The morainic material was underlain by granitic gneiss. The Attabad village was junction point of three faults **(DWG No: AFS-GE-319)** During surface geological mapping and neo-tectonic studies it is observed that fault “A” is along Hunza River, fault “D” has NE trending and another fault trending NW, merged at Attabad village **(Photo 4-33)**.



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**Photo 4-33 View of Fault Alignment Crossing Hunza River near Attabad.**



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The rock is highly sheared, fractured and intensely jointed due to tectonic activity. Blocks of rock slided down mostly due to wedge failure. The shear strength of the rock reduces due to Neo-tectonic activity / movement along fault and failure occurs **(Photo 4-34)**.

**Photo 4-34 View of Attabad Slide.**

Firstly, some cracks appeared on the surface in cultivated terraces, with the passage of time the fractures grew and became wider and wider, accelerated by Hydrological conditions. As a result of operational neo-tectonic forces and hydrological condition, failure occurred in the form of enormous slide.

Mechanically sheared material under influence of tectonic forces disturbed and moved downslope by accumulating in riverbed and completely demolished about 2km of KKH.

The rock in downstream vicinity of slide is also sheared with many shear zones at right side while at left side in downstream areas, rock is brecciated due to fault **(DWG No: AFS-GE-319)** The Attabad slide is still active, as indicated by rolling down of material can be observed along this slide. It indicates that it is tectonically active area with some stresses releases along junction point/faults from time to time.

### 4.2.9 At Sarat Village:

Coordinates:

| | |
|---|---|
| N | 4018254.850 m |
| E | 481549.816 m |
| El. | 2371.35 m a s l |

As a result of Salmanabad slide in the year 1858, a large lake developed in upstream reaches. The depositional clayey silt can be seen on both bank of Hunza River. Due to operational neo-tectonic forces, deformation including folding, jointing, and micro faulting have developed in these deposits.



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Both vertical and oblique joints can be seen in clayey silt at right side near Sarat Suspension Bridge. The strike and dip values of vertical and oblique joints are N38°W/87°NE and N32°E/63°SE respectively **(Photo 4-35)**.

**Photo 4-35 View of Vertical and Oblique Joints in Clayey Silt at Sarat Village.**

Clayey silt beds are striking N 80°E and dipping 18°NW **(Photo 4-36)** at the left side of road leading to Sarat Village while at the right side of the road these beds have strike N 32°E and dipping 9°SE **(Photo 4-37)**.

**Photo 4-36 Tiltness in Clayey Silt Beds, Left Side of Road at Sarat Village.**

The strike of the beds is NE while the dip is in opposite direction, indicating that it forms some sort of antiform. Formation of antiform in recent deposits clearly indicates that lateral shear compressional forces are operational in this area.



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**Photo 4-37 Tiltness in Clayey Silt Beds, Right Side of Road at Sarat Village.**

Just downstream of Sarat Village near the suspension Bridge, fault breccia is exposed along the river showing the alignment of fault.

**Photo 4-38 Folded and Sheared Clayey Silt at Sarat Village.**



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**Photo 4-39 Sheared and Smeared Clayey Silt at Sarat Village.**

**Photo 4-40 Fault Breccia just D/S of Suspension Bridge at Sarat Village.**

Folding, jointing, smearing and shearing of clayey silt **(Photo 4-38, 4-39, 4-40)** deposit show some lateral stresses are actively operating in this area. The active slides and rolling down of brecciated material from this slope indicate that it is tectonically active area.

### 4.2.10 At Salmanabad Village:

Coordinates:

| | |
|---|---|
| N | 4018373.023 m |
| E | 479430.485 m |
| El. | 2661.0 m a s l |



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It is situated downstream of Sarat village and accessible by unmetaled road. The whole village is founded on fault breccia having many exposures of gaugic and brecciated materials. It is present along the road with alluvium material consist of sand and RBGM.

**Photo 4-41 Fault Breccia along Road at Salmanabad Village.**

The fault is striking N20°W and dipping at 58°SW with some parallel shear zones. Alluvium material RBGM and sand lifted upward along the fault B and fault C up to this elevation and are in contact with crushed marble **(DWG No: AFS-GE-319)**.

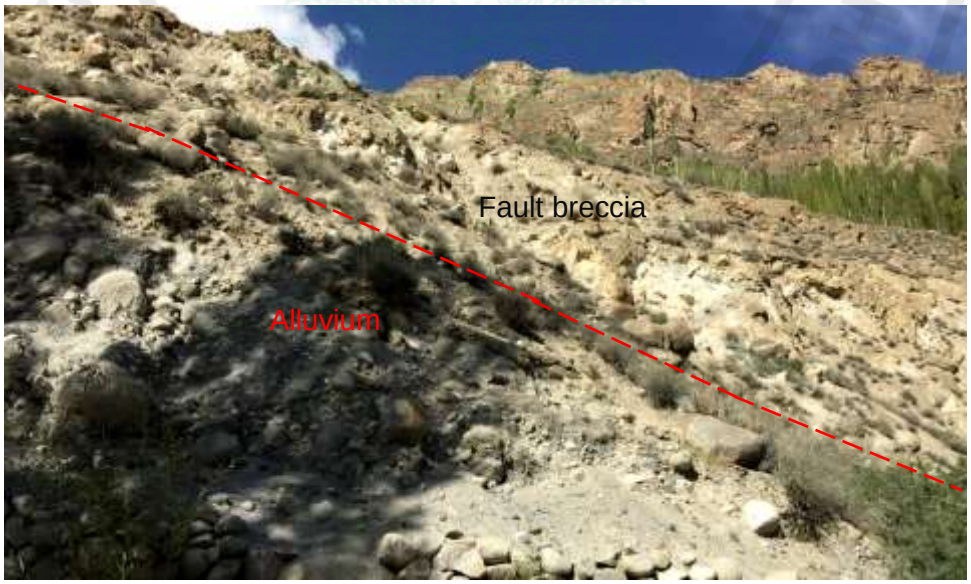


**Photo 4-42 Faulted Contact of Breccia with Alluvium at Salmanabad Village.**

As we move further up to higher elevations, the exposure of fault breccia and alluvium extend and well exposed up to elevation of 2704.02m **(Photo 4-41)**. Fault C is striking NW and dipping NE. Due to these two faults the whole rock beneath Salmanabad village is highly tectonized and crushed to the level of breccia and is well exposed along Hunza River **(Photo 4-42, 4-43).**



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**Photo 4-43 Fault Breccia beneath Salmanabad Village along Hunza River.**

### 4.2.11 At Hassanabad Nullah:

Coordinates

N 4018015.083m

E 462346.127m

El. 2216.92 m a s l

At the nullah mouth, a shear zone trending NE and dipping NW sheared the rock and turned it into breccia. Micro folding, crenulation and isoclinal folding is quite common. The slopes are unstable with rolling down of boulders is quite common **(Photo 4-44)**.

**Photo 4-44 Active Slides at Right Side Slope of Hassanabad Nullah.**



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The presence of active slides in the area is an indication of active tectonic forces.

**Photo 4-45 Fault Breccia/Gauge along Road Just D/S of Murtazabad Village.**

Just D/S of Hassanabad Nullah's confluence with Hunza River, along KKH, fault breccia of yellowish brown, reddish color, is exposed. A hot spring seepage is associated with this fault. A number of active slides have been activated along this fault. This fault extends further downstream and exposed in Nasirabad (Hindi) where a number of active slides are associated with this fault **(Photo 4-45)**.

### 4.2.12 At the Murtazabad- Shahyar Bridge:

Further downstream of Murtazabad toward Shahyar village, thick exposure of clayey silt is exposed along the road near the bridge. The beds are tilted inward, at an angle of 20° to 22° **(Photo 4.46)**.

**Photo 4-46 Inward Tiltness in Clayey Silt Just D/S of Murtazabad Village.**



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Hummocky X-bedding is quite common in this deposit, formed under wave action with huge load under depth of water **(Photo 4.47)**.

**Photo 4-47 Hummocky X-bedding in Clayey Silt near Murtazaba Village.**

The whole deposit is jointed vertically along which falling of blocks is quite common.

## 4.3 LEFT BANK OF HUNZA RIVER

### 4.3.1 At confluence of Shamshal Nullah with Hunza River:

Coordinates:

N 4039351.149m

E 490847.707m

El. 2522.91 m a s l

Near the confluence of Shamshal Nullah at left bank, morainic deposit having clay layers is exposed. It is jointed and range from clay to morainic material **(Photo 4-48)**.

Along Upstream course in Shamshal Nullah, the Geological conditions become worst. The left side of nullah is highly crushed responsible to generate many active slides, associated with active fault system. Passu Slate is highly crushed/tectonized, sheared and folded, near the confluence of Shamshal Nullah with Hunza River **(Photo 4-50)**.

At right bank of Shamshal Nullah, many active slides originating at higher elevation from Passu Cones deposited their load in foothills. The rocks are highly crushed up to higher elevations at both sides of Shamshal Nullah due to intersection of two faults, one is running from Borith Lake while other is running from Batura Glacier **(DWG No: AFS-GE-318)**

Development of joints in morainic material, active slides, highly sheared and folded strata **(Photo 4-49)** show that the area is tectonically active.



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**Photo 4-48 Jointing in Morainic Material, near Confluence of Shamshal Nullah with Hunza River.**

**Photo 4-49 View of Active Slides in Shamshal Nullah.**



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**Photo 4-50 View Of Folding, Crushed Rocks and Active Slides in Shamshal Nullah.**

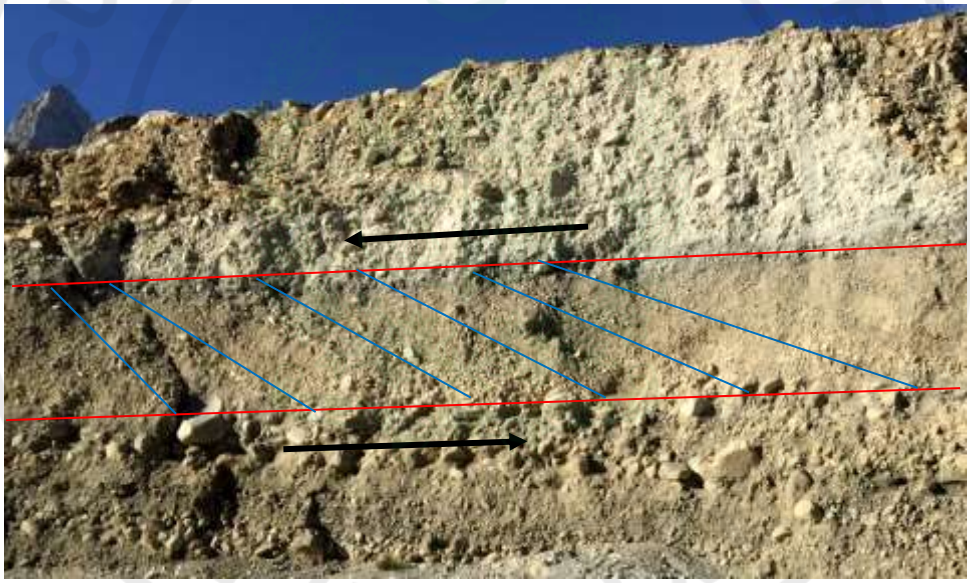

**Photo 4-51 View of Inclined Gravel Bed Near Confluence of Hunza River and Shamshal Nullah.**

Near the bridge at left bank of Hunza River, RBGM is exposed. The degree of inclination of these beds range from 15° to18° **(Photo 4-51)**. Some compressional shearing forces resulted inclination in these beds. Inclination along specific beds, packed by horizontal layers indicates that shearing force is operative along these layers.

### 4.3.2 In front of Gulmit and Gulkin Glacier:

Geological condition in this area is quite poor. A fault with strike and dip values N14°W and 42°NE respectively, **(DWG No: AFS-GE-318)**, crushed the rock into breccia. Whole rock unit disintegrated and accountable for rolling down of large boulders downwards forming active slides. The rolling down of rock pieces from higher elevation shows that some active tectonic forces are affecting on this slope and make it unstable **(Photo 4-52)**.



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**Photo 4-52 View of Active Slides along Left Bank of Hunza River.**

Further downstream, a fault passes through Shishkat village. The left side gradient becomes highly disturbed because of crushing of rock. Terraces of Shishkat village on breccia were formed by this fault.

### 4.3.3 In Perennial Nullah at the end of Tunnel 4:

Coordinates:

| | |
|---|---|
| N | 4019140.03m |
| E | 489442.982m |
| El. | 2482.0 m a s l |

At the end of Tunnel 5, a perennial nullah is present. In this nullah about 600m upstream, fault breccia is exposed **(Photo 4-53)**. This nullah seems to be developed along large shear zone; originated from this fault, which is bounded by hard rocks on both sides. This fault / shear zone crushed the rock into breccia and responsible for the bending of Hunza River at 90°. This fault crosses the river and is responsible for active slide on right bank of river **(DWG No: AFS-GE-319)**.



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**Photo 4-53 View Of Fault Breccia in Perennial Nullah.**

### 4.3.4 Inside Tunnel 2

Many cracks/joint are going to develop in the concrete especially in crown area in Tunnel-2. The pattern of the cracks indicates stress release and shear oblique joints **(Photo 4-54)**.

**Photo 4-54 View of Recently Generated Joints in Tunnel-2.**

As far as geological conditions are concerned, this portion of tunnel in is under influence of two faults **(DWG No: AFS-GE-319)**. Rock is highly crushed, rolling down of boulders is quite common along these active faults. The active tectonic forces are responsible for the development of fractures in this terrain.

The same features can also be noted in concrete structure between Tunnel 2 and 3 **(Photo 4-55)** along KKH.



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**Photo 4-55 View of Recently Generated Joints between Tunnel-2 & 3.**

The concrete slab fractured between Tunnel 2 and 3. It is evident that some tectonic forces are recently active in this area.

### 4.3.5 Between Tunnel 1 and 2

The area between Tunnel 1 and 2 is highly sheared **(Photo 4-56)** due to influence of fault with strike and dip values of N52°W and 50°NE. This fault is a splay of Hunza Fault **(DWG No: AFS-GE-319).**

**Photo 4-56 View of Fault Breccia between Tunnel-2 & 3.**

The rock is highly tectonized / brecciated. The extension of this fault is upto old KKH route and exposed in rear of old Chinese camp. The breccia with some gaugic material indicates brittle shearing responsible for originating active slides. Along the alignment of fault, two springs are present in this area.



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### 4.3.6 Power House Area

In powerhouse area near helipad along old KKH, clayey silt is present where Chinese Camp was established. The clayey silt was deposited after river choking due to Salmanabad slide. Due to operational compressional stresses, some deformations including faulting, shearing, folding, and tiltness in clayey silt have been observed.

**Photo 4-57 Micro Thrust Fault in Clayey Silt Beds near Helipad.**

The relative movement of both blocks against fault plane indicates compressional environment, which moved the hanging wall block upward **(Photo 4-57)**.

**Photo 4-58 Inclination in Clayey Silt near Sarat Village Bridge.**

The clayey silt beds are well exposed at the left side of Hunza River near Sarat Bridge. The clayey silt beds are well jointed and tilted upward at an angle ranging from 10° to 15° **(Photo 4-58)**. The inclination of the beds are in recent soil is indicative of active tectonic forces.



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Near old Chinese Camp, at powerhouse area, the clayey silt is folded **(Photo 4-59)**. Folding in recently deposited clayey silt might have resulted of slipping along fault plane under regional compressional shear forces which resulted in the formation of folding and faulting.

**Photo 4-59 Folding in Clayey Silt near Helipad/Power House Area.**

Near the SCO building, along old KKH, near Tunnel-1, some cracks are going to develop in recently deposited material. The development of joints is mostly parallel in nature but occasional cross cutting joints also present **(Photo 4-60)**.

**Photo 4-60 Development of Parallel Joints near SCO Building.**

### 4.3.7 In front of Salmanabad and Ahmadabad Village:

Along the KKH, opposite to the Salmanabad and Ahmadabad, the slope is highly disturbed. A regional fault striking NE and dipping SE is running through this area. The fault and its splays crushed the rock outcrop. The area in front of Salmanabad is highly tectonized with a number of



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active slides **(DWG No: AFS-GE-319)**. The breccia consists of rock pieces with gaugic material **(Photo 4-61)**.

**Photo 4-61 View of Active Slides in front of Salmanabad.**

While the area in front of Ahmadabad also consists of brecciated rock but slopes are stable **(Photo 4-62)**. The drainage pattern is dendritic in higher elevation changes into parallel near the road which indicates that sheared rock is present up to higher elevations.

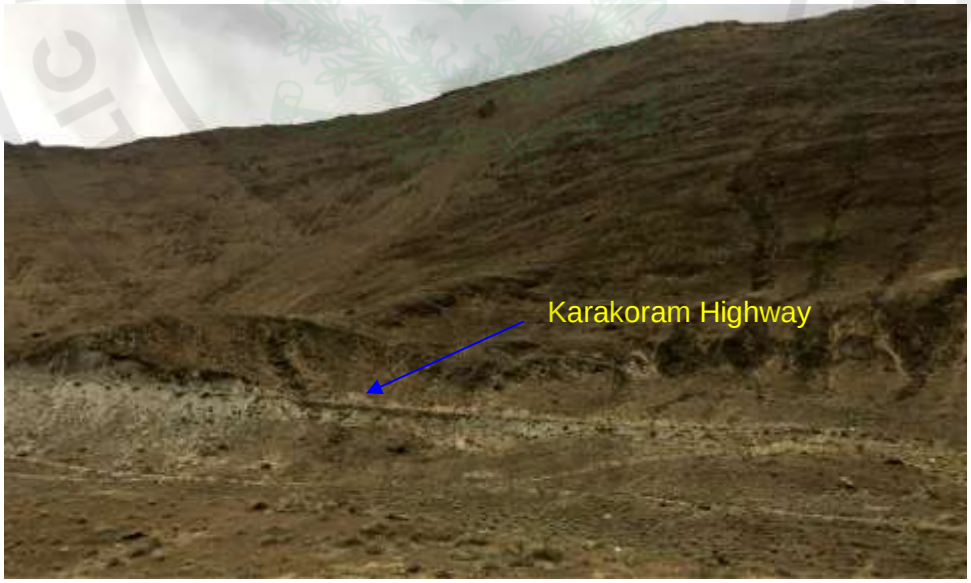


**Photo 4-62 View of Stable Slide in front of Ahmadabad.**



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**Photo 4-63 Panoramic View of Slope in front of Salmanabad and Ahmadabad Village**



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The rock at the slope in front of Ahmadbad along KKH is crushed, brecciated but there is no evidence of active tectonic forces in this section. Thin overburden ranging in thickness from 2 to 5 m underlain by sheared/ crushed rock, covers the slope. It suggests that the splay passing though this area is not active **(Photo 4-63)**. However, the topographic features, drainage pattern, left side slope of mountain terrain, and presence of brecciated rock in non-perennial nullah are clear cut indicator of fault system present in this area.

### 4.3.8 Upstream of Ganesh Bridge:

Coordinates:

| | |
|---|---|
| N | 4018284.00m |
| E | 473257.772 |
| El. | 2211.23m a s l |

Just upstream of the Ganesh Bridge, a large deposit of clayey silt is present at left bank of river underlain by thick RBGM material. It is observed that this material is under the influence of tectonic forces. The clayey silt beds have sheared zone striking at N72°E and dipping 88° SE **(Photo 4-64)**.

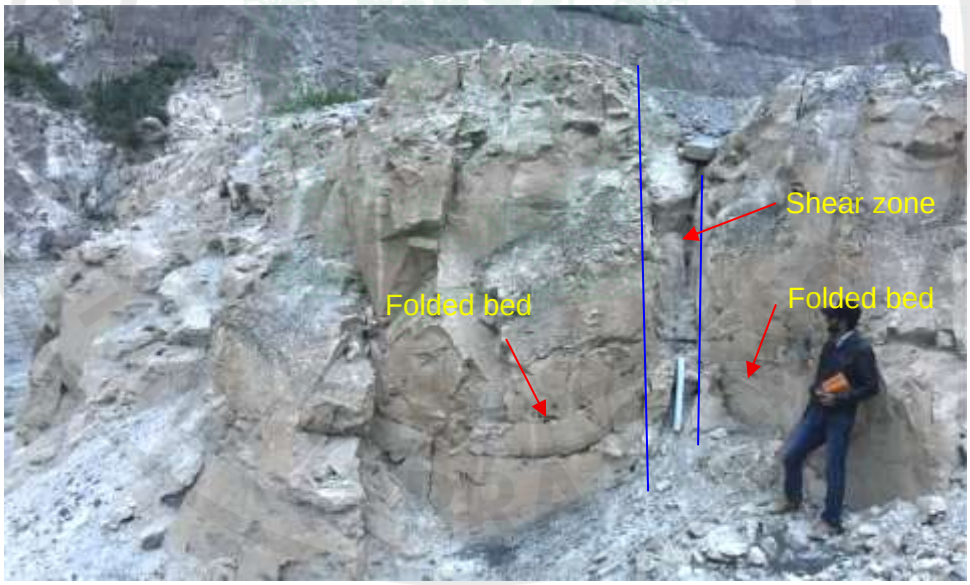


**Photo 4-64 View of Shear Zone and Folding in Clayey Silt.**

The clayey silt beds are folded across this shear zone. Associated with this, clayey silt beds have displaced along fracture plane with displacement of 12cm **(Photo 4-65)**. Beds of clayey silt are tilted up at an angle ranging from 6° to 20° in upstream direction. These features indicate that this area is under influence of active tectonic forces.


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**Photo 4-65 View of Micro Fault and Displacement of Blocks.**

### 4.3.9 Near Kiln Upstream of Ganesh Bridge:

Coordinates

N 4018656.896m

E 471625.513m

El. 2185.0 m a s l

It is observing near Kiln that gravels, cobbles, and pebble in RBGM are tilted upward against the flow of Hunza River **(Photo 4-66)**. The inclination is 20° in RBGM and 18° in clayey silt beds.

**Photo 4-66 Inclination in Gravel Bed near Kiln**



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Similarly, along KKH, tiltness in ABGM and clayey silt beds is observed ranging from 5° to 10° **(Photo 4-67).**

**Photo 4-67 Inclination in ABGM and Clayey Silt Bed along KKH.**

It is observed during site visit that some longitudinal joints are developed in morainic / slided mass, laying over the rock. It is evident that trend and sense of force is same as that of underlying rock **(Photo 4-68)**.

**Photo 4-68 Development of Jointing in ABGM Underlain by Rock along KKH.**

### 4.3.10 At Ganesh Bridge

The rock (Granotoide) with coarse to very coarse grained interbed marble is well exposed at left side along KKH. The rock is highly foliated and can split easily along this weak plane. Low amplitude folds with longitudinal joints are well developed. Some open joints intersecting with oblique joints might have caused the rock fall **(Photo 4.69)**.



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**Photo 4-69 Development of Longitudinal Joints in Rock along KKH.**

The development of longitudinal joints in rock outcrop and falling of blocks show that some recent forces are operational in this area.

### 4.3.11 Just downstream of Ganesh Bridge:

Coordinates

N 4018200.432 m

E 470296.520 m

El. 2104.05 m a s l

At the confluence of Hispar River with Hunza River, there is thick deposit of RBGM present up to high elevations. The RBGM has subordinate sand beds. This recently deposited strata are quite disturbed. Many tectonic features have developed in this deposit including: -

- Inclination
- Folding
- Crenulation
- Folds with bulbus hing

Just upstream the confluence along Hispar River, thick RBGM is present along road. The material is under influence of intense deformation. The RBGM is tilted at an angle of 45° to 50° **(Photo 4-70)**. It is tilted upstream and extends up to higher elevations.



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**Photo 4-70 Inclination in RBGM at Left Bank of Hispar River.**

The compressional forces responsible for deformation are associated with NE striking thrust faults passing near the area. Folding with bulbus hinge, box fold, recumbent fold are well exposed near the confluence **(Photo 4-71)**.

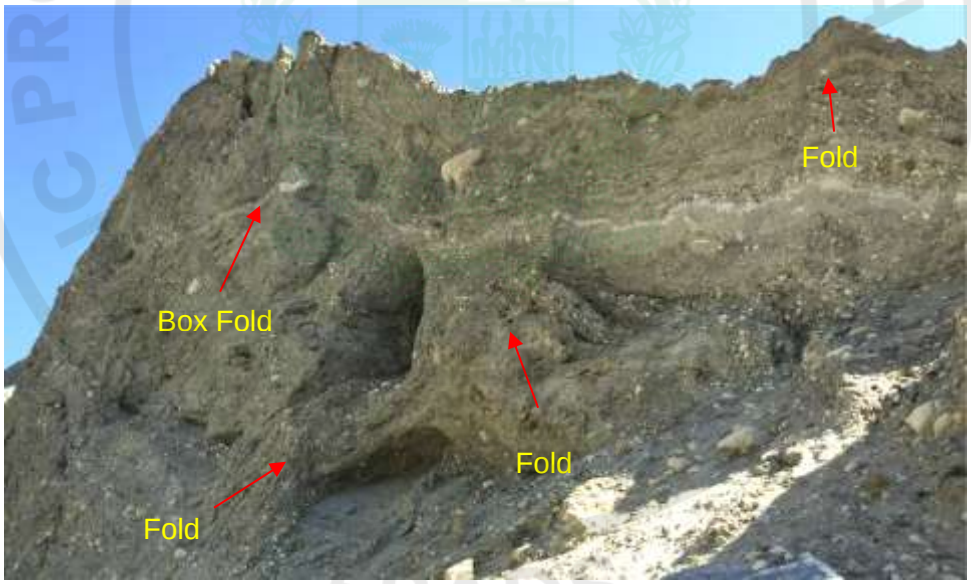


**Photo 4-71 Folding in RBGM along Hispar River.**

Due to intense compressional force, some beds are folded with inclined hinge. Both limbs are dipping in same direction **(Photo 4-72)**. The presence of folds in recent deposit indicates that, compressional force deformed this strata. The alignment of all folds is not uniform, indicates that multidirectional stress are applied in different episodes.



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**Photo 4-72 Inclined Isoclinal Fold In RBGM along Hispar River.**

### 4.3.12 In Hispar Valley:

Coordinates

N 4017966.628m

E 470008.848m

El. 2107.24m a s l

Overall the geological conditions in Hispar Nullah are quite disturbed. The right side slope is mostly brecciated and consists of ABGM with RBGM. Gravel with sand beds is well exposed at the right side of Hispar Nullah are tilted up at an angle ranging from 22° to 30° **(Photo 4-73)**.

**Photo 4-73 Inclination in Gravel Beds Tilted Upstream along Hispar River.**



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Major faults with their splays disturbed the area and extend further westward into Nagar valley. The whole valley up to Hoper Glacier is highly brecciated with some exposure of competent rocks.

**Photo 4-74 Inclination in Gravel Bed Tilted Upstream along Hispar River.**

It is clear in **(Photo 4-74)** that the sand layer is folded with inclined gravel beds with the formation of box fold, flat lower area with nearly straight limbs. These features were resulted from compressional forces associated with thrust fault.

About 3 km from confluence of Hispar and Hunza Rivers, the gravel beds are tilted at low angle ranging from 6° to 10°. The beds are tilted upstream, indicating upward movement of recent gravels **(Photo 4-75)**.

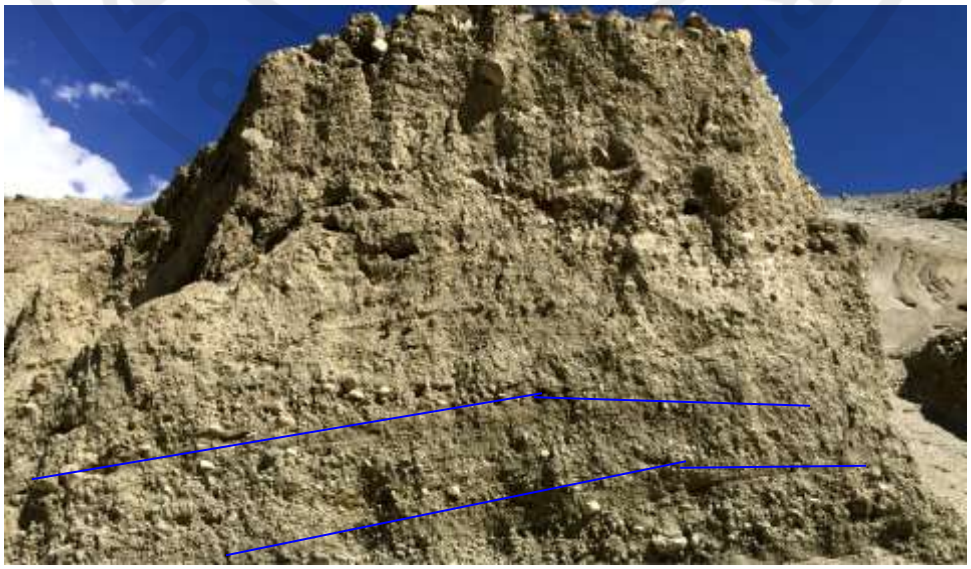

**Photo 4-75 Inclination in Gravel Beds Tilted Upstream along Hispar River.**

At Tukurkhai village, the fault breccia is exposed o both sides of a perennial nullah striking NE and dipping SE **(Photo 4-76)**.



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**Photo 4-76 Fault Breccia at Tukurkhai Village on Left Bank of Hispar River.**



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The rock is highly crushed and slopes are unstable. The nullah is developed along the extension of fault and well exposed along the road. All the terraces are developed upon the brecciated rock.

### 4.3.13 At Nagar Valley

The whole Nagar valley including Sumayar, Shahyar, and Hakuchar villages are situated on fault alignment **(DWG No: AFS-GE-320).** All the terraces were developed on fault breccia. Rocks are sheared and disturbed in this area **(Photo 4-77)**.

**Photo 4-77 Fault Breccia near Hakuchar Village with Active Slides.**

The slides are active, rolling down of material from crushed rock is quite common. It is present upto higher elevation and is responsible for the choking of Hunza River in the past. Due to development of lake, clayey silt was deposited and exposed along the both sides of river. The presence of active slides indicates that, fault is active in this area.

### 4.3.14 At Murtazabad - Shahyar Road

Coordinates:

| | |
|---|---|
| N | 4016299.113m |
| E | 465418.47m |
| El. | 2095m a s l |

Just crossing the Murtazabad to Shahyar Bridge, a thick alluvial deposit consists of gravels, cobbles, pebbles interbedded with silty sand is exposed. This material moved upward against fault plane and formed fault bend fold **(Photo 4-78)**.



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**Photo 4-78 Inclination in Clayey Silt and Gravels.**

The beds are tilted at an angle of 22° to 30°. Many micro faults in sand beds have been observed in hinge area of the fold. The ramp and flat geometry have NE strike with dip in SE direction. **(Photo 4-79)**.

**Photo 4-79 Ramp and Flat Geometry along Fault.**

Some micro faults have been observed in this alluvium. Step faulting on micro level is well preserved in sandy material **(Photo 4-80)**. This alluvium is overlain by morainic material; same joint pattern is going to be developed in it. Some open joints ranging from 10cm to 150cm have been observed there. All these features indicate that the tectonic forces are active in this area.



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**Photo 4-80 Development of Micro Faults in Sand.**

### 4.3.15 In Tashot Village

Coordinates:

| | |
|---|---|
| N | 4012830.531m |
| E | 462157.244m |
| El. | 2111.0ma s l |

After crossing suspension bridge near Tashot Bridge, a thick deposit of RBGM and clayey silt is exposed along the road toward Phakhar village. Due to some recent activity, clayey silt is displaced and smeared along micro fault. Upward inclination of 6 °in recent RBGM has been found along the road **(Photo 4-81, 4-82)**.

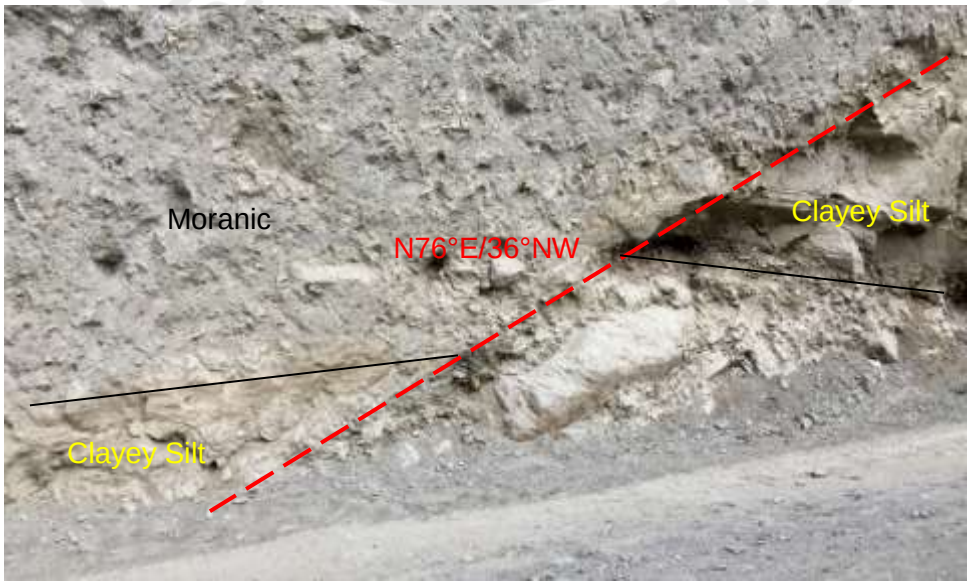


**Photo 4-81 Development of Micro Faults in Clayey Silt.**


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**Photo 4-82 Inclination in RBGM in Tashot Village along Road.**

### 4.3.16 In Maichar Vllage:

Coordinates:

| | |
|---|---|
| N | 4012909.747m |
| E | 461867.550m |
| El. | 2098.0m a s l |

At the left side slope of Hunza River, crushed rock with major constituents of gaugic material is exposed. The slopes are unstable due to active fault movement **(Photo 4-83)**. Well-developed garnets are present in granitic gneiss metamorphosed upto schistose grade.

**Photo 4-83 Highly Crushed Rock in Maicher Village along Road.**



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**Photo 4-84 Panoramic View of Crushed Rock and Drainage Pattern at Miachar Village.**



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A fault striking N45°E and Dipping 40°SE is running through Maichar village. Intersection of 3 to 4 faults, (coming from Central Hunza and Hassanabad Nullah), the rock is highly crushed and disturbed **(DWG No: AFS-GE-320).** Due to which, dendritic drainage pattern is well developed along the left side slope of the River. Fault breccia is well exposed along the road section.

Maichar village is developed on highly crushed rock with dominant gaugic material. The cultivated terraces are well developed on this material. Due to seepage of water and some tectonic movement along the faults, a large fracture seems to be opened along the slope, in back side of Maichar village. It is quite hazardous in the near future. The whole slope may become unstable and slide down.

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# 5 CONCLUSIONS OF NEOTECTONICS STUDY

- The Project Area lies in KB, where Igneous, metamorphic and sedimentary rocks are exposed.
- It is a V-shaped valley originated by glacial activity, modified by river and controlled structurally by tectonic activity. The MKT and its splays at the Western side while Karakorum Fault and its splays at the Eastern side are the factor controlling the valley's morphology.
- The Project Area lies in the vicinity of active tectonic zone, responsible for the massive landslide at Attabad village. It chocked the Hunza River and creates about 25 km long lake up to Khyber village. After the excavation of spillway, the lake length reduces to 15 km.
- The area under study shows that the active tectonic forces are operational in this area; the sliding of huge rock mass is one of the major evidence of neo-tectonic activity.
- During the current study about 40 km upstream and 50 km downstream area have been investigated. There are many deformational features observed in the recent deposit. Many evidences of chocking of Hunza River have been found in deposited clayey silt at number of locations.
- During site visit many deformation phases have been observed in the recent deposits including, faulting, folding (fault bend fold, chevron fold, ramp and flat geometry), jointing, tiltness in sand and gravels, step faulting, cross bedding etc., throughout the stretch. These structural features are associated with different thrust fault systems under compressional regime.
- The whole area suffers under tectonic forces that might have contributed some seismic events in this area. During the study fault geometry, nature of fault, and slope disturbed due to these faults have been studied to incorporate in Seismic Hazard Analysis Report.



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# 6 SEISMIC HAZARD ASSESSMENT

## 6.1 INTRODUCTION

Hydro Planning Organization (HPO), Pakistan Water and Power Development Authority (WAPDA) have undertaken the Feasibility Study of ALHPP in GB.

The proposed Project is located on Hunza River about 20 km upstream of Aliabad village about 130 km from Gilgit and about 750 km from Islamabad. Project Area is under the administrative control of GB. Hunza River is one of tributaries of the Indus River. The location coordinates of newly proposed inlet portal of diversion tunnel has been used as tentative reference coordinates for seismic hazard analysis of the Project and the coordinates are given below:

Latitude 36.313 N

Longitude 74.861 E

As the earthquakes hazard to water retaining structures is very important consideration in the design of civil structures, it requires careful analysis for selecting seismic design parameters for water retaining structures. The goal of the earthquakes-resistant design is to produce a structure that can withstand a certain level of shaking without excessive damages to the water retaining structures. Thus, the specification of design ground motion parameters is one of the most important difficult and most important problems in geotechnical earthquake engineering.

The Project Area lies in a unique geo-environment where all the typical hazards associated with mountainous areas exists including twin geo-hazards of earthquakes and landslides in addition to the possible danger of accidental and irregular melting of glacial waters resulting in huge sediments-loaded flooding potentials. Keeping all the triggering factors in view, care has been taken while selecting seismic design parameters for the updating Feasibility Study of the 54 MW ALHPP located on Hunza River. A composite map showing the location of the Project Area along with important physical features of the catchment areas and the area selected for seismicity analysis (Catalogue) is presented as Figure 6-1.

The Project Area lies in KB to the north of the MKT. Consequently, the MKT is the most prominent tectonic feature close to ALHPP, located at a distance of 32 km from the Project Site. Geological Map of Northern Pakistan and re-created Geological Map of Hunza Area were used in the softwares for seismic hazard analysis and these maps are presented as Figure 6-2.



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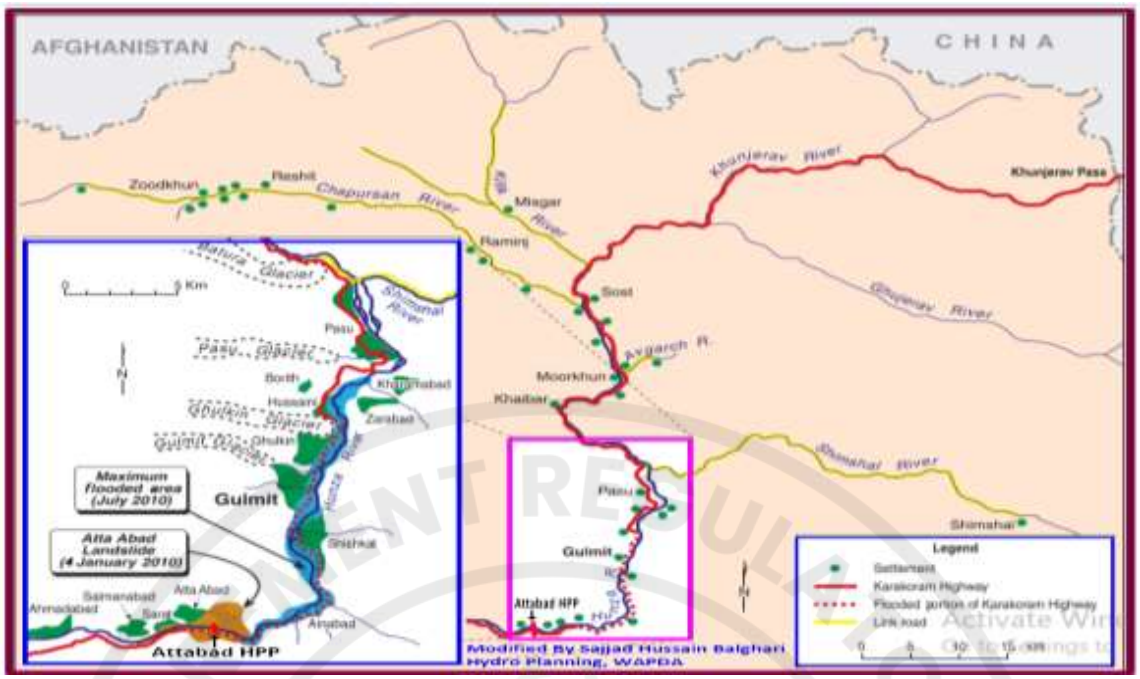


**Figure 6-1 Composite Map Showing Location of ALHPP Site.**

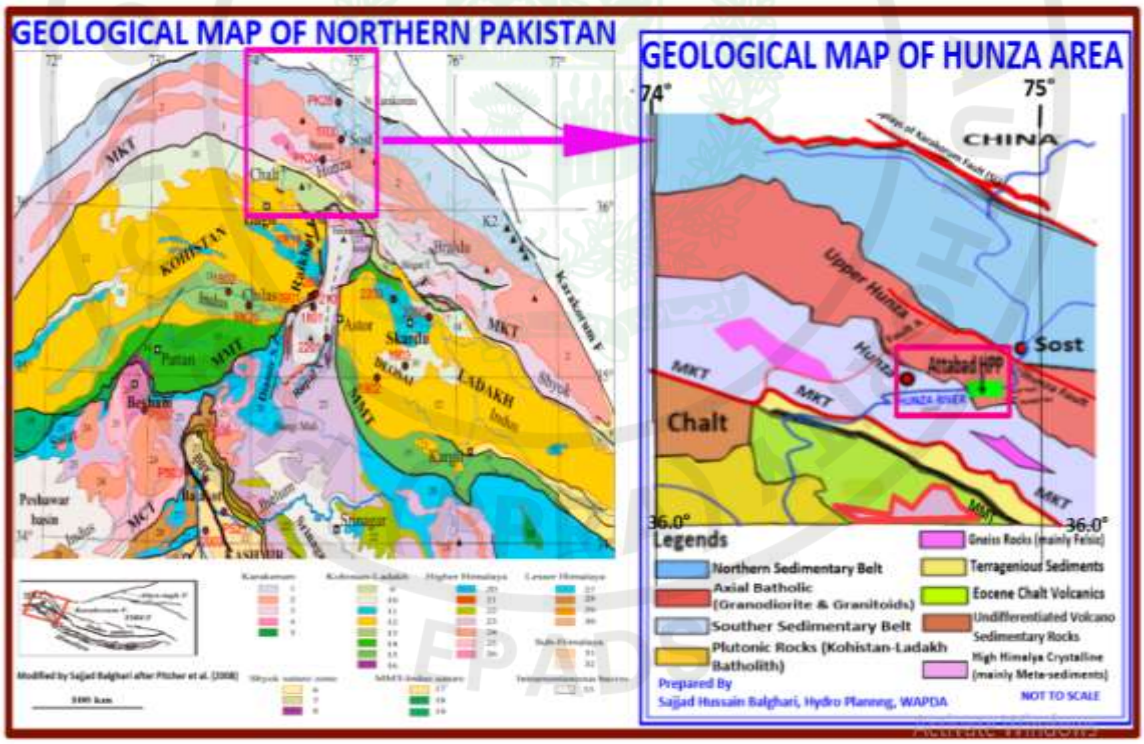


**Figure 6-2 Geological Map of Northern Pakistan (Pecher et al. 2008) & Geological Map of Hunza.**

Explanation to Legends (Left Map) i.e. Geological map of the Northern Pakistan modified by HPO, WAPDA after Pêcher et al. [2008]. Main tectonic boundaries: MKT, MMT, (Indus Suture Zone); STD, South Tibetan Detachment; MCT MBT; MFT, Main Frontal Thrust; BBT, Balakot-Bagh Thrust. Geological units at ALHPP are underlined: 1. Northern Sedimentary belt; 2, Axial Batholith, Granodiorites and other Granitoids; 3, Southern metamorphic belt; 4, Felsic gneiss; 5,



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greenstone complex, Paleozoic (Masherbrum complex). Unit B Shyok Suture Zone: reactivated along the MKT, 6, Predominantly terrigeneous formation; 7, Melange zone (volcanic); 8, Ultramafics (Shyok and Dobani-Dassu lineament). Unit C Kohistan: 9, Eocene Chalt Volcanics, Turmik volcanosediments; 10, Undifferentiated volcanosedimentary group; 11, Metasediments; 12, Plutonic rocks (Kohistan and Ladakh batholith); 13, Gabbronorites (Chilas Complex); 14, Southern amphibolites (Kohistan); 15, Dras volcanosedimentary group (Ladakh); 16, Mantle ultrabasites (Jijal complex). Unit D MMT-Indus suture zone: 17, Indus Molasses; 18, Spontang ophiolites; 19, Imbricate thrust units, with blue schists. Unit E Higher Himalaya: 20, Neotethyan Sedimentary Group (Permian-Eocene); 21, Tertiary leucogranites (Ladakh and Nanga Parbat); 22, Panjal Traps (Permian); 23, High Himalaya Crystalline (mainly metasediments, Late Proterozoic to early Paleozoic); 24, Paleozoic intrusives (Swat and Manserah Granite, Kohistan; Bhazum and Kade Granite, Ladakh); 25, Basement gneiss (dominantly Early Proterozoic orthogneiss); 26, Besham Metaigneous. Unit F Lesser Himalaya: 27, Paleozoic-Eocene cover; 28, Upper nappe, dominantly Early Proterozoic metasediments (Abbottabad, Kishtwar); 29, Lower nappe, dominantly Late Proterozoic-Paleozoic metasediments (Kishtwar, Kashmir); 30, Salt Ranges (Late Proterozoic-Eocene Indian cover). Unit G sub-Himalaya: 31, Murree and Subatu Formations (Eocene to Miocene); 32, Siwaliks (middle Miocene to Quaternary); 33, Peshawar and Srinagar intramountaneous basins (Quaternary). For seismic hazard analysis, studies of regional geological and tectonic information were collected from the available literature with requisite updates of maps wherever required.

## 6.2 TECTONIC SETTING

### 6.2.1 General

From a seismic hazard point of view, the contact zones between adjacent tectonic plates are considered to be the most vulnerable parts to generate earthquakes of varying scales and magnitudes



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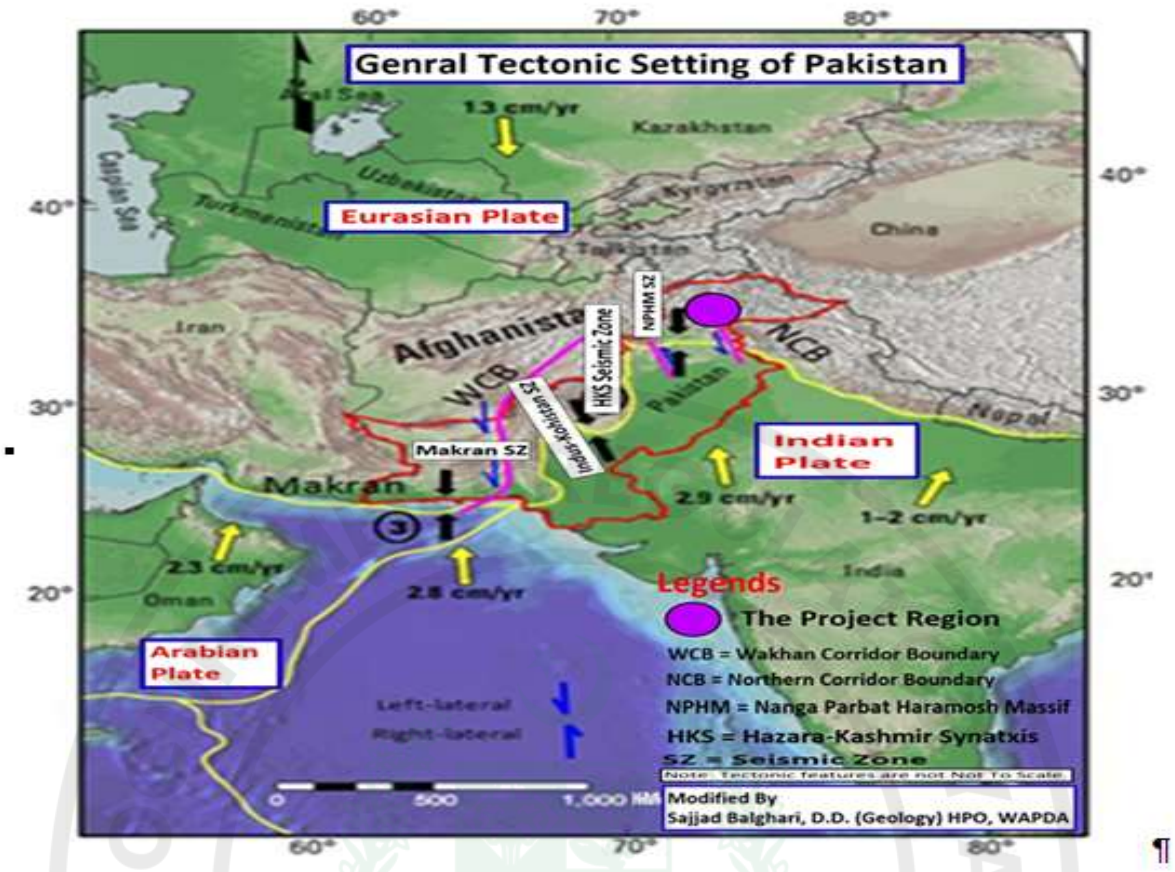


**Figure 6-3 General Tectonic Setting of Pakistan.**

ALHPP is in the proximity of the collision zone between the north moving Indian Plate and the Eurasian Plate which is over-riding the Indian Plate at a rate of 3 to 4 cm/year as shown in Figure 6-3.

## 6.3 Regional and Local Tectonic Features

### 6.3.1 General

The collision tectonics has resulted in the development of a series of geologic faults and the occurrence of frequent earthquakes in Northern Pakistan. The subduction zone of the Indian Plate beneath the Eurasian Plate has resulted in folding and thrusting of the upper crustal layers near the collisional boundary. The distribution of the modern tectonic stress field near Western Himalayan syntaxis is controlled by the collision zone of the Indian Plate and the Eurasian Plate. Due to north and north-east movement of the Indian Plate (Figure 3) in the Northern Pakistan and Kashmir Areas of Pakistan and India, the focal mechanism solution for various earthquakes reflects that the area is under principal compressive stress in the direction of NE-SW and most of the seismogenic faults are thrust fault. The thrusting has been depicted from north to south in the shape of MKT, MMT, MCT, MBT and SRT. Locations of regional and local tectonic features are shown in Figures 6-4 to 6-9.



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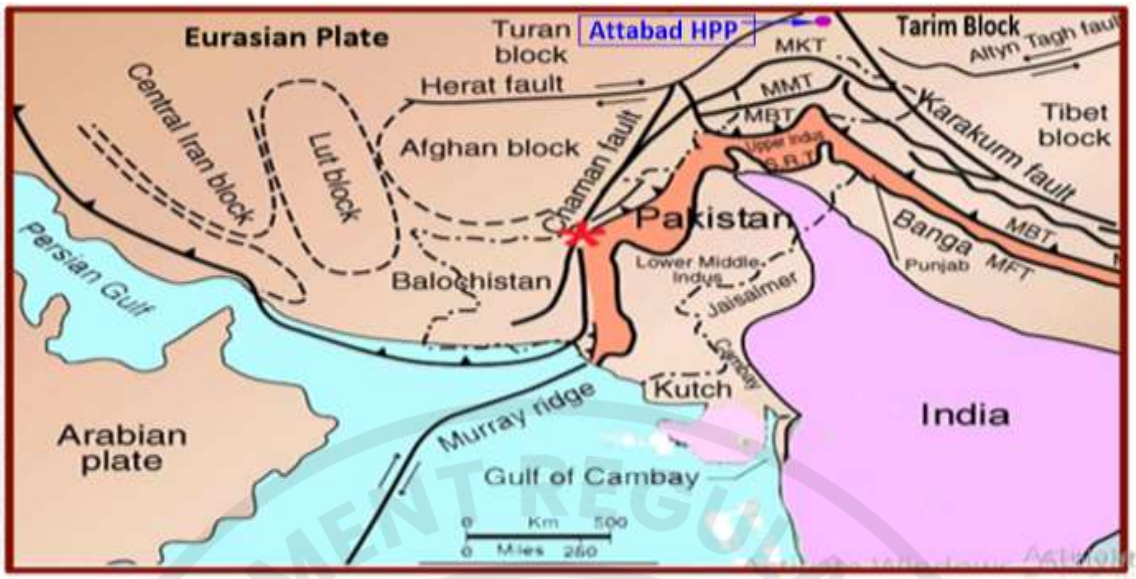


**Figure 6-4 Major Tectonic Faults of Pakistan, Pink Circle Shows the Project Area.**

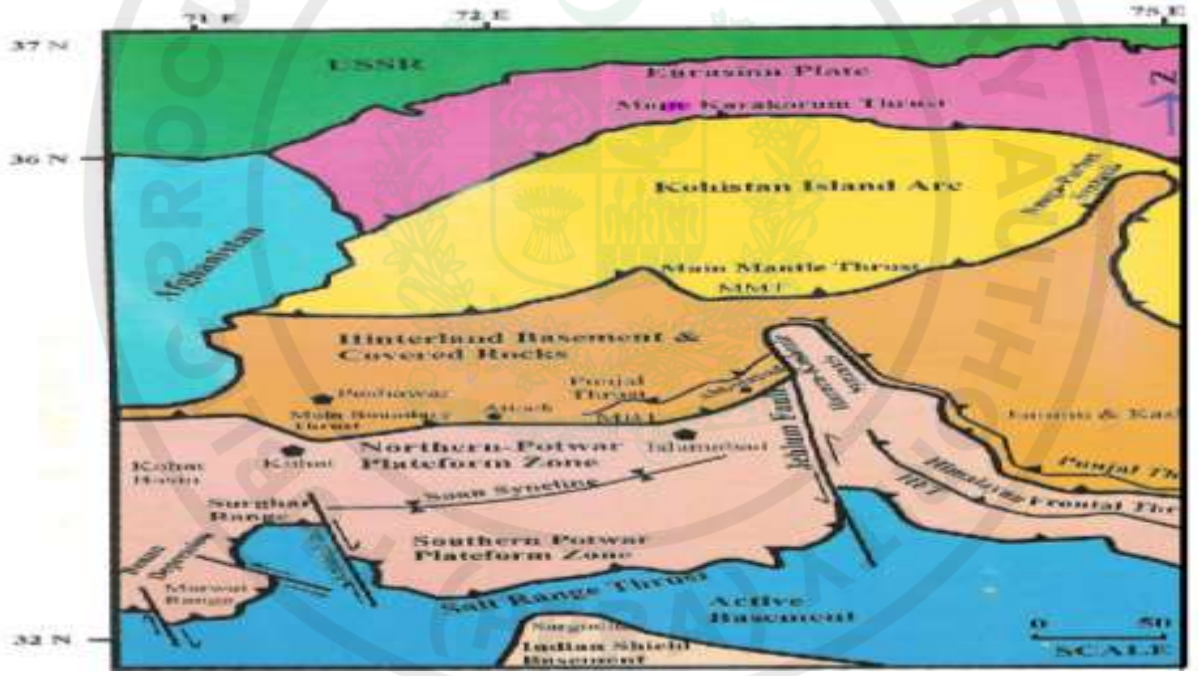


**Figure 6-5Tectonic Map of Northwestern Himalayas (Northern Pakistan)**
**(Reference: Building Code of Pakistan)**



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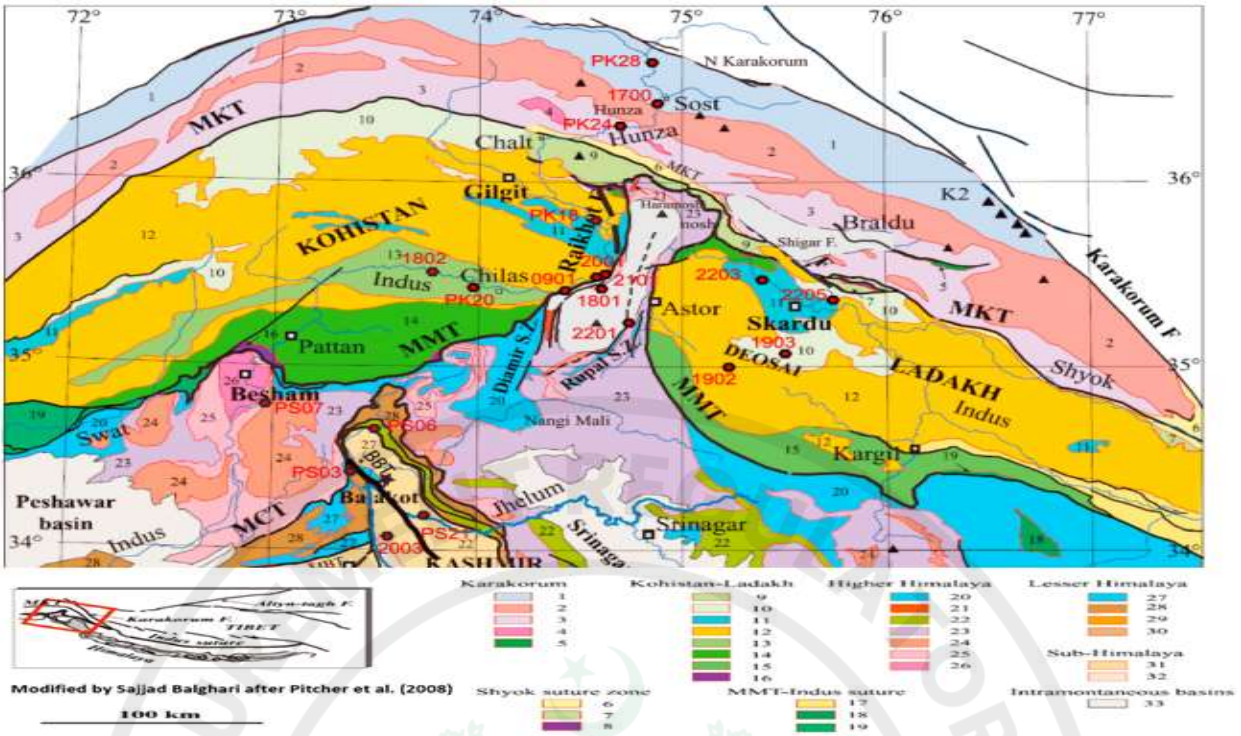


**Figure 6-6 Geological Map of Northern Pakistan.**

The major faults of region include, from North to South, the Main Karakoram Thrust (MKT), Main Mantle Thrust (MMT), Main Central Thrust (MCT), Panjal Thrust (PT), Nathia Gali Thrust (NGT), Main Boundary Thrust (MBT), Kashmir Boundary Thrust (KBT) / Himalayan Frontal Thrust (HFT) and Salt Range Thrust (SRT) and these faults are shown in Figure 6 to 8. The general trend of these faults is predominantly East-West with change in trend at places due to syntaxial bends.

The brief descriptions of these major faults are as follows: -

### 6.3.2 HUNZA FAULT (HF)

The upper HF is considered as the northern limit of Main KTF (Pitcher et al. 2008 and Desio et al. 1979) and it is present at the Project Site at a distance of about 1.4 km from the proposed intake / diversion tunnel of ALHPP. It is thrust type fault. It is considered as a major local fault to which is associated with many small local faults in the Project Area.

Although geologically the Project Area is characterized by many local faults and tectonically very disturbed area but the seismic data show that these faults are dormant due to low seismic activity with seismicity class of moderate seismicity at the site as depicted from the analysis of seismic data of the past 200 years.

### 6.3.3 MAIN KARAKORAM THRUST (MKT)

The MKT is a low angle mega-shear thrust fault with strike slip components as segmented regime at places, which passes through Chalt (near Hunza) on eastern side and extended on western side through Ishkuman and Yasin valleys into Baltistan Area in Hasupa Shigar valley, Machelu in Shyok valley and Shishi valley. In Chitral Area, it encircles the Island Arc Zone on


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the northern side. Its general trend swings between E and E-NE and dips towards the north at low to medium angle. It is 32 km away from ALHPP towards south. Some segments of this 700 km long thrust fault is seismically active.

### 6.3.4 MAIN MANTLE THRUST (MMT)

The MKT is a low angle mega-shear thrust fault with strike slip components as segmented regime at places, which passes through Chalt (near Hunza) on eastern side and extended on western side through Ishkuman and Yasin valleys into Baltistan area in Hasupa Shigar valley, Machelu in Shyok and and Shishi valleys. In Chitral area, it encircles the Island Arc Zone on the northern side. Its general trend swings between E and E-NE and dips towards the north at low to medium angle. It is 32 km away from ALHPP towards south. Some segments of this 700 km-long thrust fault is seismically active.

### 6.3.5 MAIN CENTRAL THRUST (MCT)

It is E-W trending fault separating Higher Himalayas in north and Lesser Himalayas in south, exposed in Upper Kaghan valley, Neelum valley, Northern Hazara, Swat and Dir (chaudhary et. al, 1994). Generally, it is a ductile shear zone along which a distinct break in metamorphism is observed along this thrust, toward North, metamorphism of upper amphibolites to eclogite facies took place while to the south, green schist facies are present. It is seismically active fault.

### 6.3.6 PANJAL THRUST (PT)

PT is nearly NW–SE trending fault on Eastern side, bending at 180° around Hazara Kashmir Syntaxis (HKS) and have NE-SW trend on Western side, separating Lesser Himalayan Igneous and Metamorphic Zone in the north from Sedimentary Zone in the south. It traces Eastward in Kashmir basin, at the foot hill of Pir-Panjal ranges through India and extends westward through Mansehra, Attock, Nowshera, Peshawar and Afghanistan. It is seismically active fault.

### 6.3.7 NATHIA GALI THRUST (NGT)

It is nearly NE-SW trending thrust originates from Western side of Hazara Kashmir Syntaxis (HKS) extends westward through Hazara area (well exposed in Jabri and Khanpur Area) and Kala Chitta Ranges to Afghanistan. It is low angle fault along which Tertiary rocks are in contact with Precambrian rocks (slates). It is seismically active fault.

### 6.3.8 MAIN BOUNDARY THRUST (MBT)

The MBT is the most significant and active tectonic feature of regional extent separating Lesser Himalayas in the north from Sub Himalayas in the south. It runs along the Himalayan Arc for about 2800 km from the Asam in the east to Kashmir and Parachinar in the west. MBT along with other associated thrusts forms a sharp conspicuous Hazara-Kashmir Syntaxis(HKS). This syntaxial bend is the most dominant tectonic feature of the area as all local major fault systems and geologic structures follow its trend. Near its surface trace the MBT dips Northward at a steep angle, which becomes sub horizontal with depth. The Project Area is located to the North of this fault. It is also seismically active fault.



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### 6.3.9 KASHMIR BOUNDARY THRUST / HIMALAYAN FRONTAL THRUST (KBT/HFT)

It is nearly NW-SE trending fault coming from India which become nearly NW and SE trending thrust near Kotli, joins HKS, northward with other faults in the Western epical portion. Toward south passing through Garhi Habib Ullah, Muzaffarabad, Domel and Kotli, runs eastward to India. A devastating earthquake of October 08, 2005 having magnitude 7.6 on scale is associated with rupture along this fault having epicenter, about 10 km upstream of Muzaffarabad in Gohri-da-Katha (right tributary of Neelum River).

### 6.3.10 SALT RANGE THRUST (SRT)

It is seismically active fault along which Precambrian rock e.g. SRF is exposed. It separates the Sub Himalayas from Punjab Plains. It is dissected Westward by Kalabagh Fault, a right lateral strike slip fault and eastward by Jhelum Fault, a left lateral strike slip fault.

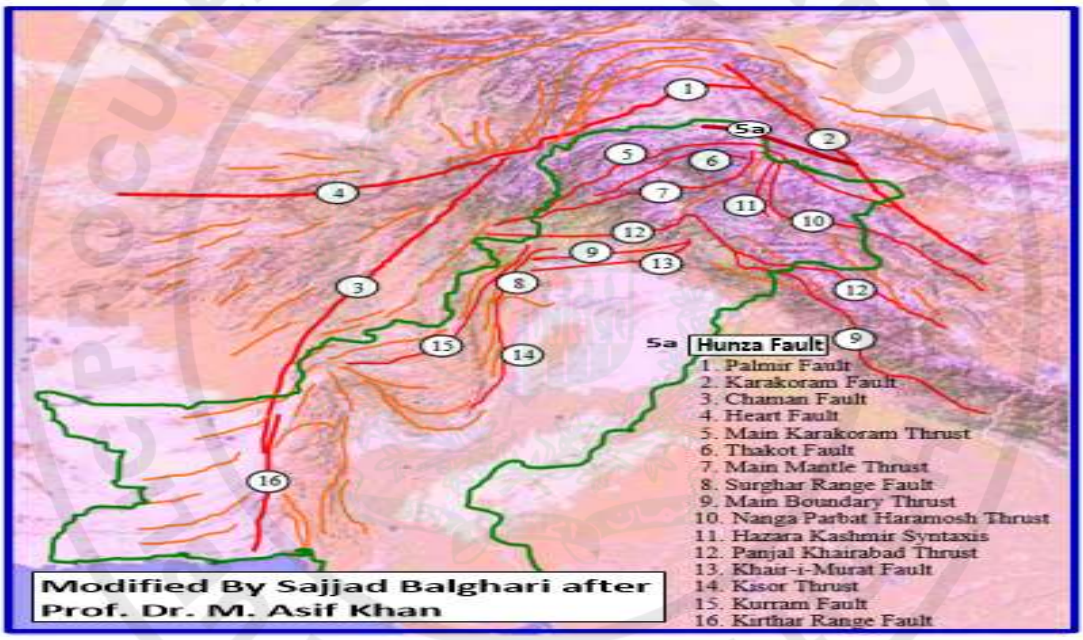


**Figure 6 -7 Faults Map of Northern Pakistan Marked on Satellite Map (Modified after Dr. Asif Khan)**



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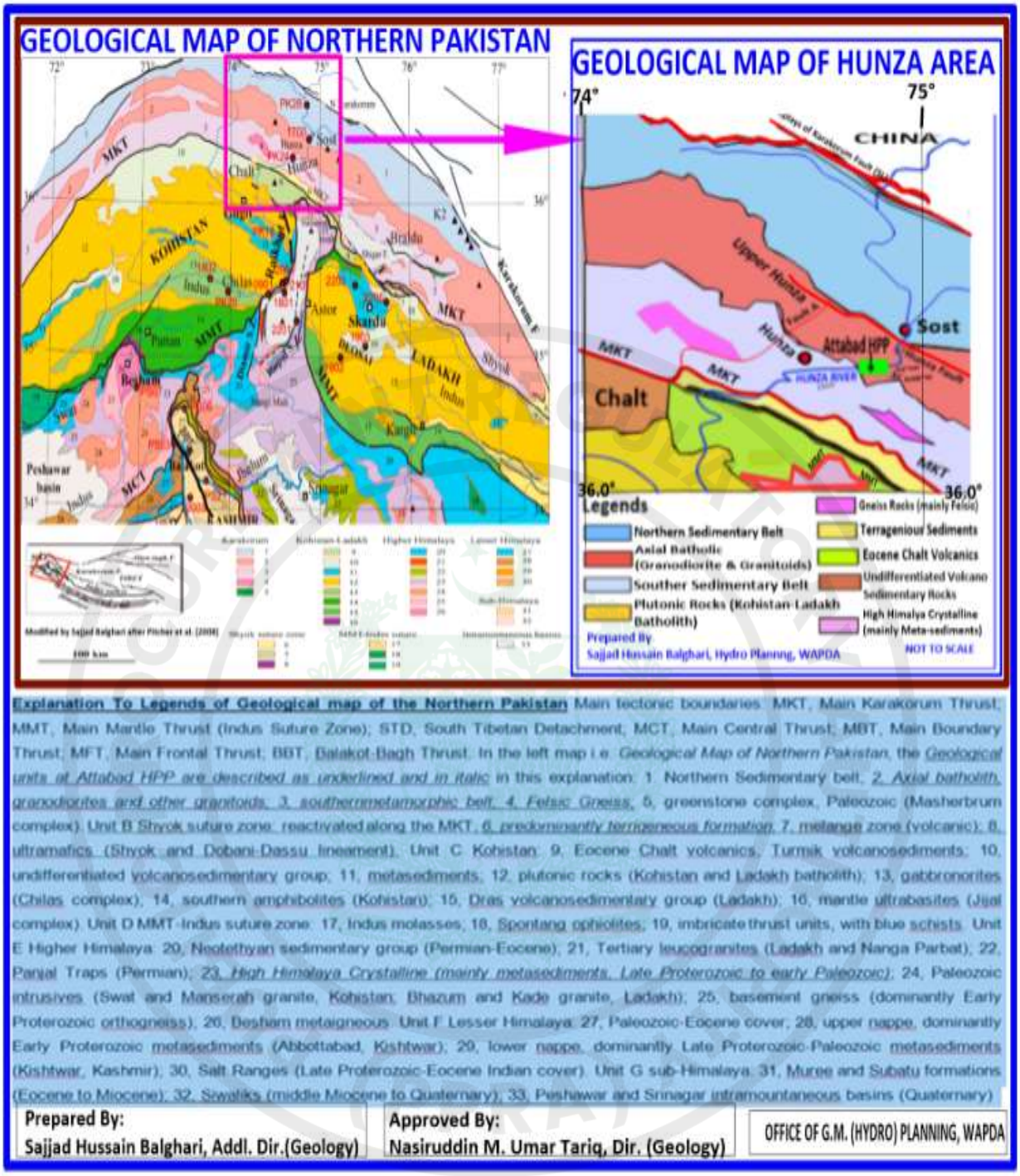


**Figure 6-8 Geological Map of Northern Pakistan and Geological Map of Hunza Area**



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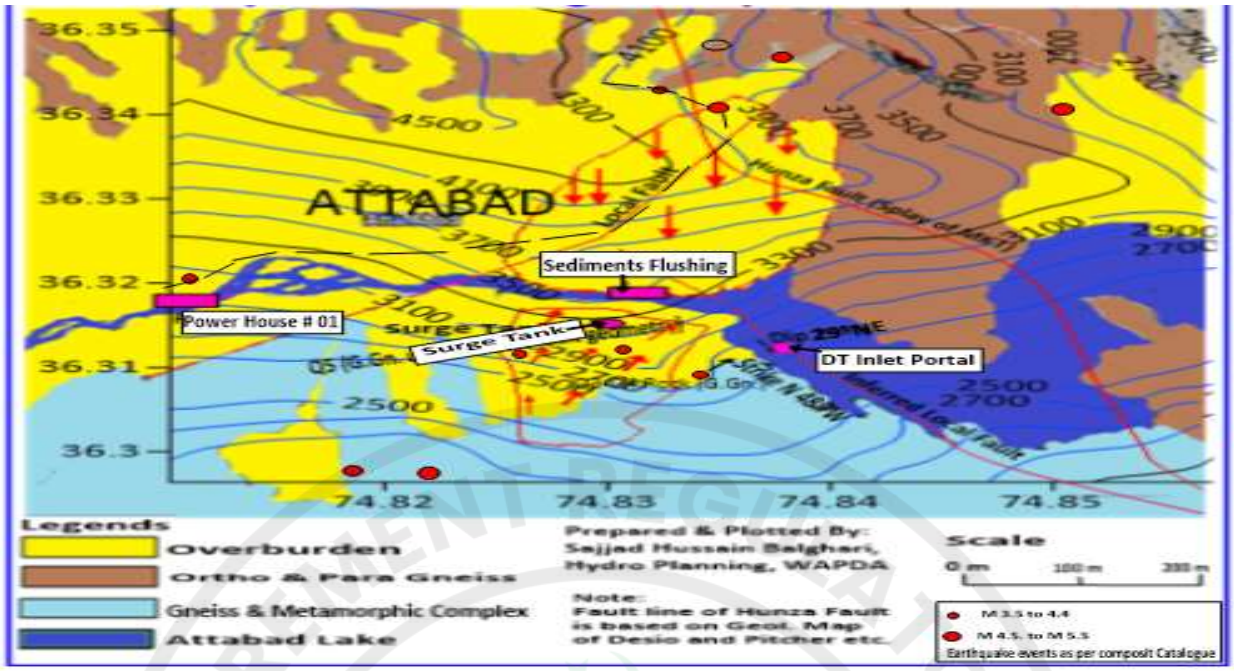


**Figure 6-9 Composite Map Showing Site Geology and Seismicity with Preliminary Project Layout.**

## 6.4 SEISMICITY OF PROJECT AREA

### 6.4.1 General

The Project Area lies in the region of Northern Pakistan which has high frequency of earthquakes especially in the Himalayan Orogenic Belt. This belt represents the contact between Indo-Pak and Eurasian Plates, which has always been the source of moderate to large earthquakes including Kangra (1905), Bihar-Nepal (1934), Assam (1897) and 2005 Kashmir earthquakes with significance consequences. The presence of some of the active faults like MKT, MMT, Raikot Fault, Riwat Fault, Panjal Khairabad Fault, Jhelum Fault and MBT etc. make the Northern Pakistan region tectonically very active. However, in this area of dominantly collisional tectonics, a large number of focal mechanism solutions indicate thrust faulting with some strike-slip faulting as segmented faulting system (Fitch, 1970; Rastogi, 1974; Armbruster et al., 1978; Verma et al., 1980; Verma and ChandraSekhar, 1986; Molnar and Lyon Caen, 1989; Pivnik and Sercombe, 1993, MonaLisa et al., 1997, MonaLisa et al., 2003 and Khwaja et al., 2003). A kinematic change from compression to transgression is believed to be taking place at places (Pivnik and Sercombe, 1993). Both historical / non instrumental and instrumental data exist in the area. The instrumentally recorded earthquake data are available only since 1904. Seismic hazard analysis involving the quantitative estimation of ground shaking hazards is of great importance for hydropower projects proposed in seismically active zones. The region selected for acquiring tele-seismic catalogues is shown as brown rectangle in the satellite map given as Figure 6-10.


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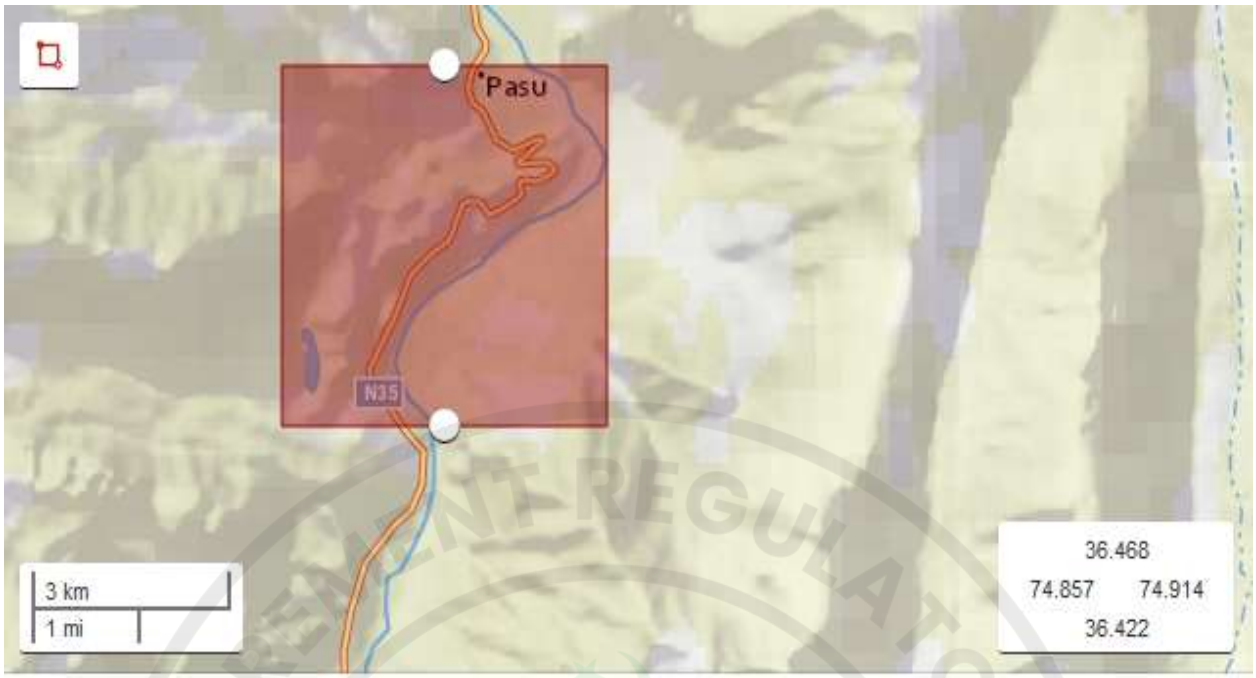


**Figure 6-10 Region Selected for Acquiring Tele-seismic Earthquakes Catalogue**

### 6.4.2 STUDY AND ANALYSIS OF EARTHQUAKES DATA

Study and analysis of the earthquake record involved several activities including;

a. Investigation of the historical seismicity
b. Acquiring earthquake catalogues both international and national catalogues including WAPDA earthquakes catalogue
c. Examination of instrumentally recorded earthquake record.
d. Statistical analysis of catalogue data and determination of standard deviation.
e. Determination of input values such as upper maximum magnitudes, minimum magnitudes, b-values, beta, lamda, rupture etc. for each seismic source.
f. Interpretative description of the new scenario after Kashmir Earthquake of October 8, 2005
g. Analysis of the earthquake records (both historical and instrumental data)
h. Preparation of seismicity maps.
i. Presentation of interpreted results including focal mechanisms etc.

Both historical and instrumetal records of earthquakes were acquired from international and national agencies for compilation of updated composite catalogue.

For seismic hazard assessment, the guidelines provided by International Commission on Large Dam (ICOLD, Bulletin 148, 2016) for selecting seismic parameters for large dams has been followed. For preparation of input maps in acceptable formats (i.e. shape files), ArcGIS and Surfer softwares were used.



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For performing seismic hazard analysis, the latest version of R-CRISIS V.20.1.1 and Ez-Frisk Software were used with a purpose of comparison of results and cross checking for validation testing.

### 6.4.3 Historical (Pre-Instrumental) Seismicity

The historical pre-instrument earthquake data for GB has been collected from the literatures and non-instrumental earthquakes catalogues such as catalogues of Oldham, 1893, Heukroth and Karim, 1970, Ambraseys et al. 1975 and Quittmeyer and Jacob, 1979 and other national and international sources as shown in Figure 6-11.

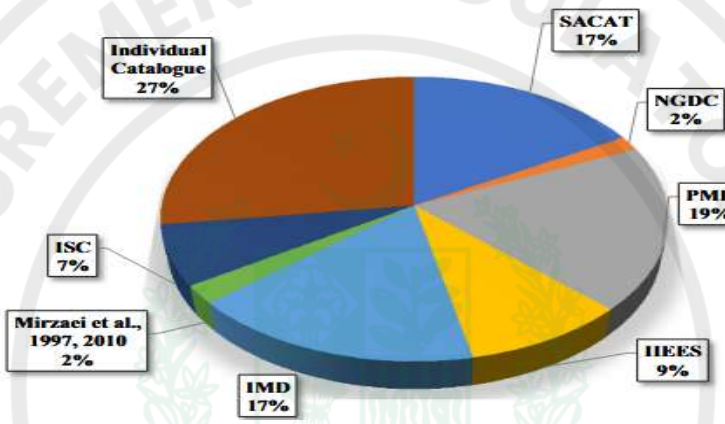


**Figure 6-11 Pie Chart of Historical Sources for Compilation of Composite Earthquake Catalogue.**

### 6.4.4 Analysis of Historical (Pre-Instrumental) Seismicity

The analysis of historical earthquake data reflects that Northern Pakistan as a whole has remained a house of prominent earthquakes but the events are sparse at the Project site (please refer to Figure 5). Taxila earthquake (25 A.D.) event is probably the most conspicuous one that had changed style of building-construction after the devastating event.

However, the catalogue of historical earthquakes for GB Region is rather sparse, mainly due to remoteness of this hilly terrain as well as non-availability of local seismic networks in the area. Since the 1700's, the historical earthquake data for GB are few and mainly concentrated on the centres of colonial administration. However, the situation is now improving as WAPDA is extending its seismic stations with the passage of time.

In the present analysis of historical earthquakes around ALHPP, the analysis of historical earthquake events was performed in Ez-Frisk Software using the historical earthquakes database and the analyzed results is presented as Figure 6-12.



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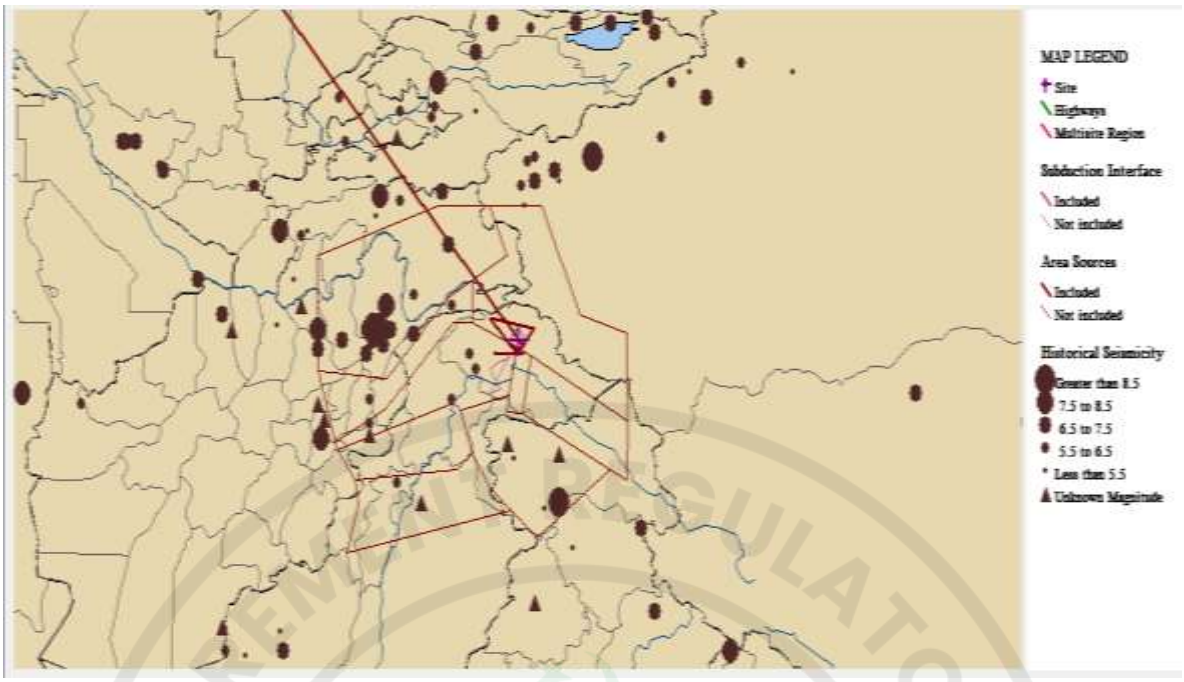


**Figure 6-12 Historical Earthquakes Map around ALHPP and Adjoining Areas Analyzed in Ez-Frisk Software.**

### 6.4.5 Instrumental Seismicity

The instrumental recording of earthquakes started in 1904 but very few seismic stations were established in the South Asian Region until the 1960's. However, with the installation of high quality seismographs under the World Wide Standard Seismograph Network (WWSSN) established by the U.S. Coast and Geodetic Survey in 1960, the quality of earthquake recording in this Region improved and resulted in a better understanding of the seismicity of Pakistan as well.

In Pakistan and most other parts of the World, the seismic record is too short and incomplete to develop a complete sample that is truly representative of the spatial and temporal distribution of earthquake shocks over a large period. Nevertheless, all the available information has been gathered for the period covering the last century, which was used to develop a satisfactory and safe assessment of seismic hazard for the Project.

For this study, the instrumental record of earthquakes within a radial distance of about 200-km of the Project was searched and acquired from both international and national sources as shown in Figure 6-13.



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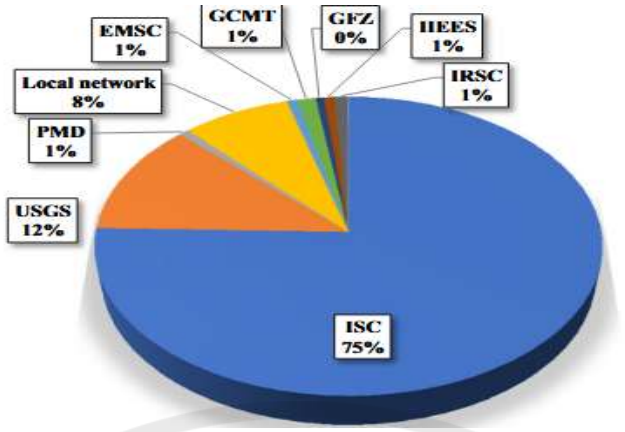


**Figure 6 -13 Pie Chart of Instrumental Sources Contributing to the Compilation of Composite Earthquake Catalogue**

### 6.4.6 Analysis of Instrumental Seismicity

The spatial and temporal distribution of the earthquakes events with magnitudes of the past 100 years at and around the ALHPP Site is shown as Figure - 14 &15. The seismicity within a 200 km radius of the Project Site were analyzed using the composite catalogue and the results are presented in Figures 6-12 to 6-18**.**

Hunza Fault exists within the Project Area at a distance of 2.4 km from weir site whereas the MKT is the second nearest fault, located at a distance 32 km from Project Site and the last limit of the MMT is at a distance of 71.69 km away from the Project Site (please refer to Figure - 2).

According to the field geologists who carried out geological mapping at the site, there are many micro faults and neotectonic features at site which shows that the Project Area is tectonically very disturbed. However, the analysis of the seismicity data (both historical and instrumental) shows that earthquake events are not concentrated in the Project Area. (please refer to Figures 6-7 to 6-12**).** The comparison and correlation of seismicity analysis with tectonic and geologic data lead to the understanding that the geologic deformations including micro faults may be viewed as deformations tectonically associated with MKT which triggered its associated splays and surrounding tectono-geologic environment in the past.



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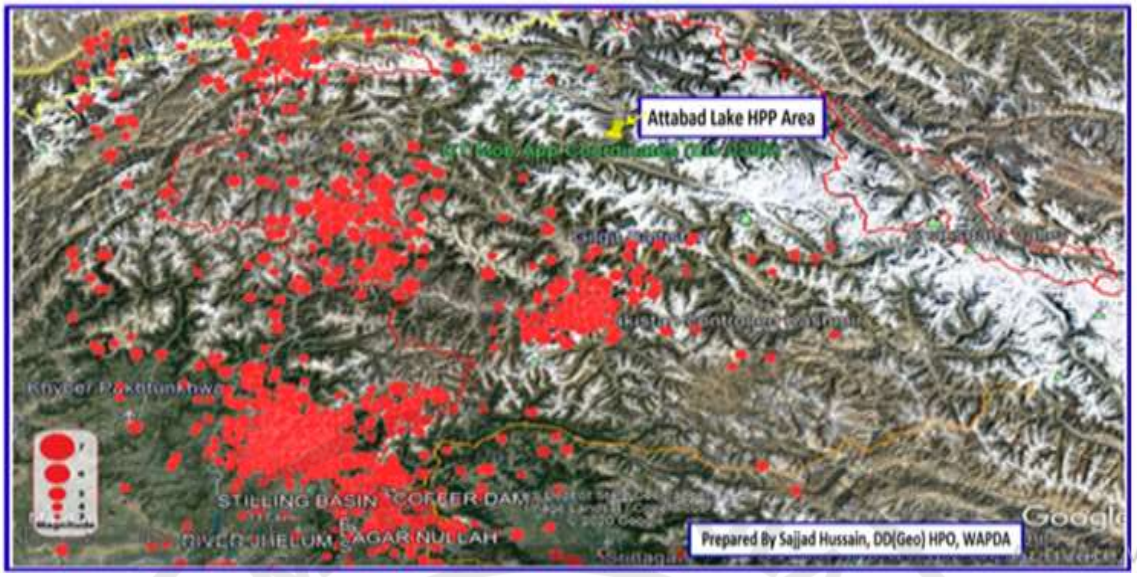


**Figure 6 14 Temporal Distribution of the Earthquakes Events with Magnitudes of the Past 100 Years, Pink Rectangle Shows ALHPP Site.**

As can be seen from instrumentally recorded earthquake events of the past 100 years data (Figure 6-14) and historical earthquakes around the Project Site (Figure 6-12) that there is very low concentration of earthquake events around the Project Site. However, if local micro-seismic network is installed at the Project Area at belated stages, more coverage and representation of the earthquakes events may result at belated stages. Analysis of the composite earthquakes catalogue data shows that the nearest magnitude at the Project Site is M4.7 and the maximum magnitude nearest to the site is M5.2. as shown in figure 6-15

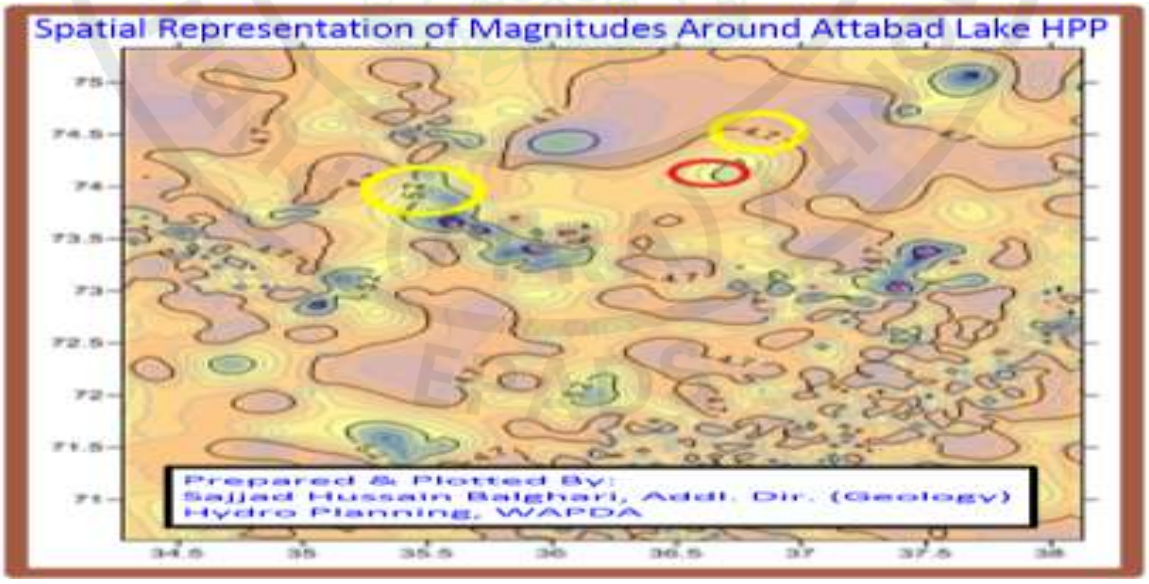


**Figure 6-15 Distribution of Earthquake Magnitudes of the Project Area (Red Circle Shows the Project Area).**

A composite map showing seismic basins of Pakistan and Hunza Area and Seismic Zonation map of Building Code of Pakistan (2007) covering historical earthquakes data is presented as


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Figure 6-16 which shows that the maximum magnitude of the Project Region (Hunza-Nagar) is M 6.1.

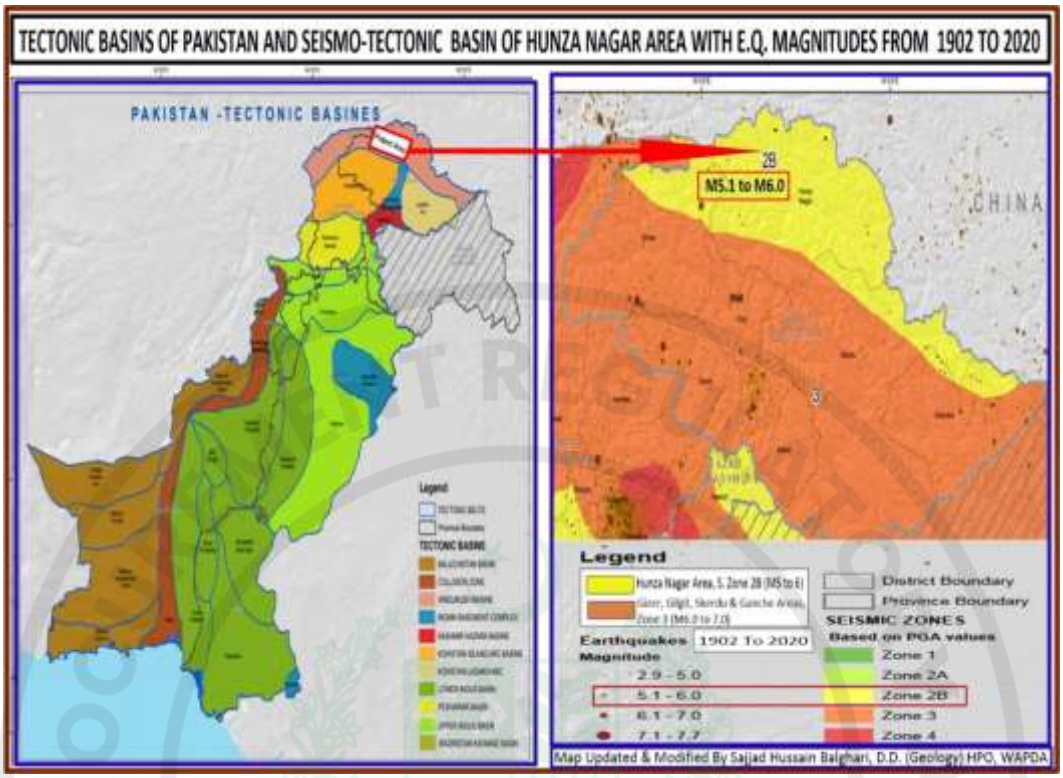


**Figure 6-16 Composite Map Showing Seismic Basins of Pakistan and Hunza Area and Modified Seismic Zonation Map (Revised Building Code of Pakistan, 2007)**

However, in the present seismic hazard analysis, the maximum magnitudes for the near-field seismic sources for the Project Site has been conservatively assigned higher in seismic hazard assessment for the Project keeping the safety factors in view as well as perceiving the tectonic scenario of Hunza Fault as a splay of MKT.

Earthquakes depth map developed from composite earthquakes catalogue data at and around the ALHPP Area is presented as Figure 6-17



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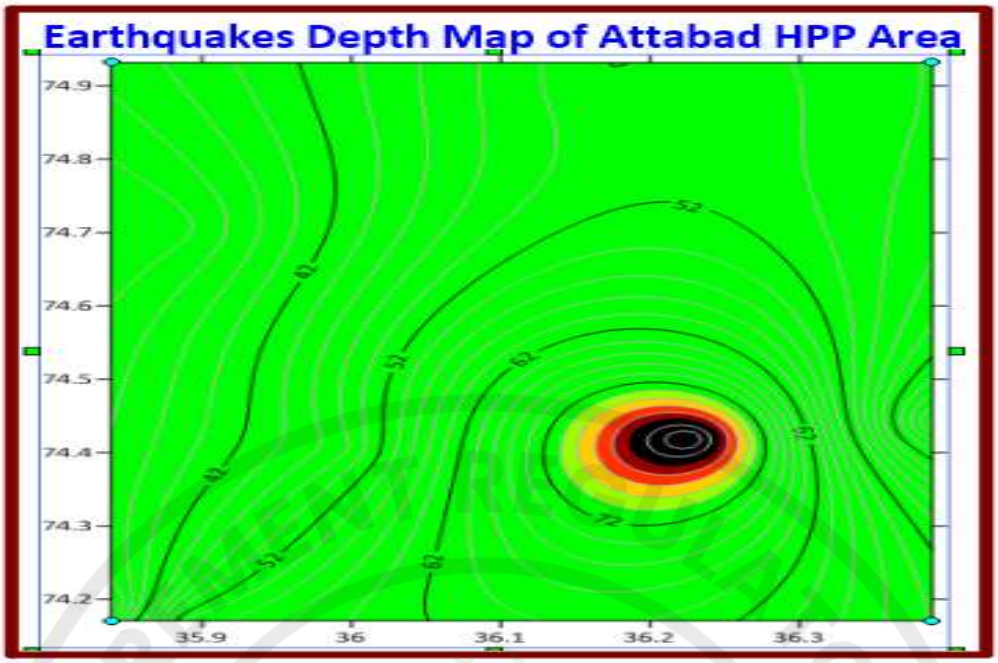


**Figure 6-17 Earthquakes Focal Depth Contour Map of ALHPP Area. The Black Circle Shows the Dam / Weir Site and the Nearest Focal Depth to the Site is 72 km.**

A composite seismic map showing both historical and instrumental earthquakes events for the past 1255 years (765 A.D. to 2020) is presented as Figure 6-18

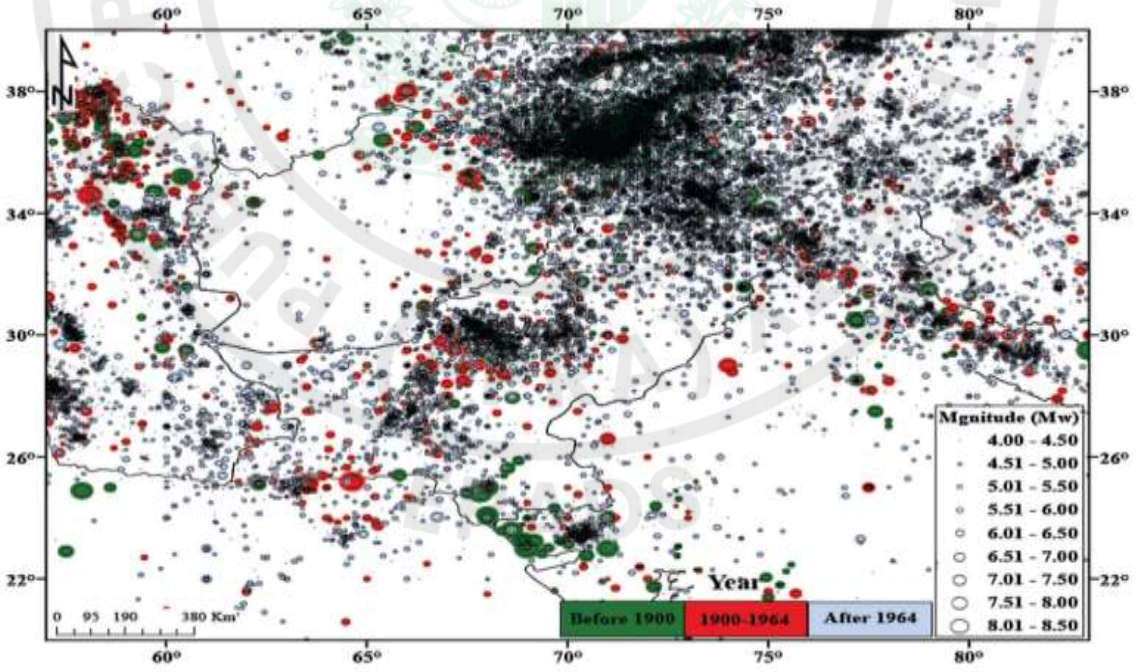


**Figure 6-18 Seismic Map Showing Events with Magnitudes of the Past 1255 Years (765 A.D. to 2020).**

### 6.4.1 Conversion of Magnitudes and Standard Deviation

The earthquakes reporting agencies have given a variety of magnitudes viz: Body-wave magnitude ($m_b$), Surface-wave magnitude ($M_S$), Richter/Local magnitude ($M_L$) or Duration-



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magnitude ($M_D$) etc. Since ground motion prediction equations are based on magnitude of given type, a single type must be selected. For data to be used in seismic hazard analysis, all these different magnitudes were converted to moment magnitude ($M_W$) by the following equations.

Conversion from $M_S$ and $m_b$ to $M_W$ was achieved through latest equation suggested by Scordilis (2006):

$M_W = 0.67\ M_S + 2.07$ for $3.0 \leq M_S \leq 6.1$

$M_W = 0.99\ M_S + 0.08$ for $6.2 \leq M_S \leq 8.2$

$M_W = 0.85\ m_b + 1.03$ for $3.5 \leq m_b \leq 6.2$

For $M_L$ up to 5.7, the value of $M_L$ was taken equal to $M_W$ as suggested by Idriss (1985) and supported by operators of local networks in Pakistan. Conversion of $M_L$ to $M_W$ beyond magnitude 5.7 was done by using the following equations suggested by Ambraseys and Bommer (1990) and Ambraseys and Bilham (2003):

$0.82\ (ML) - 0.58\ (MS) = 1.20$

$\text{Log Mo} = 19.09 + MS$ for $MS < 6.2$

$\text{Log Mo} = 15.94 + 1.5\ MS$ for $MS > 6.2$

$MW = (2/3)\ \text{Log}\ (Mo) - 10.73$

Where $m_b$ is body–wave magnitude, $M_S$ is surface-wave magnitude, $M_L$ is local magnitude, All available types of magnitudes in the catalogue were converted into a uniform magnitude-scale i.e. $M_W$ (Moment magnitude). Observed dependence of σ (standard deviations) on Moment Magnitudes is given is Figure 19. The earthquakes reporting agencies have given a variety of magnitudes viz: Body-wave magnitude ($m_b$), Surface-wave magnitude ($M_S$), Richter/Local magnitude ($M_L$) or Duration-magnitude ($M_D$) etc. Since ground motion prediction equations are based on magnitude of given type, a single type must be selected. For data to be used in seismic hazard analysis, all these different magnitudes were converted to moment magnitude ($M_W$) by the following equations.

Conversion from $M_S$ and $m_b$ to $M_W$ was achieved through latest equation suggested by Scordilis (2006):

$M_W = 0.67\ M_S + 2.07$ for $3.0 \leq M_S \leq 6.1$

$M_W = 0.99\ M_S + 0.08$ for $6.2 \leq M_S \leq 8.2$

$M_W = 0.85\ m_b + 1.03$ for $3.5 \leq m_b \leq 6.2$

For $M_L$ up to 5.7, the value of $M_L$ was taken equal to $M_W$ as suggested by Idriss (1985) and supported by operators of local networks in Pakistan. Conversion of $M_L$ to $M_W$ beyond magnitude 5.7 was done by using the following equations suggested by Ambraseys and Bommer (1990) and Ambraseys and Bilham (2003):

$0.82\ (ML) - 0.58\ (MS) = 1.20$

$\text{Log Mo} = 19.09 + MS$ for $MS < 6.2$



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Log Mo = 15.94 + 1.5 MS  for MS > 6.2

MW = (2/3) Log (Mo) – 10.73

Where $m_b$ is body–wave magnitude, $M_S$ is surface-wave magnitude, $M_L$ is local magnitude, All available types of magnitudes in the catalogue were converted into a uniform magnitude-scale i.e. $M_W$ (Moment magnitude). Observed dependence of ϭ (standard deviations) on Moment Magnitudes is given is Figure 6-19

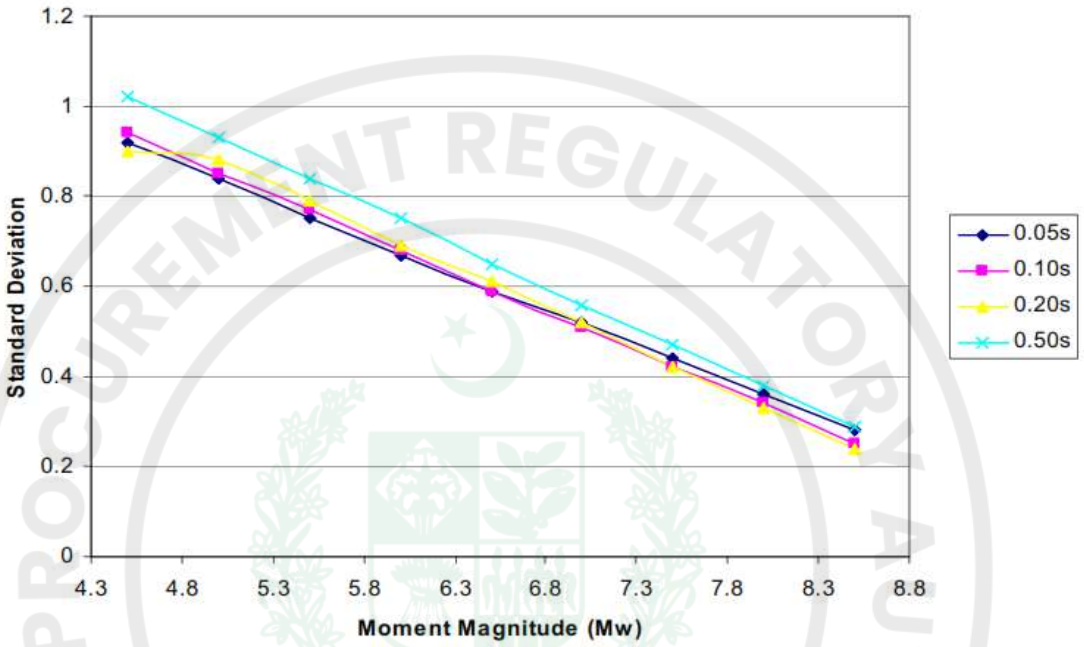


**Figure 6-19 Standard Deviations (ϭ) Vs Moment Magnitudes (Mw).**

### 6.4.2 Kashmir Earthquake (M 7.6) of October 08, 2005 and the New Scenario

The powerful earthquake with a magnitude of $M_W$ =7.6 that struck the northern part of Pakistan and Kashmir on October 08, 2005, caused widespread damage in Azad Kashmir and adjoining areas of KPK. This prompted for consideration of re-activation of previously perceived dormant faults segments as active fault segments in the new scenario.

The epicenter of this earthquake was located northeast of Muzaffarabad. This earthquake was felt for several minutes in Pakistan, northern India, and Afghanistan. The heaviest damage was recorded in the towns of Balakot, Batal, and Batagram in KPK and Muzaffarabad, Bagh and Rawalakot in Azad Kashmir where the entire population was badly affected. Building collapse were also reported in Muzaffarabad, Mansehra, Abbottabad, and Islamabad. Severe cracks were observed in many high-rise buildings in Islamabad too. The death toll due to this earthquake exceeded 80,000 people and millions were rendered homeless due to collapse of houses. The earthquake was followed by a series of more than thousand aftershocks, hundreds of them exceeding magnitude M 4.0. This earthquake was caused by the movement due to rupture along a thrust fault named the “Balakot-Bagh Thrust” (BBT) which is a northern most branch of the MBT like Riasi Thrust, a main branch of the MBT in Kashmir as shown in Figure 6-20. Ground ruptures and fresh landslides have been observed along this fault at many places near Muzaffarabad and Balakot.



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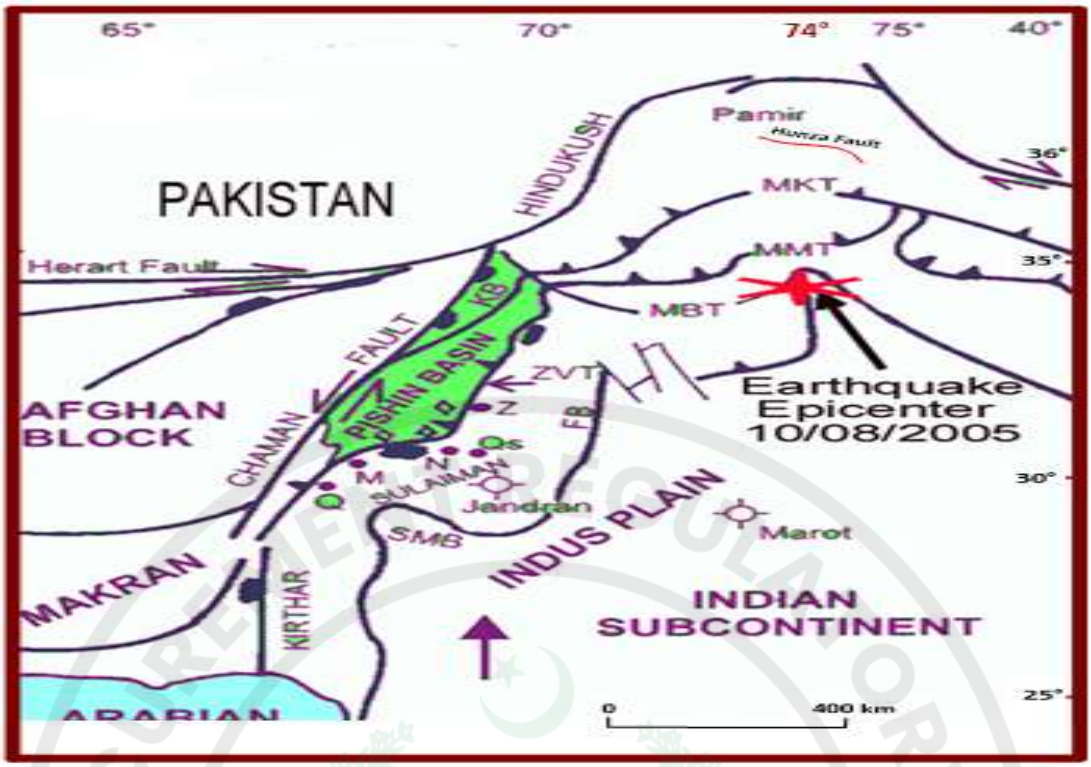


**Figure 6-20 Earthquake Epicenter of Kashmir Earthquake of October 8, 2005.**

Thus, the Kashmir earthquake of 8th October, 2005 has changed the scenario of seismic design in Pakistan and prompted for design review of Neelum Jhelum Hydropower Project where MBT and Panjal Thrust are crossing the dam area. These two faults were previously considered as dormant faults. After the earthquake of 8th October, 2005, these two faults were considered as active faults and seismic design parameters were reviewed and changed to the much safer side resulting in massive cost overruns. The new scenario also prompted to revise Building Code of Pakistan which was revised and updated in 2007 accordingly thereby enhancing the design parameters in the new scenario. Hence, previously adopted design codes and parameters were considered as under estimated and began to enhance the safety factors in seismic design for buildings and ordinary structures in Pakistan. In the wake of the new scenario seismic design parameters of dams and water retaining structures are also being given due importance towards conservative sides.

Since the revision of Next Generation Attenuation relations by Pacific Earthquakes Engineering Research Center (PEER) of USA in 2014, seismic safety factors are being given due considerations as per ICOLD's Revised Guidelines given in Bulletin 148 (2016).

The present analysis is in line with these national and global developments. In the present seismic hazard analysis, the latest ground motion prediction equations known as NGA West 2 Attenuation Relations (2014) have been used and the latest version of R-CRISIS software Ver 20.1.1. and Ez-Frisk Ver 7.65 have been used for seismic hazard analysis of ALHPP.


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## 6.5 INDENTIFICATION OF SEISMIC SOURCES

Based on the understanding of the analysis of seismicity, tectonic setting, major faults of the area and area-seismic related seismogenic features within 200 km radial distance of the Project Site, the area seismic sources for the Project include Karakorum Seismic Zone, Nanga Parbat-Haramosh Seismic Zone, Western Himalayas Seismic Zone, Hindukush Seismic Zone, Kashmir Himalayas Seismic Zone and Kohistan Seismic Zone.

The significant point seismic sources (faults) capable of generating earthquakes for ALHPP, include;

a. Hunza Fault (Thrust Fault)
b. Main Karakoram Thrust (MKT),
c. Main Mantle Thrust (MMT)

The area seismic sources within a radial distance of 200km include

Quantitative features of these controlling faults are given in tabulated form in Table 1.

**Table 6-1 The Controlling Faults with Quantitative Features (input values of DSHA)**

| Controlling Faults | Fault Type | Fault Rupture Length (km) | Distance (km) | Maximum Magnitude Potential | |
|---|---|---|---|---|---|
| | | | | As per Catalogue data | Conservatively Assigned |
| Hunza Fault | Thrust | 5 inferred | 1.4 | 6.1 | 6.7 |
| MKT | Thrust | 200 | 32 | 7.0 | 7.6 |
| MMT | Thrust | 260 | 71.69 | 6.9 | 7.6 |

Brief description of the seismogenic sources for the Project is given below,

### 6.5.1 HUNZA FAULT (HF)

The upper HF is considered as a splay fault of MKT (Pitcher et al. (2008) and as the northern limit of MKT (Desio 1979). It is present at the Project Site at a distance of about 1.4 km from the proposed intake / diversion tunnel of ALHPP (Figure 2). It is thrust type fault. Associated with HF, there are many small local faults with unknown fault parameters such as rupture length etc. in the area. Presence of HF and many minor local faults along with some neotectonic features as reported by site geological mapping indicate that the fault is active. However, analysis of tele-seismic data for the last 100 years shows that the Project Area has low concentration of earthquake events with seismicity class of low to moderate seismicity and there has been no earthquake activity greater than magnitude 5.2 as per analysis of composite catalogue.



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### 6.5.2 MAIN KARAKORUM THRUST (MKT)

The MKT is a low angle mega-shear thrust fault with strike slip components as segmented regime at places, which passes through Chalt (near Hunza) on eastern side and extended on western side through Ishkuman and Yasin valleys into Baltistan Area in Hasupa Shigar valley, Machelu in Shyok valley and and Shishi valley. It encircles the Island Arc Zone on the northern side in Chitral Area. Its general trend swings between E and E-NE and dips towards the north at low to medium angle.

MKT is located at a distance of 32 km from ALHPP towards south (Figure 6-2). Some segments of this 700km-long thrust fault is seismically active.

### 6.5.3 MAIN MANTLE THRUST (MMT)

The MMT, which is aligned with the Nanga Parbat-Haramosh Massif (NPHF) tectonically, spans over an area of about 400 km through Diamer, Kohistan, and Bajour, before entering Afghanistan. The general trend of MMT is NE-SW. It is located along the contact of the mafic/calc-alkaline meta igneous rocks and the meta-sediments belonging to the Indo-Pakistan continental mass. Along this megashear near Jijal village on Indus River (right bank), the igneous rocks have overthrusted the meta-sediments to the south over a 10-15 km wide zone. The thrust also manifests as the broad high topography of Kohistan relative to the Hazara to the south. In addition, numerous auxiliary fractures were developed and across the thrust frequent brecciation and mylonitization are also present along the contact. Some segments of MMT is seismically active. Due to its seismic activity and tectonic impacts, this fault has also been considered in seismic hazard assessment of ALHPP.

The last limit of MMT nearest to the Project Area is located at a distance of 71.69 Km from ALHPP (Figure 6-2).

The above mentioned faults have been used in DSHA approach. However, in PSHA approach, area seismic sources have been used in the present study, being more reliable as compared to point sources.

The used area seismic sources include Karakorum Seismic Zone, Nanga Parbat-Haramosh Seismic Zone, Western Himalayas Seismic Zone, Hindukush Seismic Zone, Kohistan Seismic Zone and Kashmir Himalayas Seismic Zone.

## 6.6 SEISMOTECTONICS

From the available tectonic and seismic data, seismo-tectonic analysis of ALHPP was done. Seismo-tectonic map of ALHPP and Northern Pakistan showing the seismic concentrations over active seismic sources have been developed and are presented as Figures 6-21 and 6-22.



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**Figure 6-21 Seismo-Tectonic Map of the Project Area. Rectangle Shows the Project Area.**

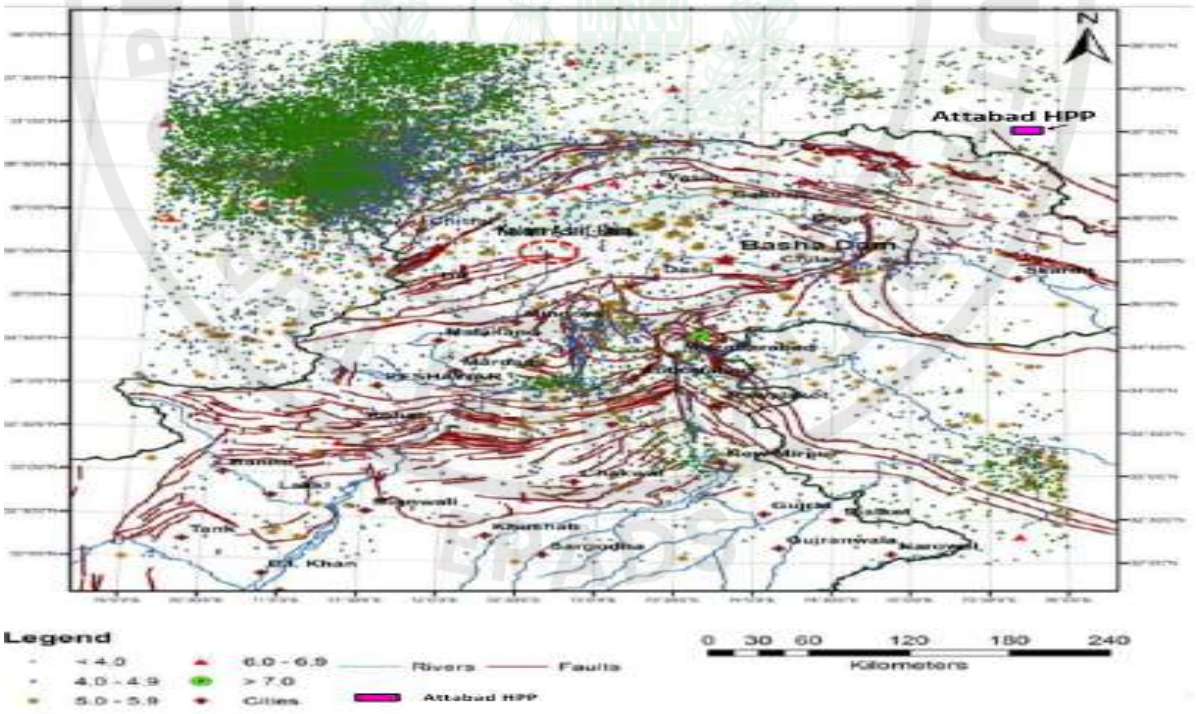


**Figure 6-22 Seismo-Tectonic Map of Northern Pakistan Showing Project Area.**

## 6.7 PROBABILISTIC SEISMIC HAZARD ASSESSMENT (PSHA)

### 6.7.1 PSHA Methodology



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The principle of the analysis, first developed by Cornell (1968) and later refined by various researchers, is to evaluate at the site of interest the probability of exceedance of a ground motion parameter (e.g. acceleration) due to the occurrence of a strong event around the site. This approach combines the probability of exceedance of the earthquake size (recurrence relationship), and probability on the distance from the epicenter to the site. Each seismic source zone is divided into elementary source zones at a certain distance from the site. Integration is carried out within each zone by summing the effects of the various elementary source zones taking into account the attenuation effect with distance. Total hazard is finally obtained by adding the influence of various sources. The results are expressed in terms of a ground motion parameter associated with return period (return period is the inverse of the annual frequency of exceedance of a given level of ground motion). The seismic hazard model used in the present analysis was developed based on both area source as well as fault sources in the light of findings of the seismotectonic synthesis. Each seismic source zone is defined as a zone with homogenous seismic and tectonic features, inferred from geological, tectonic and seismic data. These zones are first defined, and then a maximum earthquake and an earthquake recurrence equation are elaborated for each of these seismic source zones. The present work is the first of its kind in which both NGA West 1 and NGA West 2 ground motions equations have been used for seismic hazard assessment of ALHPP.

The seismic parameters attached to the various seismic source zones are: a recurrence relationship relating the number of events for a specific period of time to the magnitude; the maximum earthquake giving an upper bound of potential magnitude in the zone; and an attenuation relationship representing the decrease of acceleration with distance. The PSHA requires a detailed analysis of distribution of observed seismic data to the seismic sources, determination of b-value and activity rate of each seismic source and assigning maximum magnitude potential to each seismic source.

### 6.7.2 Earthquake Recurrence Model

A general equation that describes earthquake recurrence may be expressed as follows:

$$N(m) = f(m, t) \qquad (1)$$

Where N (m) is the number of earthquakes with magnitude equal to or greater than m, and t is time period.

The simplest form of equation (1) that has been used in most engineering applications is the well-known Richter's law which states that the cumulated number of earthquakes occurred in a given period of time can be approximated by the relationship

$$\text{Log } N(m) = a - b\,m \qquad (2)$$

Equation (2) assumes spatial and temporal independence of all earthquakes, i.e. it has the properties of a Poisson model. Coefficients 'a' and 'b' can be derived from seismic data related to the source of interest. Coefficient 'a' is related to the total number of events occurred in the source zone and depends on its area, while coefficient 'b' represents the coefficient of proportionality between log N (m) and the magnitude.



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The composite catalogue of earthquakes prepared for the ALHPP Area provided the necessary database for the computation of b-value for each seismic area source zone. The composite earthquake list contains limited number of earthquakes prior to 1960 and only few of these earthquakes have been assigned magnitude values. Due to installation of WWSSN, the earthquake recording in this region improved and a better and complete recording of earthquake data are available after 1960. The completeness analysis of the overall data for the region showed that earthquake data up to magnitude 4.0 is complete after 1960.The converted moment magnitude for the period between 1961 and 2020 was therefore used in the PSHA after excluding the aftershocks. Magnitude-frequency curves were made for each seismic area source and presented as Figure-23. The b-value for each seismic area source zone was calculated using linear regression through least square method. The minimum magnitude for each area source zone was selected from the magnitude-frequency curve based on completeness checks suggested by Woeffner and Weimer (2005). The b–values, minimum magnitude and the activity rates for the seismic area source zones used in the PSHA are shown in Table 6-2.



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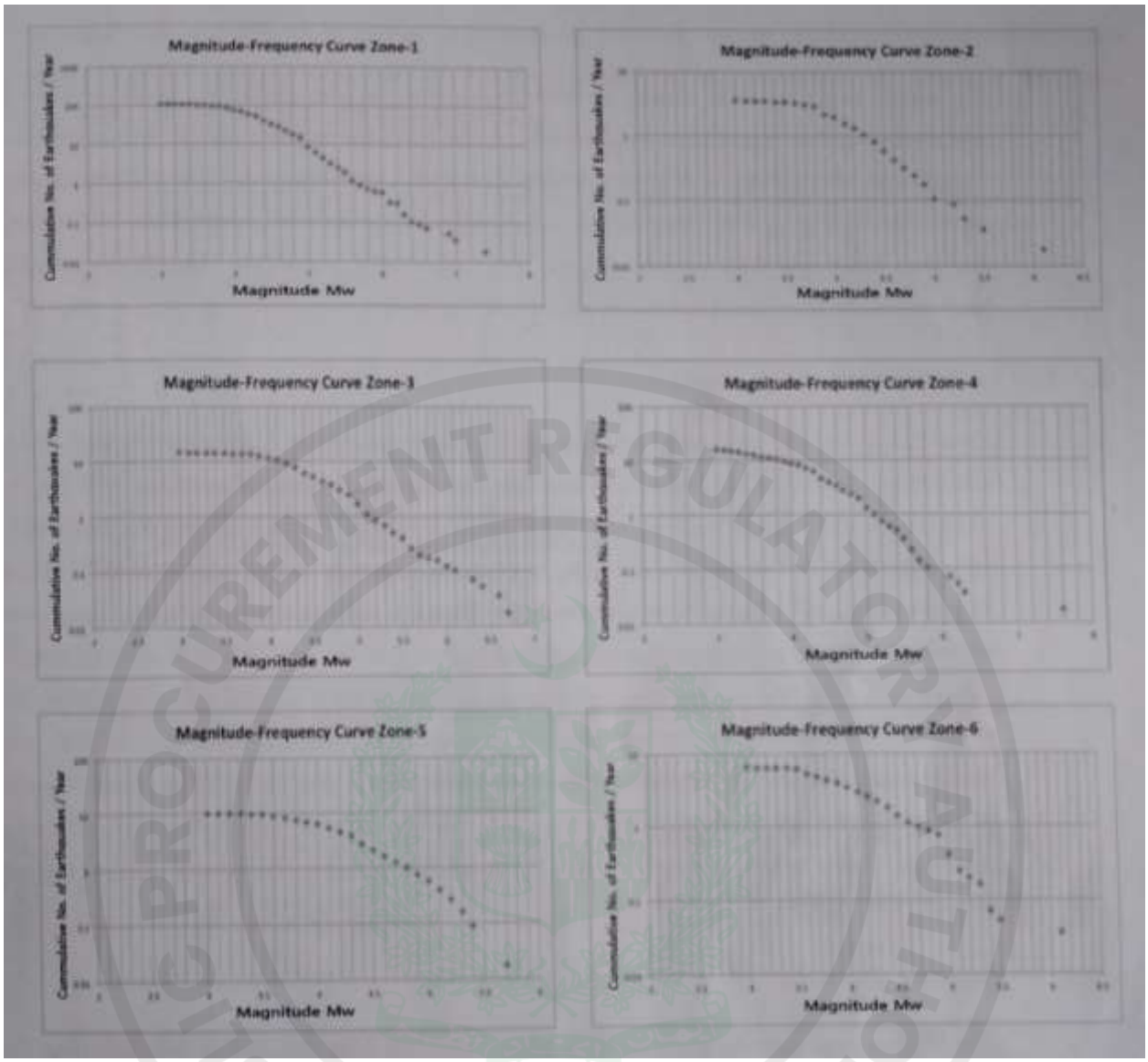


**Figure 6-23 Magnitude-Frequency Curves of Seismic Sources.**

### 6.7.3 Activity Rate of Seismic Sources

Activity rate of seismic sources have been worked out using Ez-Frisk software and the results of the analysis are shown in Figure 6-24.



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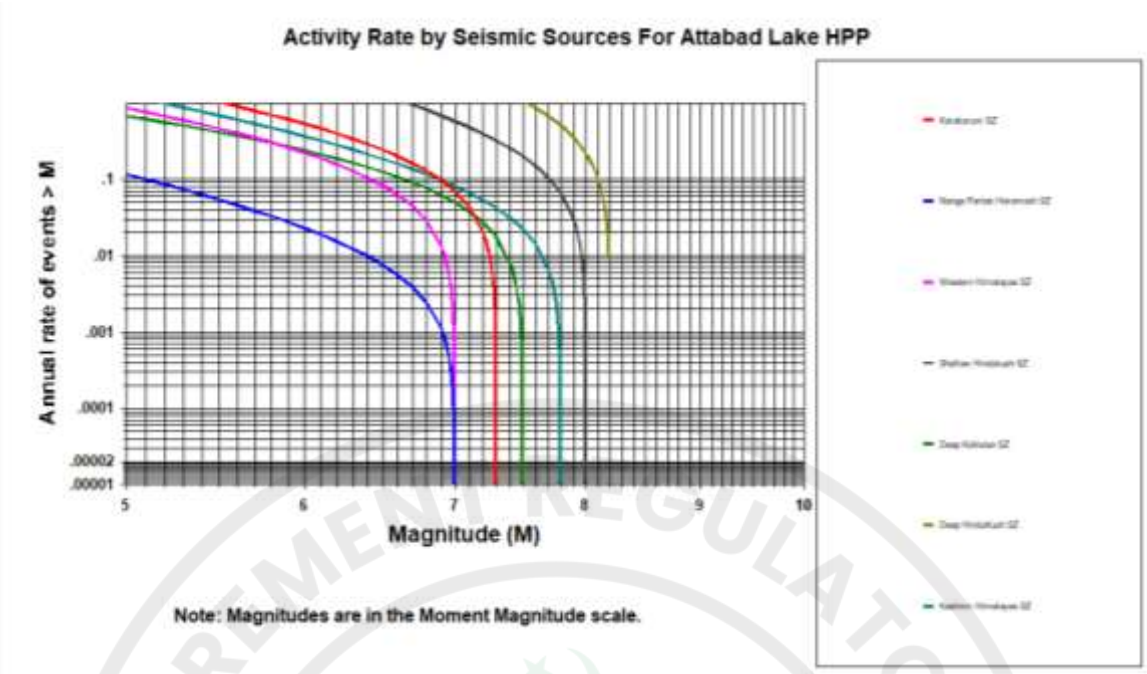


**Figure 6-24 Activity Rate by Seismic Sources for ALHPP Area.**

### 6.7.4 Maximum Magnitude

To each seismic source zone, a maximum magnitude potential was assigned based on the maximum observed seismicity in the historical seismic record and enhancing by 0.5 magnitude the maximum observed magnitude in the instrumental seismic record for that area seismic source zone and also determining the maximum magnitude of the longest active fault in the area using Well & Coppersmith equation (1994). The maximum potential magnitude used for each seismic area source zone is given in Table 6-1 and 6-2.

### 6.7.5 Ground Motion Prediction Equations

A number of ground motion prediction equations have been developed from strong motion database collected by USGS and Pacific Earthquake Engineering Research (PEER) Centre, USA. The latest ground motion prediction equations developed by PEER well known as Standard Five Sets of Next Generation Attenuations (NGA) West 2 have been used in the present analysis for ALHPP.

### 6.7.6 Seismic Sources Modeling

On the basis of tectonic, geologic and seismic characteristics, the following area source models within a radial distance of 200 km have been worked out and the same have been used as input parameters in PSHA for ALHPP.



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**Table 6-2 Seismic Source Zones Parameters for PSHA**

| Source Zone No. | Seismic Source Zone Name | Minimum Magnitude Mw | Activity Rate / Year | b-Value | Maximum Magnitude Mw |
|---|---|---|---|---|---|
| 1 | Karakorum Seismic Zone | 4.0 | 1.929 | 1.120 | 7.3 |
| 2 | Nanga Parbat Seismic Zone | 4.2 | 1.112 | 1.101 | 7.0 |
| 3 | Western Himayan Seismic Zone | 4.1 | 5.339 | 1.44 | 7.0 |
| 4 | Hindukush Seismic Zone | 4.2 | 59.107 | 1.20 | 8.0 |
| 5 | Kashmir Himalaya SZ | 4.2 | 7.143 | 1.13 | 7.8 |
| 6 | Kohistan SZ | 4.1 | 10.500 | 1.07 | 7.5 |

Each of these area sources were assigned a maximum magnitude based on recorded seismicity and potential of the faults within the zone and a minimum magnitude based on threshold magnitude observed in the magnitude-frequency curve for the source zones (Figure - 23). As the shallow earthquakes are of more concern to seismic hazard, the minimum depth of the earthquakes is taken as 5 km for all area sources.

The source zone parameters used in deterministic approach is given in Table 6 - 1 and seismic sources parameters for PSHA for the ALHPP are presented in Table 6 - 2.

As the description of all these area seismic sources is found in already published literatures, therefore, their repetition has been avoided here for the sack of conciseness and brevity of the report.

## 6.8 RESULTS OF PROBABILISTIC HAZARD ANALYSIS

Both PSHA and DSHA were carried out using EZ-FRISK software Version 7.65 developed by Risk Engineering Inc. USA. The latest version of R-CRISIS Software Version 21.1.1 developed by PEER, USA was also used during the current study. The purpose of using both softwares was to cross check the validation comparing the quality of the seismic hazard analysis of the two software for the Project. During the study it was found that Ez-Frisk software is more standardized as compared to R-CRISIS software in quality of analysis as well as the smart outputs of the analyzed results. Therefore, Ez-Frisk software has been preferred and used in the in the final analysis.

Important input parameters used in probabilistic approach are presented in Table - 2. It is assumed that weir/dam foundation will mainly be placed on gravelly soil (alluvium), therefore, the site condition was taken as gravelly soil with average shear wave velocity at 30 meters



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depth ($V_{s30}$) of 450 m/sec for soil site (alluvium) and 760 m/s for rock sites. The mean total hazard curve was obtained by giving equal weighting to all the Five NGA W2 Ground Motion Prediction Equations. The analyzed results of PSHA are presented in Figures 6-23 to 6-27.

The total hazard curve obtained for the Project Area is shown as Figure - 25 and the total mean Hazard Spectra showing combination of all used Ground Motion Prediction Equations for ALHPP is presented as Figure 6-26.

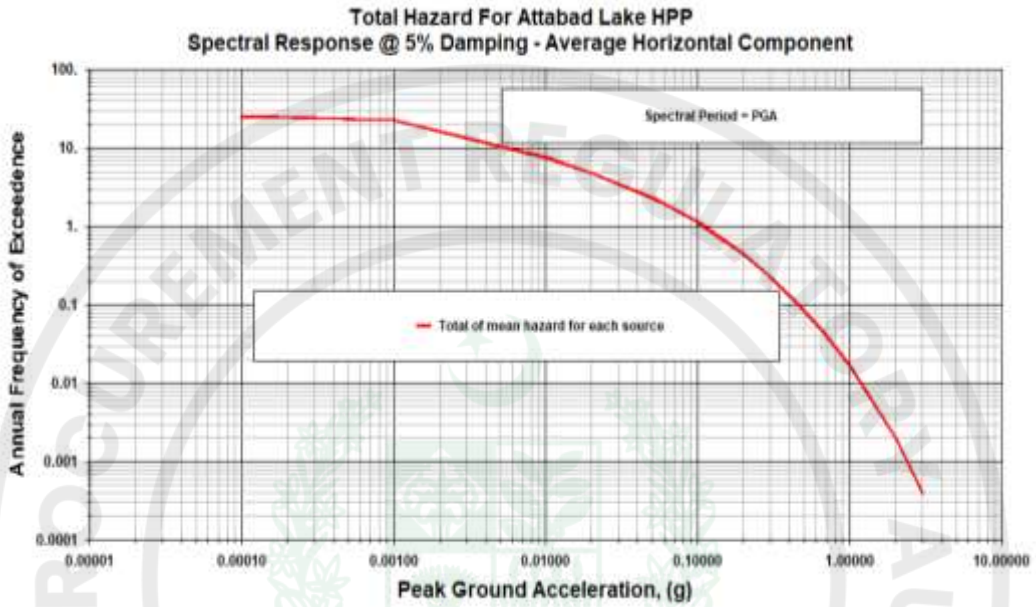


**Figure 6-25 Total Hazard Curve for ALHPP**

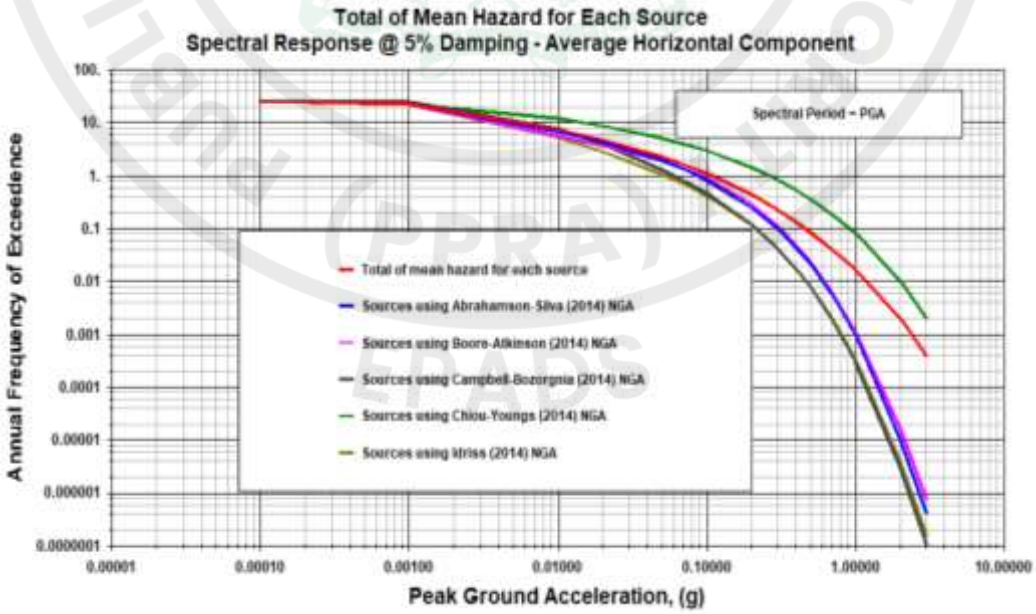


**Figure 6-26 Total Hazard Spectra for ALHPP.**



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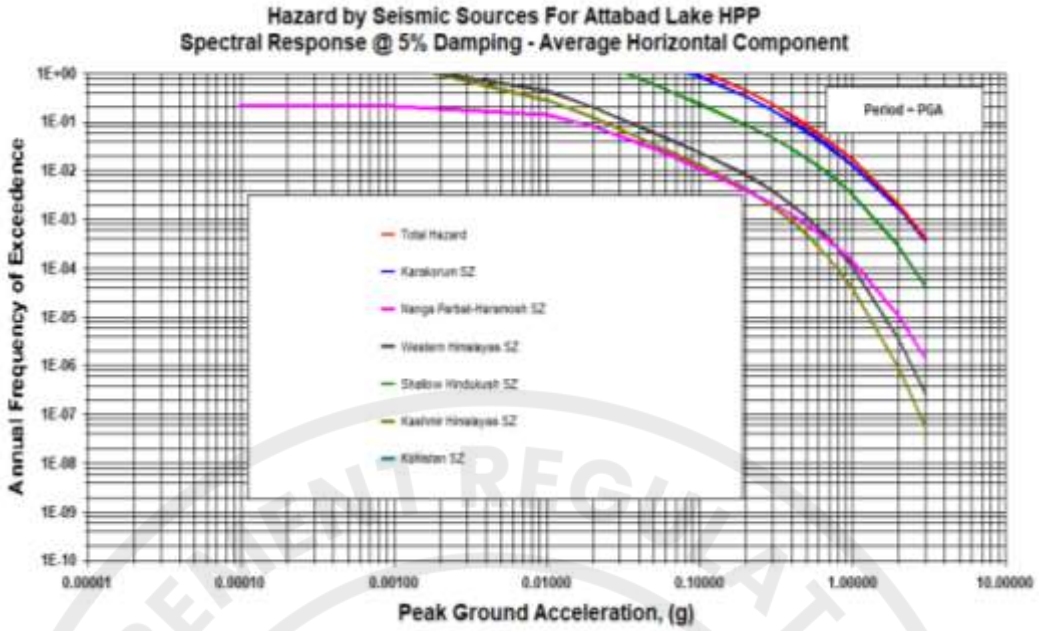


**Figure 6-27 Hazard by Seismic Sources Contribution, Spectral Response @ 5% Damping for Average Horizontal Component for ALHPP..**

## 6.9 DETERMINISTIC SEISMIC HAZARD ANALYSIS (DSHA)

The capability of the faults to generate earthquakes is ascertained by means of analysis of historical and instrumental seismic data and geological criteria such as rupture length – magnitude relationship or fault movement – magnitude relationship.

The main tectonic features around the Project Site within a radius of 200 km which could be controlling the maximum earthquake hazard are as follows:

1 Hunza Fault
2 Main Karakoram Thrust (MKT),
3 Main Mantle Thrust (MMT)

Empirical correlations have been developed between maximum potential of a fault and key fault parameters like rupture length, fault area, fault displacement and slip rate. Out of these fault parameters, only fault lengths are known with sufficient accuracy. For the faults around the ALHPP Site, the half rupture length of the faults has been taken for determination of maximum potential magnitude. The maximum earthquake magnitude (in moment magnitude $M_W$) of each of the fault was calculated using Wells & Coppersmith (1994) relationship between fault rupture length and magnitude and the input data given in Table - 1 has been used for deterministic approach.

Ground motion prediction equations developed under the Next Generation Attenuation (NGA) West 2 Project of PEER (Pacific Earthquake Engineering Research Center, University of California at Berkeley, USA) are used to obtain the median and median plus-one percentile levels of peak horizontal ground acceleration (PGA) in deterministic approach.


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The NGA equations are developed using a large worldwide database of strong motion recording of earthquakes of magnitude 4-8 and distances ranging from 0-200 km in accordance with ICOLD Guidelines. The NGA equations are preferable over the older equations for the evaluation of seismic hazard particularly in the near field as these are based on a broad spectrum of data recorded in the near field. The same attenuation equations were used for the PSHA approach too.

For all the seismic sources, thrust rupture mechanism has been considered. It is assumed that dam foundation will mainly be placed on gravelly soil therefore the site condition for dam/weir was taken as gravelly soil with average shear wave velocity for top 30 meters ($V_{s30}$) of 760 m/sec. The depth to basement rocks ($Z_{25}$) is taken as 5 km. The PGA g values have been calculated using the latest Five sets of NGA West 2 Ground Motion Prediction Equations (GMPEs).

Input values in DSHA are given in Table - 1. The analyzed results obtained through DSHA are presented in Figures 6-28 to 6-30.

### 6.9.1 DETERMINISTIC RESPONSE SPECTRA

Deterministic response spectra for SEE at 50th percentile and 84th percentile levels are shown in Figure - 28 and Figure - 29 respectively.

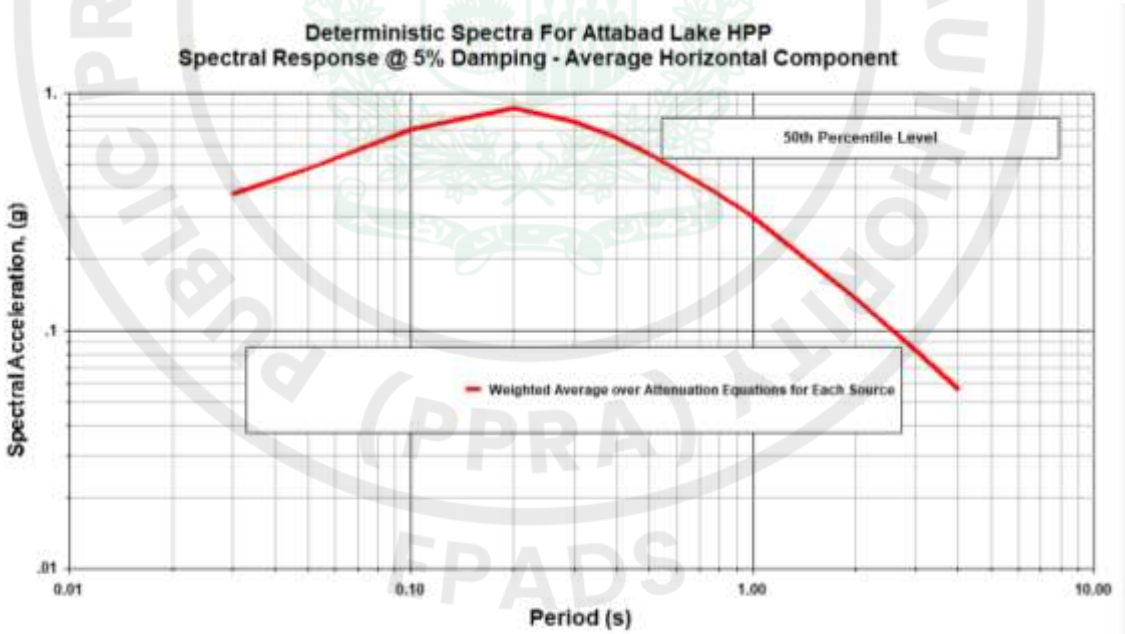


**Figure 6-28 Deterministic Spectra at 50th Percentile Level**



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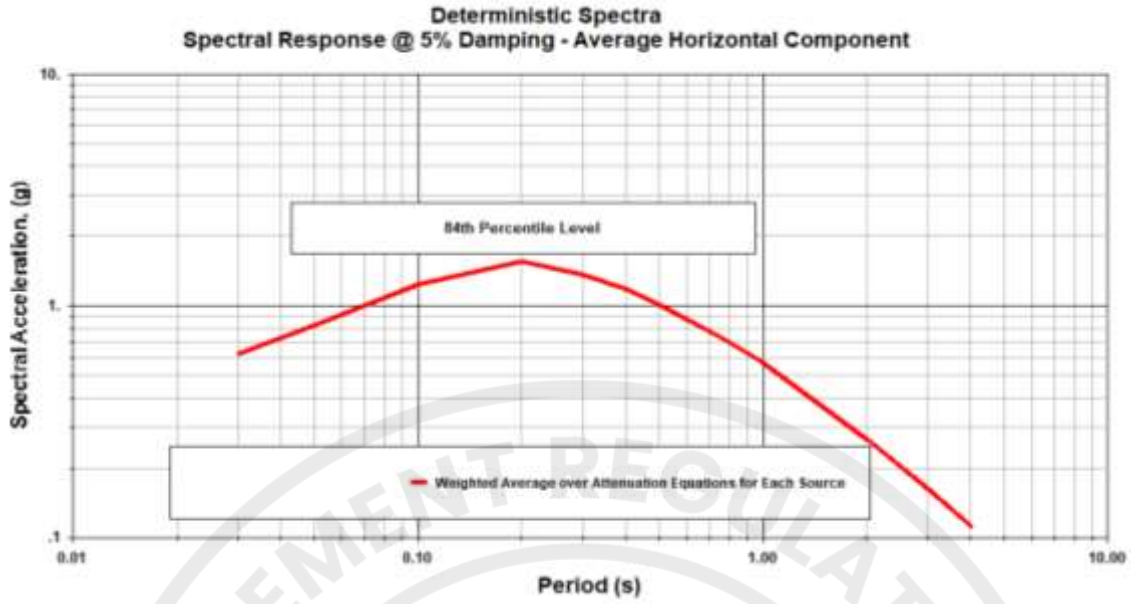


**Figure 6-29 Deterministic Spectra at 84th Percentile Level.**

### 6.9.2 Deterministic Pseudo Spectral Acceleration (PSA)

Pseudo spectral acceleration has been worked out using the latest version of R-CRISIS software. Pseudo spectral acceleration Vs time is given in Figure 6-30.

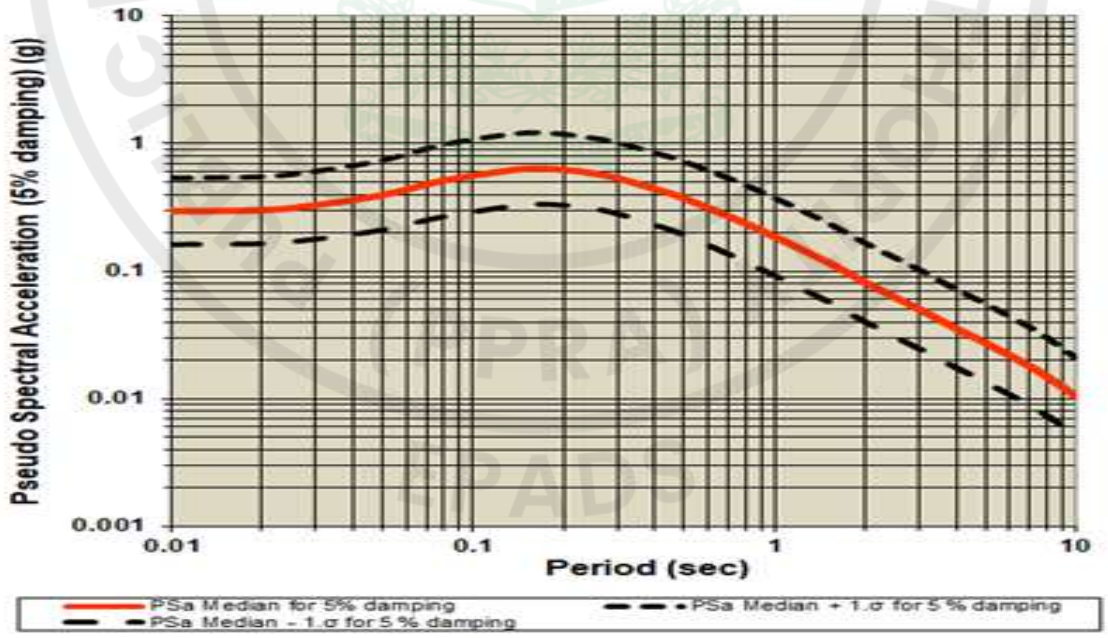


**Figure 6-30 Deterministic Pseudo Spectral Acceleration (g) at 5% Damping.**



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## 6.10 SELECTION OF SEISMIC DESIGN PARAMETERS

### 6.10.1 Safety Evaluation Earthquake (SEE)

As per ICOLD guidelines, (2016) the SEE will produce the maximum level of ground motion for which the dam should be designed or analyzed. For dams whose failure would present a great social hazard, the SEE will normally be characterized by a level of motion equal to that expected at the dam site from the occurrence of deterministically evaluated MCE or of the probabilistically-evaluated SEE earthquake ground motion with a very long return period, for example 10,000 years for high consequence large dams. Depending on the circumstances (e.g. the importance of the dam, the consequences of a dam failure, it is recommended to design safety-critical elements such as the bottom outlet and/or spillway gates for the SEE. It will be required at least that there is no uncontrolled release of water when the dam is subjected to the seismic load imposed by the SEE.

As per the latest ICOLD Guidelines, for medium consequence dams, median value ($50^{th}$ percentile level) is recommended whereas for high consequence dams, the SEE ground motion parameters should be estimated at median plus one ($84^{th}$ percentile level) if developed by a deterministic approach and need not have a mean annual exceedance probability (AEP) smaller than 1/10,000 if developed by a probabilistic approach. For a particular project of importance such as hydropower project, optimum percentile level may be any optimum percentile level between $50^{th}$ percentile level to $95^{th}$ percentile level. For ALHPP, $66^{th}$ percentile level has been worked out and the same is recommended.

The worked out SEE for ALHPP are given in Figures 6-31.



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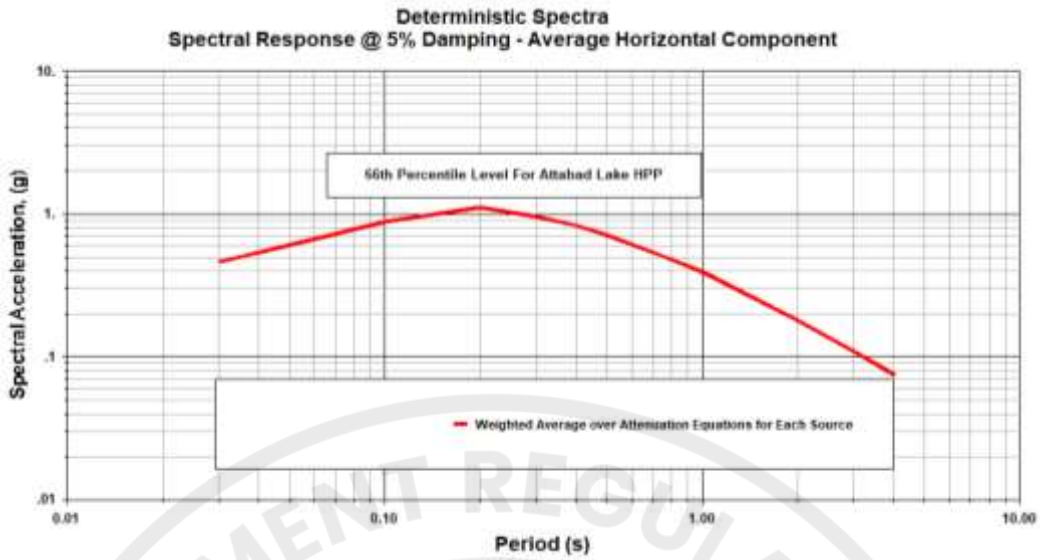


**Figure 6 -31 Deterministic Spectra at 66th Percentile Level of SEE, Weighted Average over the Five NGA West 2 Equations for ALHPP.**

### 6.10.2 Operating Basis Earthquake (OBE)

The OBE represents the level of ground motion at the dam site at which only minor damage is acceptable. In theory the OBE can be determined from an economic analysis, but this is not always feasible and, in many cases, it will be appropriate to choose a return period of about 145 years (i.e. a 50 % probability of not being exceeded in 100 years). The dam, appurtenant structures and equipment should remain functional and damage easily repairable, from the occurrence of earthquake shaking not exceeding the OBE.

Since the consequences of exceeding the OBE are normally economic, the circumstances in a particular case may justify use of a more severe or less severe event for the OBE. The resulting return period depends on prevailing conditions.

Because of the above definition, the OBE is the best determined by using probabilistic procedure. OBE ground motions are significantly lower than those for SEE.

### 6.10.3 Uniform Hazard Spectra (UHS)

Uniform hazard spectra for ALHPP for OBE (145 year return period), DBE (475 year and 2475 years return period) and SEE (10,000-years return period) are presented as Figure 6-32.



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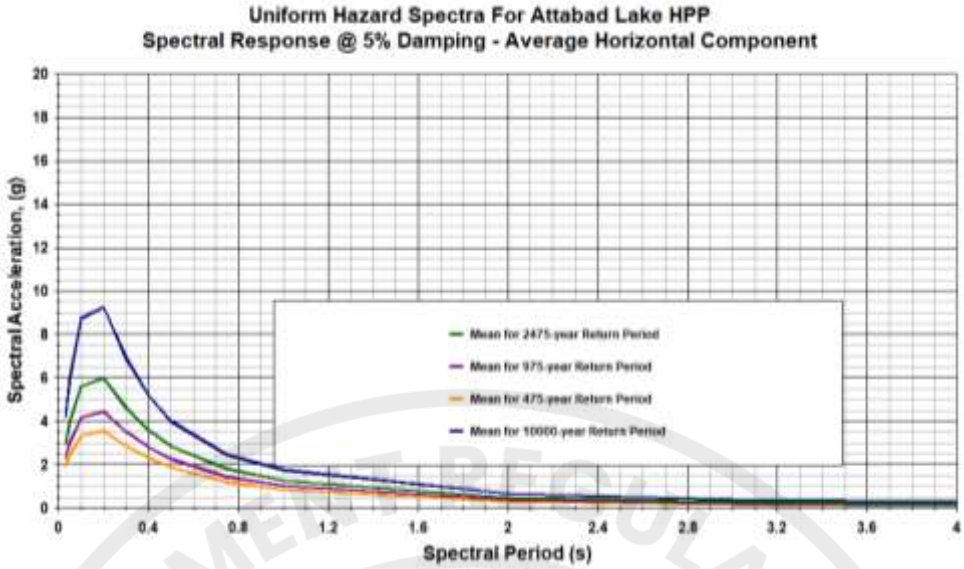


**Figure 6-32 Uniform Hazard Spectra (UHS) for ALHPP.**

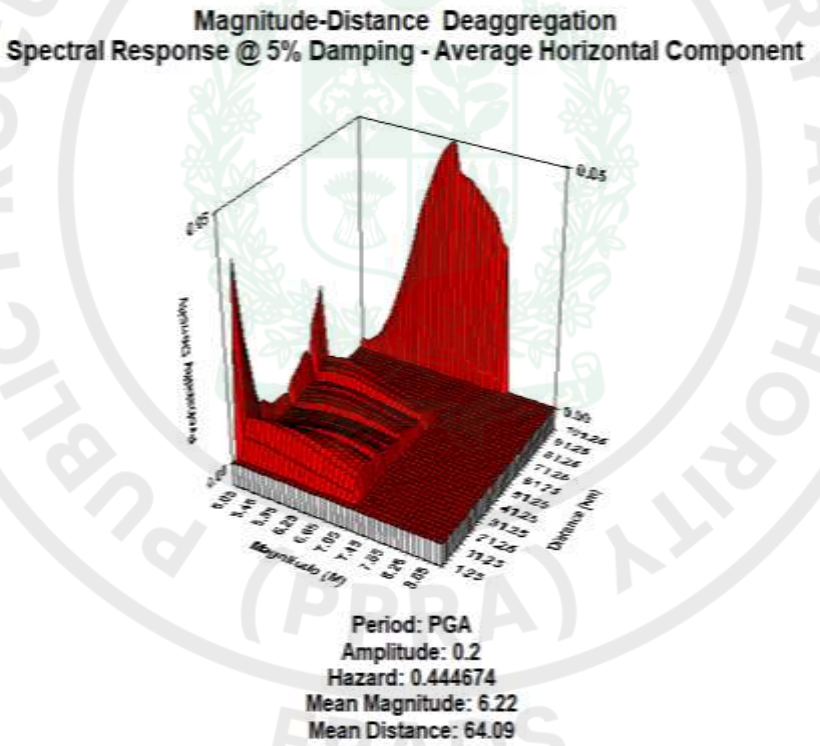


**Figure 6-33 Deaggregation of Mean Hazard, Magnitude and Distance for SEE by PSHA for ALHPP**

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# 7 CONCLUSION AND RECOMMENDATIONS

Based on the analysis results, the following earthquakes design parameters are concluded and recommended for ALHPP.

## 7.1 Operation Basis Earthquakes (OBE):

OBE at return period of 145 years is recommended as follows:

OBE Horizontal = 0.24 g

OBE Vertical = 0.17 g

## 7.2 Safety Evaluation Earthquakes (SEE):

For the design of dam / weir, the following PGA ‘g’ values for SEE are recommended:

SEE Horizontal = 0.44g

SEE Vertical = 0.29g

For the design of appurtinent structures including spillway etc. the following PGA ‘g’ values for SEE are recommended:

SEE Horizontal = 0.38g

SEE Vertical = 0.26g



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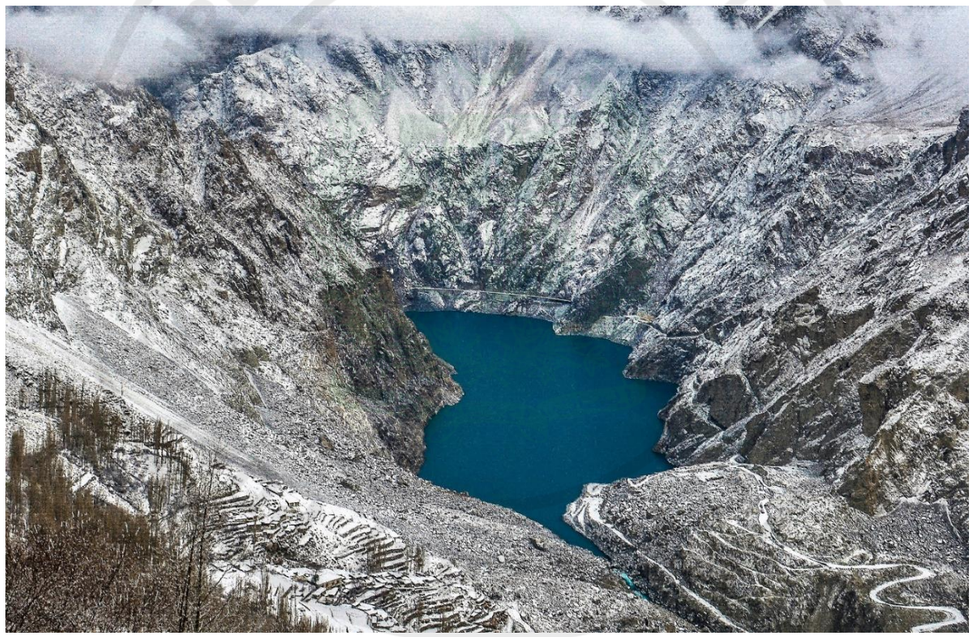
# PAKISTAN

## WATER AND POWER DEVELOPMENT AUTHORITY

## ATTABAD LAKE HYDROPOWER PROJECT

# FEASIBILITY STUDY



# VOLUME – 5
# BOREHOLE & TEST PIT LOGS

**JUNE 2021**

## GENERAL MANAGER (HYDRO) PLANNING

WAPDA, SUNNY VIEW ESTATE, LAHORE ☎ 99202717 99202722.

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# BOREHOLE LOGS

# BH-01

| HYDRO PLANNING WAPDA | | |

| HYDRO PLANNING | BOREHOLE No. | BH-01 | Project: | ATTABAD LAKE HYDROPOWER PROJECT | Page | 2 of 12 |
|---|---|---|---|---|---|---|
| | | | Site: | Weir (L/S) | | |

| DRILLING | | | | | RECOVERY | | Standared Penetration Test / Cone Penetration Test | | | | | | | | | | GENERAL DESCRIPTION | Remarks | Elevation (masl) | Depth (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | Core Recovery % | Solid Core pieces (cm) | Test # | Penetration Blows 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | Field Test | Permeability test Result | Profile | SOIL: Soil Type: Colour, Consistency, Structure, | | | |
| 8 | 8 | 1.00 | Rotary Drilling method, 76 mm/ NQ Diamond Bit with Double Tube Core barrel | 100 | 40 | 5,7,3,13 | | | | | | | | | | Head could not be maintained. | | **Overburden:** It consists of Angular Boulder Gravels of slided mass, light grey to grey in color, mostly of Granodiorite and Granitic Gneiss. | Borehole is stabilized with HW Casing from 5.00 to 32.70 m. | | 8 |
| 9 | 9 | 1.00 | | 100 | 29 | 23 | CPT-03 | 5 | 4 | 4 | 5 | 5 | 18 | | | | | | | | 9 |
| 10 | 10 | 1.00 | | 100 | 31 | 9,7,4 | | | | | | | | | | | | | | | 10 |
| 11 | 11 | 1.00 | | 100 | 30 | 19,7 | | | | | | | | | | | | | | | 11 |
| 12 | 12 | 1.00 | | 100 | 32 | 21,7 | CPT-04 | 3 | 4 | 6 | 4 | 5 | 19 | | | | | | | | 12 |
| 13 | 13 | 1.00 | | 100 | 12 | 2 | CPT-05 | 3 | 4 | 3 | 3 | 3 | 13 | | | | | | | | 13 |
| 14 | 14 | 1.00 | | 100 | 42 | 3,12,17 | | | | | | | | | | | | | | | 14 |
| 15 | 15 | 1.00 | | 30 | 90 | 18,8,55 | CPT-06 | 10 | 10/0 | | | | Refusal | | | | | | | | 15 |

**LEGEND:** Standard Penetration Test | Cone Penetration Test | Gravelly Sand | Sandy Gravel/ Cobble/boulder | Boulder/ Gravel

**Note:**

1 Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable

2 SOP for Refusal criteria: (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

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| HYDRO PLANNING | BOREHOLE No. | BH-01 | Project: | ATTABAD LAKE HYDROPOWER PROJECT | Page | 3 of 12 |
|---|---|---|---|---|---|---|
| | | | Site: | Weir (L/S) | | |

| DRILLING | | | | | RECOVERY | | Standared Penetration Test / Cone Penetration Test | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | Core Recovery % | Solid Core pieces (cm) | Test # | Penetration Blows 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | Field Test | Permeability test Result | Profile | GENERAL DESCRIPTION<br>SOIL: Soil Type: Colour, Consistency, Structure, | Remarks | Elevation (masl) | Depth (m) |
| 16 | 16 | 1.00 | Rotary Drilling method, 76 mm/ NQ Diamond Bit with Double Tube Core barrel | NIL | 49 | 49 | | | | | | | | | | K=0.002858 cm/sec | | **Overburden:**<br>It consists of Angular Boulder Gravels of slided mass, light grey to grey in color, mostly of Granodiorite and Granitic Gneiss. | A 25 cm wash sample composed of grey coloured sandy clayey silt found in core barrel. | | 16 |
| 17 | 17 | 1.00 | | 30 | 43 | 19,12 | | | | | | | | | | | | | | | 17 |
| 18 | 18 | 1.00 | | 60 | 16 | 3,13 | CPT-07 | 3 | 10/0 | | | | Refusal | | | | | | | | 18 |
| 19 | 19 | 1.00 | | 10 | 96 | 6,90 | | | | | | | | | | K= 0.012294 cm/sec | | | | | 19 |
| 20 | 20 | 1.00 | | NIL | 100 | 86,5,4 | | | | | | | | | | | | | | | 20 |
| 21 | 21 | 2.00 | | 100 | 90 | 170,6 | CPT-08 | 10/0 | | | | | Refusal | | | Head could not be maintained. | | | | | 21 |
| 22 | | | | | | | | | | | | | | | | | | | | | 22 |
| 23 | 22 | 1.00 | | 100 | 65 | 25,16,23 | | | | | | | | | | | | | Borehole is stabilized with HW Casing from 5.00 to 32.70 m. | | 23 |

**LEGEND:** Standard Penetration Test | Cone Penetration Test | Gravelly Sand | Sandy Gravel/ Cobble/ boulder | Boulder/ Gravel

**Note:**

1 Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable

2 Refusal criteria is adopted as (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

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| HYDRO PLANNING | BOREHOLE No. | BH-01 | Project: | ATTABAD LAKE HYDROPOWER PROJECT | Page | 4 of 12 |
|---|---|---|---|---|---|---|
| | | | Site: | Weir (L/S) | | |

| DRILLING | | | | | RECOVERY | | Standared Penetration Test / Cone Penetration Test | | | | | | | Field Test | Permeability test Result | Profile | GENERAL DESCRIPTION | Remarks | Elevation (masl) | Depth (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | Core Recovery % | Solid Core pieces (cm) | Test # | Penetration Blows 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | | | | SOIL: Soil Type: Colour, Consistency, Structure, | | | |
| 24 | 23 | 2.00 | Rotary Drilling method, 76 mm / NQ Diamond Bit with Double Tube Core barrel | 100 | 98 | 49,146 | CPT-09 | 10/0 | | | | | Refusal | | | Head could not be maintained. | **Overburden:** It consists of Angular Boulder Gravels of slided mass, light grey to grey in color, mostly of Granodiorite and Granitic Gneiss. | Head could not be maintained due to 100% water loss. | | 24 |
| 25 | | | | | | | | | | | | | | | | | | | | 25 |
| 26 | 24 | 1.00 | | 100 | 33 | 23,4 | | | | | | | | | | | | | | 26 |
| 27 | 25 | 1.00 | | 100 | 45 | 38,3 | CPT-10 | 8 | 10/0 | | | | Refusal | | | Head could not be maintained. | | | | 27 |
| 28 | 26 | 1.00 | | 100 | 35 | 4,5,12,5 | | | | | | | | | | | | | | 28 |
| 29 | 27 | 1.00 | | 100 | 55 | 50,2 | | | | | | | | | | | | | | 29 |
| 30 | 28 | 1.00 | | 100 | 99 | 4,15,62, 12 | CPT-11 | 10/0 | | | | | Refusal | | | Head could not be maintained. | | | | 30 |
| 31 | 29 | 1.00 | | 100 | 100 | 100 | | | | | | | | | | | | Borehole is stabilized with HW Casing from 5.00 to 32.70 m. | | 31 |

**LEGEND:** Standard Penetration Test | Cone Penetration Test | Gravelly Sand | Sandy Gravel /Cobble/boulder | Boulder/ Gravel

**Note:**

1 Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable

2 Refusal criteria is adopted as (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

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| HYDRO PLANNING | BOREHOLE No. | BH-01 | Project: | ATTABAD LAKE HYDROPOWER PROJECT | Page | 5 of 12 |
|---|---|---|---|---|---|---|
| | | | Site: | Weir (L/S) | | |

| DRILLING | | | | | RECOVERY | | Standared Penetration Test / Cone Penetration Test | | | | | | | | | | GENERAL DESCRIPTION | Remarks | Elevation (masl) | Depth (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | Core Recovery % | Solid Core pieces (cm) | Test # | Penetration Blows 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | Field Test | Permeability test Result | Profile | SOIL: Soil Type: Colour, Consistency, Structure, | | | |
| 32 | 30 | 1.00 | Rotary Drilling method, 76 mm / NQ Diamond Bit with Double Tube Core barrel | 100 | 62 | 7,8,42 | | | | | | | | | | Head could not be maintained. | | **Overburden:** It consists of Angular Boulder Gravels of slided mass, light grey to grey in color, mostly of Granodiorite and Granitic Gneiss. | Head could not be maintained due to 100% water loss. | | 32 |
| 33 | 31 | 1.00 | | 100 | 88 | 87 | CPT-07 | 3 | 10/0 | | | | Refusal | | | | | | Borehole is stabilized with HW Casing from 5.00 to 32.70 m. | | 33 |
| 34 | 32 | 1.00 | | 100 | 83 | 32,15 | | | | | | | | | | | | | Borehole is stabilized with cement from 32.70 to 85.00 m. | | 34 |
| 35 | 33 | 1.00 | | 100 | 100 | 19,58,19 | | | | | | | | | | | | | | | 35 |
| 36 | 34 | 1.00 | | 100 | 70 | 5,4G,6,11,40,4G | CPT-07 | 3 | 10/0 | | | | Refusal | | | Head could not be maintained. | | | | | 36 |
| 37 | 35 | 1.00 | | 100 | 78 | 3,2G,16,57 | | | | | | | | | | | | | | | 37 |
| 38 | 36 | 1.00 | | 100 | 58 | 39,19 | | | | | | | | | | | | | | | 38 |
| 39 | 37 | 1.00 | | 100 | 69 | 5G,3,48,3G | | | | | | | | | | | | | | | 39 |

**LEGEND:** Standard Penetration Test | Cone Penetration Test | Gravelly Sand | Sandy Gravel /Cobble/boulder | Boulder/ Gravel

**Note:**

1 Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable

2 Refusal criteria is adopted as (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

| HYDRO PLANNING | BOREHOLE No. | BH-01 | Project: | ATTABAD LAKE HYDROPOWER PROJECT | Page | 6 of 12 |
|---|---|---|---|---|---|---|
| | | | Site: | Weir (L/S) | | |

| DRILLING | | | | | RECOVERY | | Standared Penetration Test / Cone Penetration Test | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | Core Recovery % | Solid Core pieces (cm) | Test # | Penetration Blows 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | Field Test | Permeability test Result | Profile | GENERAL DESCRIPTION<br>SOIL: Soil Type: Colour, Consistency, Structure, | Remarks | Elevation (masl) | Depth (m) |
| 40 | 38 | 1.00 | Rotary Drilling method, 76 mm / NQ Diamond Bit with Double Tube Core barrel | 100 | 45 | 9,9,5G,6,16 | | | | | | | | | | Head could not be maintained. | | **Overburden:**<br>It consists of Angular Boulder Gravels of slided mass, light grey to grey in color, mostly of Granodiorite and Granitic Gneiss. | Borehole is stabilized with cement from 32.70 to 85.00 m. | | 40 |
| 41 | 39 | 1.00 | | 100 | 46 | 6,21,19 | | | | | | | | | | | | | | | 41 |
| 42 | 40 | 1.00 | | 100 | 45 | 15G,14,6,7,3G | | | | | | | | | | | | | | | 42 |
| 43 | 41 | 1.00 | | 100 | 53 | 11,8,7,4,5G,6,12 | | | | | | | | | | Head could not be maintained. | | | | | 43 |
| 44 | 42 | 1.00 | | 100 | 68 | 6G,5,8G,7,6,10,1G,10,12, 3G | | | | | | | | | | | | | | | 44 |
| 45 | 43 | 1.00 | | 100 | 81 | 41,8,9,5,4,10G | | | | | | | | | | | | | | | 45 |
| 46 | 44 | 1.00 | | 100 | 56 | 3,40,13 | | | | | | | | | | Head could not be maintained. | | | | | 46 |
| 47 | 45 | 1.00 | | 100 | 89 | 89 | | | | | | | | | | | | | | | 47 |

**LEGEND:** Standard Penetration Test | Cone Penetration Test | Gravelly Sand | Sandy Gravel /Cobble/boulder | Boulder/ Gravel

**Note:**

1 Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable

2 Refusal criteria is adopted as (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

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| HYDRO PLANNING | BOREHOLE No. | BH-01 | Project: | ATTABAD LAKE HYDROPOWER PROJECT | Page | 7 of 12 |
|---|---|---|---|---|---|---|
| | | | Site: | Weir (L/S) | | |

| DRILLING | | | | | RECOVERY | | Standared Penetration Test / Cone Penetration Test | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | Core Recovery % | Solid Core pieces (cm) | Test # | Penetration Blows 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | Field Test | Permeability test Result | Profile | GENERAL DESCRIPTION<br>SOIL: Soil Type: Colour, Consistency, Structure, | Remarks | Elevation (masl) | Depth (m) |
| 48 | 46 | 1.00 | Rotary Drilling method, 76 mm / NQ Diamond Bit with Double Tube Core barrel | 100 | 65 | 26,9,6,6 G,18 | | | | | | | | | | Head could not be maintained. | | **Overburden:**<br>It consists of Angular Boulder Gravels of slided mass, light grey to grey in color, mostly of Granodiorite and Granitic Gneiss. | Borehole is stabilized with cement from 32.70 to 85.00 m. | | 48 |
| 49 | 47 | 1.00 | | 100 | 58 | 19,7,3,5, 6G,10,8 G | | | | | | | | | | | | | | | 49 |
| 50 | 48 | 1.00 | | 100 | 63 | 51,12G | | | | | | | | | | | | | | | 50 |
| 51 | 49 | 1.00 | | 100 | 66 | 3,15,21, 27 | | | | | | | | | | | | | | | 51 |
| 52 | 50 | 1.00 | | 100 | 33 | 7,17,3G, 6 | | | | | | | | | | Head could not be maintained. | | | | | 52 |
| 53 | 51 | 1.00 | | 100 | 28 | 23G,5 | | | | | | | | | | | | | | | 53 |
| 54 | 52 | 1.00 | | 100 | 68 | 12G,15, 4,10,8,1 6,3G | | | | | | | | | | | | | | | 54 |
| 55 | 53 | 1.00 | | 100 | 56 | 14,11, 31 | | | | | | | | | | | | | | | 55 |

**LEGEND:** Standard Penetration Test | Cone Penetration Test | Gravelly Sand | Sandy Gravel /Cobble/boulder | Boulder/ Gravel

**Note:**

1 Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable

2 Refusal criteria is adopted as (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

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| HYDRO PLANNING | BOREHOLE No. | BH-01 | Project: | ATTABAD LAKE HYDROPOWER PROJECT | Page | 8 of 12 |
|---|---|---|---|---|---|---|
| | | | Site: | Weir (L/S) | | |

| DRILLING | | | | | RECOVERY | | Standared Penetration Test / Cone Penetration Test | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | Core Recovery % | Solid Core pieces (cm) | Test # | Penetration Blows 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | Field Test | Permeability test Result | Profile | GENERAL DESCRIPTION<br>SOIL: Soil Type: Colour, Consistency, Structure, | Remarks | Elevation (masl) | Depth (m) |
| 56 | 54 | 1.00 | Rotary Drilling method, 76 mm / NQ Diamond Bit with Double Tube Core barrel | 100 | 100 | 7,93 | | | | | | | | | | Head could not be maintained. | | **Overburden**<br>It consists of Angular Boulder Gravels of slided mass, light grey to grey in color, mostly of Granodiorite and Granitic Gneiss. | Borehole is stabilized with cement from 32.70 to 85.00 m. | | 56 |
| 57 | 55 | 1.00 | | 100 | 47 | 37,3G,7 | | | | | | | | | | | | | | | 57 |
| 58 | 56 | 1.00 | | 100 | 50 | 5G,15, 30 | | | | | | | | | | | | | | | 58 |
| 59 | 57 | 1.00 | | 100 | 23 | 7G,12,4 | | | | | | | | | | Head could not be maintained. | | | | | 59 |
| 60 | 58 | 1.00 | | 100 | 53 | 3G,4,9,7 ,30G | | | | | | | | | | | | | | | 60 |
| 61 | 59 | 1.00 | | 100 | 44 | 7G,17,1 6,4G | | | | | | | | | | | | | | | 61 |
| 62 | 60 | 1.00 | | 100 | 54 | 3G,7,9, 6G,26,3 | | | | | | | | | | Head could not be maintained. | | | | | 62 |
| 63 | 61 | 1.00 | | 100 | 44 | 28,16 | | | | | | | | | | | | | | | 63 |

**LEGEND:** Standard Penetration Test | Cone Penetration Test | Gravelly Sand | Sandy Gravel /Cobble/boulder | Boulder/ Gravel

**Note:**

1 Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable

2 Refusal criteria is adopted as (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

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| HYDRO PLANNING | BOREHOLE No. | BH-01 | Project: | ATTABAD LAKE HYDROPOWER PROJECT | Page | 9 of 12 |
|---|---|---|---|---|---|---|
| | | | Site: | Weir (L/S) | | |

| DRILLING | | | | | RECOVERY | | Standared Penetration Test / Cone Penetration Test | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | Core Recovery % | Solid Core pieces (cm) | Test # | Penetration Blows 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | Field Test | Permeability test Result | Profile | GENERAL DESCRIPTION<br>SOIL: Soil Type: Colour, Consistency, Structure, | Remarks | Elevation (masl) | Depth (m) |
| 64 | 62 | 1.00 | Rotary Drilling method, 76 mm / NQ Diamond Bit with Double Tube Core barrel | 100 | 55 | 5G,50 | | | | | | | | | | | | **Overburden:**<br>It consists of Angular Boulder Gravels of slided mass, light grey to grey in color, mostly of Granodiorite and Granitic Gneiss. | Borehole is stabilized with cement from 32.70 to 85.00 m. | | 64 |
| 65 | 63 | 1.00 | | 100 | 31 | 5,3,8,15 | | | | | | | | | | Head could not be maintained. | | | | | 65 |
| 66 | 64 | 1.00 | | 100 | 32 | 12,4,4, 6,6G | | | | | | | | | | | | | | | 66 |
| 67 | 65 | 1.00 | | 30 | 44 | 9G,10,2 5,17 | | | | | | | | | | | | | | | 67 |
| 68 | 66 | 1.00 | | 30 | 45 | 18,11G, 13,3 | | | | | | | | | | | | | | | 68 |
| 69 | 67 | 1.00 | | 100 | 88 | 10G,16, 3G,23, 9G,21 | | | | | | | | | | Head could not be maintained. | | | | | 69 |
| 70 | 68 | 1.00 | | 100 | 61 | 9G,6, 11G,7,1 6,7,5 | | | | | | | | | | | | | | | 70 |
| 71 | 69 | 1.00 | | 100 | 56 | 9G,14,8, 11G,12, 2G | | | | | | | | | | | | | | | 71 |

**LEGEND:** Standard Penetration Test | Cone Penetration Test | Gravelly Sand | Sandy Gravel /Cobble/boulder | Boulder/ Gravel

**Note:**

1 Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable

2 Refusal criteria is adopted as (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

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| HYDRO PLANNING | BOREHOLE No. | BH-01 | Project: | ATTABAD LAKE HYDROPOWER PROJECT | Page | 10 of 12 |
|---|---|---|---|---|---|---|
| | | | Site: | Weir (L/S) | | |

| DRILLING | | | | | RECOVERY | | Standared Penetration Test / Cone Penetration Test | | | | | | | | | | | | GENERAL DESCRIPTION | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | Core Recovery % | Solid Core pieces (cm) | Test # | Penetration Blows 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | Field Test | Permeability test Result | Profile | SOIL: Soil Type: Colour, Consistency, Structure, | Remarks | Elevation (masl) | Depth (m) |
| 72 | 70 | 1.00 | Rotary Drilling method, 76 mm / NQ Diamond Bit with Double Tube Core barrel | 100 | 53 | 42,4,7 | | | | | | | | | | Head could not be maintained. | | **Overburden:** It consists of Angular Boulder Gravels of slided mass, light grey to grey in color, mostly of Granodiorite and Granitic Gneiss. | Borehole is stabilized with cement from 32.70 to 85.00 m. | | 72 |
| 73 | 71 | 1.00 | | 100 | 65 | 14,2,13, 23,13 | | | | | | | | | | | | | | | 73 |
| 74 | 72 | 1.00 | | 100 | 65 | 4,22,39 | | | | | | | | | | | | | | | 74 |
| 75 | 73 | 1.00 | | 100 | 77 | 5G,18, 1G,6,3G ,6,38 | | | | | | | | | | Head could not be maintained. | | | | | 75 |
| 76 | 74 | 1.00 | | 100 | 87 | 7G,11,6, 12,20, 6G,6,13, 2 | | | | | | | | | | | | | | | 76 |
| 77 | 75 | 2.00 | | 100 | 87 | 125,22,2 7 | | | | | | | | | | | | | | | 77 |
| 78 | | | | | | | | | | | | | | | | Head could not be maintained. | | | | | 78 |
| 79 | 76 | 1.00 | | 100 | 64 | 11,8,10, 23,6,6G | | | | | | | | | | | | | | | 79 |

**LEGEND:** Standard Penetration Test | Cone Penetration Test | Gravelly Sand | Sandy Gravel /Cobble/boulder | Boulder/ Gravel

**Note:**

1 Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable

2 Refusal criteria is adopted as (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

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| HYDRO PLANNING | BOREHOLE No. | BH-01 | Project: | ATTABAD LAKE HYDROPOWER PROJECT | Page | 11 of 12 |
|---|---|---|---|---|---|---|
| | | | Site: | Weir (L/S) | | |

| DRILLING | | | | | RECOVERY | | Standared Penetration Test / Cone Penetration Test | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | Core Recovery % | Solid Core pieces (cm) | Test # | Penetration Blows 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | Field Test | Permeability test Result | Profile | GENERAL DESCRIPTION<br>SOIL: Soil Type: Colour, Consistency, Structure, | Remarks | Elevation (masl) | Depth (m) |
| 80 | 77 | 1.00 | Rotary Drilling method, 76 mm / NQ Diamond Bit with Double Tube Core barrel | 100 | 37 | 10,15G, 11 | | | | | | | | | | | | **Overburden:**<br>It consists of Angular Boulder Gravels of slided mass, light grey to grey in color, mostly of Granodiorite and Granitic Gneiss. | Borehole is stabilized with cement from 32.70 to 85.00 m. | | 80 |
| 81 | 78 | 1.00 | | 100 | 89 | 11G,69, 9 | | | | | | | | | | Head could not be maintained. | | | | | 81 |
| 82 | 79 | 1.00 | | 100 | 57 | 8,2G,27, 20 | | | | | | | | | | | | | | | 82 |
| 83 | 80 | 1.00 | | 100 | 32 | 30,2G | | | | | | | | | | | | | | | 83 |
| 84 | 81 | 1.00 | | 100 | 45 | 32,3G, 10 | | | | | | | | | | Head could not be maintained. | | | | | 84 |
| 85 | 82 | 1.00 | | 100 | 38 | 4,13,21 | | | | | | | | | | | | | | | 85 |
| 86 | 83 | 1.00 | | 100 | 56 | 11,22,5, 4,7G,7 | | | | | | | | | | | | | | | 86 |
| 87 | 84 | 1.00 | | 100 | 66 | 13,6,8,6, 6,24,3 | | | | | | | | | | | | | | | 87 |

**LEGEND:** Standard Penetration Test | Cone Penetration Test | Gravelly Sand | Sandy Gravel /Cobble/boulder | Boulder/ Gravel

**Note:**

1 Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable

2 Refusal criteria is adopted as (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

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| HYDRO PLANNING | BOREHOLE No. | BH-01 | Project: | ATTABAD LAKE HYDROPOWER PROJECT | Page | 12 of 12 |
|---|---|---|---|---|---|---|
| | | | Site: | Weir (L/S) | | |

| DRILLING | | | | | RECOVERY | | Standared Penetration Test / Cone Penetration Test | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | Core Recovery % | Solid Core pieces (cm) | Test # | Penetration Blows 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | Field Test | Permeability test Result | Profile | GENERAL DESCRIPTION<br>SOIL: Soil Type: Colour, Consistency, Structure, | Remarks | Elevation (masl) | Depth (m) |
| 88 | 85 | 1.00 | Rotary Drilling method, 76 mm / NQ Diamond Bit with Double Tube Core barrel | 100 | 59 | 21G,10, 9,8,11 | | | | | | | | | | Head could not be maintained. | | **Overburden:**<br>It consists of Angular Boulder Gravels of slided mass, light grey to grey in color, mostly of Granodiorite and Granitic Gneiss. | Borehole is stabilized with cement from 32.70 to 85.00 m. | | 88 |
| 89 | 86 | 1.00 | | 100 | 55 | 33,8,11, 3 | | | | | | | | | | | | | | | 89 |
| 90 | 87 | 1.00 | | 100 | 59 | 34,4G, 21 | | | | | | | | | | | | Borehole terminated at 90.00 m. | | | 90 |
| 91 | | | | | | | | | | | | | | | | | | | | | 91 |
| 92 | | | | | | | | | | | | | | | | | | | | | 92 |
| 93 | | | | | | | | | | | | | | | | | | | | | 93 |
| 94 | | | | | | | | | | | | | | | | | | | | | 94 |
| 95 | | | | | | | | | | | | | | | | | | | | | 95 |

**LEGEND:** Standard Penetration Test | Cone Penetration Test | Gravelly Sand | Sandy Gravel /Cobble/boulder | Boulder/ Gravel

**Note:**

1 Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable

2 Refusal criteria is adopted as (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

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# BH-02

| HYDRO PLANNING WAPDA | | |

| HYDRO PLANNING | BOREHOLE No. | BH-02 | Project: | ATTABAD LAKE HYDROPOWER PROJECT | Page | 2 of 8 |
|---|---|---|---|---|---|---|
| | | | Site: | SEDIMENT FLUSHING CHANNEL (INLET) | | |

| DRILLING | | | | | RECOVERY | | Standared Penetration Test / Cone Penetration Test | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | Core Recovery % | Solid Core pieces (cm) | Test # | Penetration Blows 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | Field Test | Permeability test Result | Profile | GENERAL DESCRIPTION<br>SOIL: Soil Type: Colour, Consistency, Structure, | Remarks | Elevation (masl) | Depth (m) |
| 8 | 8 | 1.00 | Rotary Drilling method, 76 mm / NQ Diamond Bit with Double Tube Core barrel | 100 | 21 | 13G,8 | | | | | | | | | | Head could not be maintained. | | **Overburden:**<br>It consists of Angular Boulder Gravels of slided mass, light grey to grey in color, mostly of Granodiorite and Granitic Gneiss. | Borehole is stabilized with HW casing from 0.00 to 35.00 m. | | 8 |
| 9 | 9 | 1.00 | | 100 | 29 | 29G | | | | | | | | | | | | | | | 9 |
| 10 | 10 | 1.00 | | 100 | 55 | 13G,42 | CPT-03 | 10/0 | | | | | Refusal | | | Head could not be maintained. | | | | | 10 |
| 11 | 11 | 1.00 | | 100 | 47 | 47 | | | | | | | | | | | | | | | 11 |
| 12 | 12 | 1.00 | | 100 | 29 | 11,3,8,7 | | | | | | | | | | | | | | | 12 |
| 13 | 13 | 1.00 | | 100 | 24 | 6,2G,11,5 | CPT-04 | 10/0 | | | | | Refusal | | | Head could not be maintained. | | | | | 13 |
| 14 | 14 | 1.00 | | 100 | 42 | 13,22G,7 | | | | | | | | | | | | | | | 14 |
| 15 | 15 | 1.00 | | 100 | 29 | 10G,5,3,11 | | | | | | | | | | | | | | | 15 |

**LEGEND:** Standard Penetration Test | Cone Penetration Test | Gravelly Sand | Sandy Gravel/ Cobble/boulder | Boulder/ Gravel

**Note:**
1. Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable
2. SOP for Refusal criteria: (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

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| HYDRO PLANNING | BOREHOLE No. | BH-02 | Project: | ATTABAD LAKE HYDROPOWER PROJECT | Page | 3 of 8 |
|---|---|---|---|---|---|---|
| | | | Site: | SEDIMENT FLUSHING CHANNEL (INLET) | | |

| DRILLING | | | | | RECOVERY | | Standared Penetration Test / Cone Penetration Test | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | Core Recovery % | Solid Core pieces (cm) | Test # | Penetration Blows 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | Field Test | Permeability test Result | Profile | GENERAL DESCRIPTION<br>SOIL: Soil Type: Colour, Consistency, Structure, | Remarks | Elevation (masl) | Depth (m) |
| 16 | 16 | 1.00 | Rotary Drilling method, 76 mm / NQ Diamond Bit with Double Tube Core barrel | 100 | 39 | 10G,6,23 | CPT-05 | 10/0 | | | | | Refusal | | | Head could not be maintained. | | **Overburden:**<br>It consists of Angular Boulder Gravels of slided mass, light grey to grey in color, mostly of Granodiorite and Granitic Gneiss. | Borehole is stabilized with HW casing from 0.00 to 35.00 m. | | 16 |
| 17 | 17 | 1.00 | | 100 | 25 | 13,7,5 | | | | | | | | | | | | | | | 17 |
| 18 | 18 | 2.00 | | 100 | 65 | 130 | | | | | | | | | | | | | | | 18 |
| 19 | | | | | | | | | | | | | | | | | | | | | 19 |
| 20 | 19 | 1.00 | | 100 | 27 | 13G,14 | CPT-06 | 10/0 | | | | | Refusal | | | Head could not be maintained. | | | | | 20 |
| 21 | 20 | 1.00 | | 100 | 36 | 9,6,21G | | | | | | | | | | | | | | | 21 |
| 22 | 21 | 1.00 | | 100 | 42 | 6,6,14, 16G | | | | | | | | | | | | | | | 22 |
| 23 | 22 | 1.00 | | 100 | 60 | 60 | CPT-07 | 10/0 | | | | | Refusal | | | Head could not be maintained. | | | | | 23 |

**LEGEND:** Standard Penetration Test | Cone Penetration Test | Gravelly Sand | Sandy Gravel/ Cobble/ boulder | Boulder/ Gravel

**Note:**

1 Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable

2 Refusal criteria is adopted as (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

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| HYDRO PLANNING | BOREHOLE No. | BH-02 | Project: | ATTABAD LAKE HYDROPOWER PROJECT | Page | 4 of 8 |
|---|---|---|---|---|---|---|
| | | | Site: | SEDIMENT FLUSHING CHANNEL (INLET) | | |

| DRILLING | | | | | RECOVERY | | Standared Penetration Test / Cone Penetration Test | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | Core Recovery % | Solid Core pieces (cm) | Test # | Penetration Blows 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | Field Test | Permeability test Result | Profile | GENERAL DESCRIPTION<br>SOIL: Soil Type: Colour, Consistency, Structure, | Remarks | Elevation (masl) | Depth (m) |
| 24 | 23 | 1.00 | Rotary Drilling method, 76 mm / NQ Diamond Bit with Double Tube Core barrel | 100 | 23 | 16G,7 | | | | | | | | | | | | **Overburden:**<br>It consists of Angular Boulder Gravels of slided mass, light grey to grey in color, mostly of Granodiorite and Granitic Gneiss. | Borehole is stabilized with HW casing from 0.00 to 35.00 m. | | 24 |
| 25 | 24 | 1.00 | | 100 | 9 | 9G | | | | | | | | | | | | | | | 25 |
| 26 | 25 | 1.00 | | 100 | 16 | 9G,7 | | | | | | | | | | | | | | | 26 |
| 27 | 26 | 1.00 | | 100 | 15 | 15G | CPT-08 | 10/0 | | | | | Refusal | | | Head could not be maintained. | | | | | 27 |
| 28 | 27 | 1.00 | | 100 | 32 | 4G,28 | | | | | | | | | | | | | | | 28 |
| 29 | 28 | 1.00 | | 100 | 22 | 11G,9, 2G | | | | | | | | | | | | | | | 29 |
| 30 | 29 | 1.00 | | 100 | 22 | 4G,6,9,3 G | CPT-09 | 10/0 | | | | | Refusal | | | Head could not be maintained. | | | | | 30 |
| 31 | 30 | 1.00 | | 100 | 34 | 21,13G | | | | | | | | | | | | | | | 31 |

**LEGEND:** Standard Penetration Test | Cone Penetration Test | Gravelly Sand | Sandy Gravel /Cobble/boulder | Boulder/ Gravel

**Note:**

1 Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable

2 Refusal criteria is adopted as (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

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| HYDRO PLANNING | BOREHOLE No. | BH-02 | Project: | ATTABAD LAKE HYDROPOWER PROJECT | Page | 5 of 8 |
|---|---|---|---|---|---|---|
| | | | Site: | SEDIMENT FLUSHING CHANNEL (INLET) | | |

| DRILLING | | | | | RECOVERY | | Standared Penetration Test / Cone Penetration Test | | | | | | | | | | GENERAL DESCRIPTION | Remarks | Elevation (masl) | Depth (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | Core Recovery % | Solid Core pieces (cm) | Test # | Penetration Blows 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | Field Test | Permeability test Result | Profile | SOIL: Soil Type: Colour, Consistency, Structure, | | | |
| 32 | 31 | 1.00 | Rotary Drilling method, 76 mm / NQ Diamond Bit with Double Tube Core barrel | 100 | 28 | 28G | | | | | | | | | | Head could not be maintained. | | **Overburden:**<br>It consists of Angular Boulder Gravels of slided mass, light grey to grey in color, mostly of Granodiorite and Granitic Gneiss. | Borehole is stabilized with HW casing from 0.00 to 35.00 m. | | 32 |
| 33 | 32 | 1.00 | | 100 | 33 | 33G | | | | | | | | | | | | | | 33 |
| 34 | 33 | 1.00 | | 100 | 23 | 6,17G | | | | | | | | | | | | | | 34 |
| 35 | 34 | 1.00 | | 100 | 27 | 18,9G | | | | | | | | | | Head could not be maintained. | | | | 35 |
| 36 | 35 | 1.00 | | 100 | 21 | 15,6G | | | | | | | | | | | | | Borehole is stabilized with cement from 35.00 to 57.00 m. | 36 |
| 37 | 36 | 1.00 | | 100 | 24 | 14G,10 | | | | | | | | | | | | | | 37 |
| 38 | 37 | 1.00 | | 100 | 25 | 22,3G | | | | | | | | | | | | | | 38 |
| 39 | 38 | 1.00 | | 100 | 12 | 12G | | | | | | | | | | Head could not be maintained. | | | | 39 |

**LEGEND:** Standard Penetration Test | Cone Penetration Test | Gravelly Sand | Sandy Gravel /Cobble/boulder | Boulder/ Gravel

**Note:**

1 Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable

2 Refusal criteria is adopted as (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

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| HYDRO PLANNING | BOREHOLE No. | BH-02 | Project: | ATTABAD LAKE HYDROPOWER PROJECT | Page | 6 of 8 |
|---|---|---|---|---|---|---|
| | | | Site: | SEDIMENT FLUSHING CHANNEL (INLET) | | |

| DRILLING | | | | | RECOVERY | | Standared Penetration Test / Cone Penetration Test | | | | | | | | | | GENERAL DESCRIPTION | Remarks | Elevation (masl) | Depth (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | Core Recovery % | Solid Core pieces (cm) | Test # | Penetration Blows 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | Field Test | Permeability test Result | Profile | SOIL: Soil Type: Colour, Consistency, Structure, | | | |
| 40 | 39 | 1.00 | Rotary Drilling method, 76 mm / NQ Diamond Bit with Double Tube Core barrel | 100 | 15 | 9,3,3G | | | | | | | | | | | | **Overburden:**<br>It consists of Angular Boulder Gravels of slided mass, light grey to grey in color, mostly of Granodiorite and Granitic Gneiss. | Borehole is stabilized with cement from 35.00 to 57.00 m. | | 40 |
| 41 | 40 | 1.00 | | 100 | 44 | 38,6G | | | | | | | | | | | | | | 41 |
| 42 | 41 | 1.00 | | 100 | 30 | 30G | | | | | | | | | | | | | | 42 |
| 43 | 42 | 1.00 | | 100 | 28 | 22G,6 | | | | | | | | | | | | | | 43 |
| 44 | 43 | 1.00 | | 100 | 37 | 18,19G | | | | | | | | | | | | | | 44 |
| 45 | 44 | 1.00 | | 100 | 27 | 12,15G | | | | | | | | | | | | | | 45 |
| 46 | 45 | 1.00 | | 100 | 25 | 10,15G | | | | | | | | | | | | | | 46 |
| 47 | 46 | 1.00 | | 100 | 41 | 10,11,8, 12G | | | | | | | | | | | | | | 47 |

**LEGEND:** Standard Penetration Test | Cone Penetration Test | Gravelly Sand | Sandy Gravel /Cobble/boulder | Boulder/ Gravel

**Note:**

1 Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable

2 Refusal criteria is adopted as (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

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| HYDRO PLANNING | BOREHOLE No. | BH-02 | Project: | ATTABAD LAKE HYDROPOWER PROJECT | Page | 7 of 8 |
|---|---|---|---|---|---|---|
| | | | Site: | SEDIMENT FLUSHING CHANNEL (INLET) | | |

| DRILLING | | | | | RECOVERY | | Standared Penetration Test / Cone Penetration Test | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | Core Recovery % | Solid Core pieces (cm) | Test # | Penetration Blows 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | Field Test | Permeability test Result | Profile | GENERAL DESCRIPTION<br>SOIL: Soil Type: Colour, Consistency, Structure, | Remarks | Elevation (masl) | Depth (m) |
| 48 | 47 | 1.00 | Rotary Drilling method, 76 mm / NQ Diamond Bit with Double Tube Core barrel | 100 | 27 | 14,13G | | | | | | | | | | | | **Overburden:**<br>It consists of Angular Boulder Gravels of slided mass, light grey to grey in color, mostly of Granodiorite and Granitic Gneiss. | Borehole is stabilized with cement from 35.00 to 57.00 m. | | 48 |
| 49 | 48 | 1.00 | | 100 | 24 | 24G | | | | | | | | | | | | | | | 49 |
| 50 | 49 | 1.00 | | 100 | 25 | 6,19G | | | | | | | | | | | | | | | 50 |
| 51 | 50 | 1.00 | | 100 | 29 | 8,21G | | | | | | | | | | | | | | | 51 |
| 52 | 51 | 1.00 | | 100 | 36 | 15G,21 | | | | | | | | | | | | | | | 52 |
| 53 | 52 | 1.00 | | 100 | 21 | 14,7G | | | | | | | | | | | | | | | 53 |
| 54 | 53 | 1.00 | | 100 | 25 | 25G | | | | | | | | | | | | | | | 54 |
| 55 | 54 | 1.00 | | 100 | 36 | 8,16, 12G | | | | | | | | | | | | | | | 55 |

**LEGEND:** Standard Penetration Test | Cone Penetration Test | Gravelly Sand | Sandy Gravel /Cobble/boulder | Boulder/ Gravel

**Note:**

1 Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable

2 Refusal criteria is adopted as (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

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| HYDRO PLANNING | BOREHOLE No. | BH-02 | Project: | ATTABAD LAKE HYDROPOWER PROJECT | Page | 8 of 8 |
|---|---|---|---|---|---|---|
| | | | Site: | SEDIMENT FLUSHING CHANNEL (INLET) | | |

| DRILLING | | | | | RECOVERY | | Standared Penetration Test / Cone Penetration Test | | | | | | | | | | GENERAL DESCRIPTION | Remarks | Elevation (masl) | Depth (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | Core Recovery % | Solid Core pieces (cm) | Test # | Penetration Blows 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | Field Test | Permeability test Result | Profile | SOIL: Soil Type: Colour, Consistency, Structure, | | | |
| 56 | 55 | 1.00 | Rotary Drilling method, 76 mm / NQ Diamond Bit with Double Tube Core barrel | 100 | 22 | 7,15G | | | | | | | | | | | | **Overburden:**<br>It consists of Angular Boulder Gravels of slided mass, light grey to grey in color, mostly of Granodiorite and Granitic Gneiss. | Borehole is stabilized with cement from 35.00 to 57.00 m. | | 56 |
| 57 | 56 | 1.00 | | 100 | 27 | 14,5,5,3 | | | | | | | | | | | | | | 57 |
| 58 | 57 | 1.00 | | 100 | 27 | 4,6,7G,8,2 | | | | | | | | | | | | | | 58 |
| 59 | 58 | 1.00 | | 100 | 39 | 6,9,24 | | | | | | | | | | | | | | 59 |
| 60 | 59 | 1.00 | | 100 | 24 | 4,11,5,1,3 | | | | | | | | | | | | **BOTTOM OF THE HOLE** | | | 60 |
| 61 | | | | | | | | | | | | | | | | | | | | 61 |
| 62 | | | | | | | | | | | | | | | | | | | | 62 |
| 63 | | | | | | | | | | | | | | | | | | | | 63 |

**LEGEND:** Standard Penetration Test | Cone Penetration Test | Gravelly Sand | Sandy Gravel /Cobble/boulder | Boulder/ Gravel

**Note:**

1 Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable

2 Refusal criteria is adopted as (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

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# BH-03

| HYDRO PLANNING WAPDA | GRAIN SIZE (ASTM D2487) | | | CONSISTENCY | | | | Project : | ATTABAD LAKE HYDROPOWER PROJECT | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Silt and clay | | < 75 µm | CLAY / SILT | | SAND / GRAVEL | | Site: | Sediment Flushing Channel | | |
| | | | | N Value | | | | Easting : | 483541.73 | Borehole No. : | BH-03 |
| | Sand | Fine | 75 µm - 425 µm | very soft | <2 | <4 | very loose | Northing: | 4018061.58 | Page : | 1 of 8 |
| | | Medium | 425 µm - 2 mm | Soft | 2-4 | 4-10 | Loose | Elevation : | 2456.92 m | Logged by: | Toqeer/Jabbar/Nauman |
| | | Coarse | 2 mm - 4.75 mm | Firm | 4-8 | 10-30 | Medium Dense | Dip : | 90° | Checked By | Umar Tariq |
| BOREHOLE NO. | Gravels | Fine | 4.75 m - 19 mm | Stiff | 8-15 | 30-50 | Dense | Final Depth : | 61 m | Date Started: | 26.10.2020 |
| BH-03 | | Coarse | 19 mm - 75 mm | Very Stiff | 15-30 | >50 | Very Dense | Bearing : | Nil | Date Completed: | 04.12.2020 |
| | Cobbles | | 75 mm -300 mm | Hard | >30 | | | Drilling Co. : | DD, WAPDA | Water Table: | NIL |
| | Boulders | | > 300 mm | | | | | Driller : | Mr. Maqbool | RIG: | Longyear |

| DRILLING | | | | | RECOVERY | | Standared Penetration Test / Cone Penetration Test | | | | | | | | Permeability test Result | Profile | GENERAL DESCRIPTION | Remarks | Elevation (masl) | Depth (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | Core Recovery % | Solid Core pieces (cm) | Test # | Penetration Blows 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | Field Test | | | SOIL: Soil Type: Colour, Consistency, Structure, | | | |
| 1 | 1 | 1.00 | Rotary Drilling method, 96 mm / HQ Bit with Single Tube Core barrel | NIL | | 16,17 | | | | | | | | | | | **Overburden/ Sandy Gravels (0.00-26.00 m):** It consists of light grey to grey, fine to medium grained sand with occasionally silt and angular to sub angular gravels of variegated origin. | 17 cm wash sample is collected comprising of grey fine sand, trace coarse quartz and fine gravels. | | 1 |
| 2 | 2 | 1.00 | | 30 | 70 | 22,7,16, 9,6 | | | | | | | | | | | | 15 cm wash sample is collected comprising of grey fine to medium sand and coarse quartz cuttings. | | 2 |
| 3 | 3 | 1.00 | | 30 | 32 | 15,16 | | | | | | | | | | | | 16 cm wash sample is collected comprising of grey fine sand and coarse quartz cuttings. | | 3 |
| 4 | 4 | 2.00 | | 100 | 24 | 3,10,4 | | | | | | | | | | | | | | 4 |
| 5 | 5 | 3.00 | Rotary Drilling method, 96 mm / HQ Bit with Double Tube Core barrel | 100 | 34 | 2,5 | | | | | | | | | | | | | | 5 |
| 6 | 6 | 4.00 | | 60 | 83 | | | | | | | | | | | | | | | 6 |
| 7 | 7 | 5.00 | | 100 | 51 | 42,3 | | | | | | | | | | | | | | 7 |

**LEGEND:** Standard Penetration Test | Cone Penetration Test | Gravelly Sand | Sandy Gravel/ Cobble/boulder | Boulder/ Gravel

**Note:**

1 Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable

2 SOP for Refusal criteria: (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

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| HYDRO PLANNING | BOREHOLE No. | BH-03 | Project: | ATTABAD LAKE HYDROPOWER PROJECT | Page | 2 of 8 |
|---|---|---|---|---|---|---|
| | | | Site: | Sediment Flushing Channel | | |

| DRILLING | | | | | RECOVERY | | Standared Penetration Test / Cone Penetration Test | | | | | | | | | | GENERAL DESCRIPTION | Remarks | Elevation (masl) | Depth (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | Core Recovery % | Solid Core pieces (cm) | Test # | Penetration Blows 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | Field Test | Permeability test Result | Profile | SOIL: Soil Type: Colour, Consistency, Structure, | | | |
| 8 | 8 | 1.00 | Rotary Drilling method, 96 mm / HQ Bit with Double Tube Core barrel | 100 | 25 | 4,8 | | | | | | | | | | | | **Overburden/ Sandy Gravels (0.00-26.00 m):** It consists of light grey to grey, fine to medium grained sand with occasionally silt and angular to sub angular gravels of variegated origin. | | | 8 |
| 9 | 9 | 1.00 | | 40 | 23 | | | | | | | | | | | | | | 10 cm wash sample is collected comprising of white medium silty sand and rock cuttings. | | 9 |
| 10 | 10 | 1.00 | | 40 | 27 | 5 | | | | | | | | | | | | | 10 cm wash sample is collected comprising of white medium silty sand and rock cuttings. | | 10 |
| 11 | 11 | 1.00 | | 30 | 20 | 3,6 | | | | | | | | | | | | | 12 cm wash sample is collected comprising of brownish grey, silty medium to fine sand and rock cuttings. | | 11 |
| 12 | 12 | 1.00 | | 20 | 62 | 18,40 | | | | | | | | | | | | | 15 cm wash sample is collected comprising of grey plastic clayey silt. | | 12 |
| 13 | 13 | 2.00 | | 100 | 59 | 20,20 | | | | | | | | | | | | | | | 13 |
| 14 | 14 | 1.00 | | 100 | 46 | | | | | | | | | | | | | | | | 14 |
| 15 | 15 | 1.00 | | 100 | 37 | | | | | | | | | | | | | | | | 15 |

**LEGEND:** Standard Penetration Test | Cone Penetration Test | Gravelly Sand | Sandy Gravel/ Cobble/boulder | Boulder/ Gravel

**Note:**

1 Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable

2 SOP for Refusal criteria: (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

| HYDRO PLANNING | BOREHOLE No. | BH-03 | Project: | ATTABAD LAKE HYDROPOWER PROJECT | Page | 3 of 8 |
|---|---|---|---|---|---|---|
| | | | Site: | Sediment Flushing Channel | | |

| DRILLING | | | | | RECOVERY | | Standared Penetration Test / Cone Penetration Test | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | Core Recovery % | Solid Core pieces (cm) | Test # | Penetration Blows 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | Field Test | Permeability test Result | Profile | GENERAL DESCRIPTION<br>SOIL: Soil Type: Colour, Consistency, Structure, | Remarks | Elevation (masl) | Depth (m) |
| 16 | 16 | 1.00 | Rotary Drilling method, 96 mm / HQ Bit with Double Tube Core barrel | 100 | 35 | | | | | | | | | | | | | **Overburden/ Sandy Gravels (0.00-26.00 m):** It consists of light grey to grey, fine to medium grained sand with occasionally silt and angular to sub angular gravels of variegated origin. | | | 16 |
| 17 | 17 | 1.00 | | 100 | 15 | 3,10 | | | | | | | | | | | | | | | 17 |
| 18 | 18 | 1.00 | | 100 | 37 | 94 | | | | | | | | | | | | | | | 18 |
| 19 | 19 | 1.00 | | 100 | 96 | 9,36,9 | | | | | | | | | | | | | | | 19 |
| 20 | 20 | 1.00 | | 100 | 79 | | | | | | | | | | | | | | | | 20 |
| 21 | 21 | 1.00 | | 100 | 77 | 25,40 | | | | | | | | | | | | | | | 21 |
| 22 | 22 | 1.00 | | 100 | 41 | 10 | | | | | | | | | | | | | | | 22 |
| 23 | 23 | 1.00 | | 100 | 48 | 3 | CPT-01 | 14 | 12/0 | | | | Refusal | | | | | | | | 23 |

k1=Head could not be maintained.

k2=Head could't be maintained.

| LEGEND: | Standard Penetration Test | Cone Penetration Test | Gravelly Sand | Sandy Gravel/ Cobble/ boulder | Boulder/ Gravel |
|---|---|---|---|---|---|

**Note:**

1 Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable

2 Refusal criteria is adopted as (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

| HYDRO PLANNING | BOREHOLE No. | BH-03 | Project: | ATTABAD LAKE HYDROPOWER PROJECT | Page | 4 of 8 |
|---|---|---|---|---|---|---|
| | | | Site: | Sediment Flushing Channel | | |

| DRILLING | | | | | RECOVERY | | Standared Penetration Test / Cone Penetration Test | | | | | | | | | | | | GENERAL DESCRIPTION | Remarks | Elevation (masl) | Depth (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | Core Recovery % | Solid Core pieces (cm) | Test # | Penetration Blows 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | Field Test | Permeability test Result | Profile | SOIL: Soil Type: Colour, Consistency, Structure, | | | |
| 24 | 24 | 1.00 | HQ Bit with Double Tube Core barrel | 100 | 29 | 2 | | | | | | | | | | k3=Head could't be maintained. | | **Overburden/ Sandy Gravels (0.00-26.00 m):** It consists of light grey to grey, fine to medium grained sand with occasionally silt and angular to sub angular gravels of variegated origin. | | | 24 |
| 25 | 25 | 1.00 | Rotary Drilling method, 76 mm / NQ Diamond Bit with Double Tube Core barrel | 100 | 60 | 3,14,3,2,5 | | | | | | | | | | | | | | | 25 |
| 26 | 26 | 1.00 | | 100 | 73 | 27,28,7 | | | | | | | | | | | | | | | 26 |
| 27 | 27 | 1.00 | | 25 | 36 | 12,10 | CPT-02 | 10/0 | | | | | Refusal | | | k4=0.001226 cm/sec | | **Overburden/ Sandy Gravels (26.00-30.00 m):** It consists of light grey to grey, coarse to medium grained sand with angular to sub angular gravels of variegated origin. | 17 cm wash sample is collected comprising of grey medium to coarse sand. | | 27 |
| 28 | 28 | 1.00 | | 35 | 34 | 12 | | | | | | | | | | | | | 17 cm wash sample is collected comprising of grey medium to coarse sand. | | 28 |
| 29 | 29 | 1.00 | | 100 | 75 | 15,7,11, 28 | | | | | | | | | | | | | | | 29 |
| 30 | 30 | 1.00 | | 30 | 30 | 3,2,3 | CPT-03 | 10/0 | | | | | Refusal | | | | | | 2 No. wash samples (each of 15 cm) comprising of grey medium sand are collected. | | 30 |
| 31 | 31 | 1.00 | | 30 | 20 | 5 | | | | | | | | | | | | **Overburden/ Sandy Gravels (30.00-41.00 m):** It consists of light grey to grey, fine to medium grained sand with angular to sub angular gravels of variegated origin. | 2 No. wash samples (each of 17 cm) comprising of grey fine to medium sand are collected. | | 31 |

**LEGEND:** Standard Penetration Test | Cone Penetration Test | Gravelly Sand | Sandy Gravel /Cobble/boulder | Boulder/ Gravel

**Note:**

1 Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable

2 Refusal criteria is adopted as (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

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| HYDRO PLANNING | BOREHOLE No. | BH-03 | Project: | ATTABAD LAKE HYDROPOWER PROJECT | Page | 5 of 8 |
|---|---|---|---|---|---|---|
| | | | Site: | Sediment Flushing Channel | | |

| DRILLING | | | | | RECOVERY | | Standared Penetration Test / Cone Penetration Test | | | | | | | | | | | GENERAL DESCRIPTION | Remarks | Elevation (masl) | Depth (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | Core Recovery % | Solid Core pieces (cm) | Test # | Penetration Blows 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | Field Test | Permeability test Result | Profile | SOIL: Soil Type: Colour, Consistency, Structure, | | | |
| 32 | 32 | 1.00 | Rotary Drilling method, 76 mm / NQ Diamond Bit with Double Tube Core barrel | 40 | 30 | 15,13 | | | | | | | | | | k5=0.007040 cm/sec | | **Overburden/ Sandy Gravels (30.00-41.00 m):** It consists of light grey to grey, fine to medium grained sand with angular to sub angular gravels of variegated origin. | 2 No. wash samples (each of 16 cm) comprising of grey medium sand are collected. | | 32 |
| 33 | 33 | 1.00 | | 50 | 12 | 4 | | | | | | | | | | | | | 2 No. wash samples (each of 17 cm) comprising of grey, fine to medium sand are collected. | | 33 |
| 34 | 34 | 1.00 | | 50 | 40 | 4,15 | CPT-04 | 21 | 40/0 | | | | Refusal | | | | | | 2 No. wash samples (each of 17 cm) comprising of grey, silty, fine to medium sand are collected. | | 34 |
| 35 | 35 | 1.00 | | 40 | 54 | 3,38,11 | | | | | | | | | | | | | 2 No. wash samples (each of 16 cm) comprising of grey, fine to medium sand are collected. | | 35 |
| 36 | 36 | 1.00 | | 40 | 29 | 3,3 | | | | | | | | | | k6=0.003243 cm/sec | | | 17 cm wash sample is collected comprising of grey medium sand. | | 36 |
| 37 | 37 | 1.00 | | 40 | 20 | 2 | CPT-05 | 20 | 11 | 23/0 | | | Refusal | | | | | | 2 No. wash samples (each of 15 cm) comprising of grey, fine to medium sand are collected. | | 37 |
| 38 | 38 | 1.00 | | 100 | 45 | 25,14 | | | | | | | | | | | | | | | 38 |
| 39 | 39 | 1.00 | | 100 | 100 | 100 | CPT-06 | 20/0 | | | | | Refusal | | | | | | | | 39 |

**LEGEND:** Standard Penetration Test | Cone Penetration Test | Gravelly Sand | Sandy Gravel /Cobble/boulder | Boulder/ Gravel

**Note:**

1 Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable

2 Refusal criteria is adopted as (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

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| HYDRO PLANNING | BOREHOLE No. | BH-03 | Project: | ATTABAD LAKE HYDROPOWER PROJECT | Page | 6 of 8 |
|---|---|---|---|---|---|---|
| | | | Site: | Sediment Flushing Channel | | |

| DRILLING | | | | | RECOVERY | | Standared Penetration Test / Cone Penetration Test | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | Core Recovery % | Solid Core pieces (cm) | Test # | Penetration Blows 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | Field Test | Permeability test Result | Profile | GENERAL DESCRIPTION<br>SOIL: Soil Type: Colour, Consistency, Structure, | Remarks | Elevation (masl) | Depth (m) |
| 40 | 40 | 1.00 | Rotary Drilling method, 76 mm / NQ Diamond Bit with Double Tube Core barrel | 100 | 98 | 3,9,14,4, 38,15,15 | | | | | | | | | | | | **Overburden/ Sandy Gravels (30.00-41.00 m):** It consists of light grey to grey, fine to medium grained sand with angular to sub angular gravels variegated origin. | | | 40 |
| 41 | 41 | 1.00 | | 100 | 66 | 13,7,9,9, 8,20 | | | | | | | | | | | | | | | 41 |
| 42 | 42 | 1.00 | | 40 | 31 | 18,8,5 | | | | | | | | | | k7=0.002813 cm/sec | | **Overburden/ Sandy Gravels (41.00-46.00 m):** It consists of light grey to grey, coarse to medium grained sand with angualr to sub angular gravels of variegated origin. | 17 cm wash sample is collected comprising of grey medium to coarse sand. | | 42 |
| 43 | 43 | 1.00 | | 50 | 27 | 6,9,3,9 | CPT-07 | 20 | 15 | 10/0 | ? | ? | Refusal | | | | | | 16 cm wash sample is collected comprising of grey medium to coarse sand. | | 43 |
| 44 | 44 | 1.00 | | 50 | 34 | 5,13,6,1 0 | | | | | | | | | | | | | 16 cm wash sample is collected comprising of grey medium to coarse sand. | | 44 |
| 45 | 45 | 1.00 | | 50 | 30 | 9,2,7,2,2 ,3,5 | | | | | | | | | | | | | 16 cm wash sample is collected comprising of grey medium to coarse sand. | | 45 |
| 46 | 46 | 1.00 | | 40 | 25 | 11,6,2,6 | CPT-08 | 16 | 18 | 20/0 | | | Refusal | | | k8=0.001832 cm/sec | | | 34 cm wash sample is collected comprising of grey to dark grey coarse sand. | | 46 |
| 47 | 47 | 1.00 | | 40 | 27 | 8,19 | | | | | | | | | | | | **Overburden/ Sandy Gravels (46.00-54.00 m):** It consists of light grey to grey, fine to medium grained sand with angular to sub angular gravels of variegated origin. | 34 cm wash sample is collected comprising of grey medium to fine sand. | | 47 |

**LEGEND:** Standard Penetration Test | Cone Penetration Test | Gravelly Sand | Sandy Gravel /Cobble/boulder | Boulder/ Gravel

**Note:**

1 Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable

2 Refusal criteria is adopted as (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

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| HYDRO PLANNING | BOREHOLE No. | BH-03 | Project: | ATTABAD LAKE HYDROPOWER PROJECT | Page | 7 of 8 |
|---|---|---|---|---|---|---|
| | | | Site: | Sediment Flushing Channel | | |

| DRILLING | | | | | RECOVERY | | Standered Penetration Test / Cone Penetration Test | | | | | | | | | | | GENERAL DESCRIPTION | Remarks | Elevation (masl) | Depth (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | Core Recovery % | Solid Core pieces (cm) | Test # | Penetration Blows 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | Field Test | Permeability test Result | Profile | SOIL: Soil Type: Colour, Consistency, Structure, | | | |
| 48 | 48 | 1.00 | Rotary Drilling method, 76 mm / NQ Diamond Bit with Double Tube Core barrel | 50 | 41 | 5,24,3,9 | | | | | | | | | | k9=0.002621 cm/sec | | **Overburden/ Sandy Gravels (46.00-54.00 m):** It consists of light grey to grey, fine to medium grained sand with gravels of rounded to sub rounded and variegated origin. | 17 cm wash sample is collected comprising of grey medium to fine sand. | | 48 |
| 49 | 49 | 1.00 | | 50 | 37 | 6,6,20,5 | | | | | | | | | | | | | 17 cm wash sample is collected comprising of grey fine to medium sand. | | 49 |
| 50 | 50 | 1.00 | | 50 | 23 | 23 | CPT-09 | 14 | 10 | 15 | 19 | ? | Refusal | | | | | | 17 cm wash sample is collected comprising of grey fine to medium sand. | | 50 |
| 51 | 51 | 1.00 | | 50 | 24 | 8,8,8 | | | | | | | | | | k10=0.001082 cm/sec | | | 34 cm wash sample is collected comprising of grey medium to fine sand. | | 51 |
| 52 | 52 | 1.00 | | 30 | 66 | 45,4,7,8,2 | CPT-10 | 4 | 7 | 6 | 8 | 8 | 29 | | | | | | 17 cm wash sample is collected comprising of grey medium to fine sand. | | 52 |
| 53 | 53 | 1.00 | | 30 | 75 | 45,20,10 | | | | | | | | | | | | | 17 cm wash sample is collected comprising of grey medium to fine sand. | | 53 |
| 54 | 54 | 1.00 | | 40 | 45 | 6,4,8,2,17,8 | | | | | | | | | | | | | 17 cm wash sample is collected comprising of grey medium to fine sand. | | 54 |
| 55 | 55 | 1.00 | | 30 | 78 | 9,2,4,2,11,14,36 | | | | | | | | | | | | **Overburden/ Sandy Gravels (54.00-61.00 m):** It consists of light grey to grey, coarse grained sand with angular to sub angular gravels of variegated origin. | 17 cm wash sample is collected comprising of grey coarse sand. | | 55 |

**LEGEND:** Standard Penetration Test | Cone Penetration Test | Gravelly Sand | Sandy Gravel /Cobble/boulder | Boulder/ Gravel

**Note:**

1 Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable

2 Refusal criteria is adopted as (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

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| HYDRO PLANNING | BOREHOLE No. | BH-03 | Project: | ATTABAD LAKE HYDROPOWER PROJECT | Page | 8 of 8 |
|---|---|---|---|---|---|---|
| | | | Site: | Sediment Flushing Channel | | |

| DRILLING | | | | | RECOVERY | | Standared Penetration Test / Cone Penetration Test | | | | | | | | | | | GENERAL DESCRIPTION | Remarks | Elevation (masl) | Depth (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | Core Recovery % | Solid Core pieces (cm) | Test # | Penetration Blows 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | Field Test | Permeability test Result | Profile | SOIL: Soil Type: Colour, Consistency, Structure, | | | |
| 56 | 56 | 1.00 | Rotary Drilling method, 76 mm / NQ Diamond Bit with Double Tube Core barrel | 30 | 56 | 17,23,10,6 | CPT-11 | 11 | 9 | 13 | 10/0 | | Refusal | | | k11=0.001436 cm/sec | | **Overburden/ Sandy Gravels (54.00-61.00 m):** It consists of light grey to grey, coarse grained sand with angular to sub angular gravels of variegated origin. | 17 cm wash sample is collected comprising of grey coarse sand. | | 56 |
| 57 | 57 | 1.00 | | 40 | 49 | 12,2,14,16,5 | | | | | | | | | | | | | 17 cm wash sample is collected comprising of grey coarse sand. | | 57 |
| 58 | 58 | 1.00 | | 30 | 68 | 12,47,9 | | | | | | | | | | | | | 17 cm wash sample is collected comprising of grey coarse sand. | | 58 |
| 59 | 59 | 1.00 | | 30 | 68 | 13,14,33,8 | CPT-12 | 20 | 10/0 | | | | Refusal | | | k12=0.000724 cm/sec | | | 17 cm wash sample is collected comprising of grey coarse sand. | | 59 |
| 60 | 60 | 1.00 | | 30 | 59 | 6,8,12,6,9,12,6 | | | | | | | | | | | | | 34 cm wash sample is collected comprising of grey coarse sand. | | 60 |
| 61 | 61 | 1.00 | | 60 | 23 | 6,7,10 | | | | | | | | | | | | Bottom of borehole at 61.00 m. | 34 cm wash sample is collected comprising of grey coarse sand. | | 61 |
| 62 | | | | | | | | | | | | | | | | | | | | | 62 |
| 63 | | | | | | | | | | | | | | | | | | | | | 63 |

**LEGEND:** Standard Penetration Test | Cone Penetration Test | Gravelly Sand | Sandy Gravel /Cobble/boulder | Boulder/ Gravel

**Note:**

1 Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable

2 Refusal criteria is adopted as (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

PUBLIC PROCUREMENT REGULATORY AUTHORITY EPADS

# BH-04

**HYDRO PLANNING, WAPDA**

**BOREHOLE No.:** BH-04

| ROCK FABRIC TYPE | | GRAIN SIZE | | mm |
|---|---|---|---|---|
| M | Massive | V F | Very Fine | <0.06 |
| B | Bedded / Banded | F | Fine | 0.06-0.2 |
| CB | Cross-bedded | M | Medium | 0.2-0.6 |
| L | Laminated | C | Coarse | 0.6-2.0 |
| F | Foliated | VC | Very Coarse | >2.0 |
| C | Cleaved | Beds / Laminations | | mm |
| S | Schistose | tn | Thin | <100 |
| G | Gneissose | tk | Thick | >300 |

| ROUGHNESS | | | | DISCONT. SPACING | | | WEATHERING | | | ROCK STRENGTH - MPa and DISCONTINUITY WALL HARDNESS | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sl | Slickensided | | | EC | E. Closely | <0.02m | T | Transported Soil | | | | | |
| Sm | Smooth | | | VC | V. Closely | 0.02-0.06m | | | | | | | |
| SR | Slightly Rough | | | C | Closely | 0.06-0.2m | R | Residual Soil | | | | | |
| M | Medium Rough | | | M | Medium | 0.2-0.6m | C | Completely | | VL | Very Low | 1-25 | |
| R | Rough | | | W | Widely | 0.6-2.0m | H | Highly | | L | Low | 25-50 | |
| VR | Very Rough | | | VW | V. Widely | 2.0 -6.0m | M | Moderately | | M | Medium | 50-100 | |
| P | Planar | St | Stepped | EW | E. Widely | >6m | S | Slightly | | H | High | 100-200 | |
| U | Undulating | | | V | Very | Extremely | U | Unweathered | | VH | Very High | >200 | |

| | |
|---|---|
| **Project :** | ATTABAD LAKE HYDROPOWER PROJECT |
| **Site:** | POWER TUNNEL ALIGNMENT |
| Easting: | 482609.57 |
| Northing: | 4017721.34 |
| Elevation : | 2445.37 m |
| Dip : | 90° |
| Bearing : | N/A |
| Final Depth : | 80 m |
| Drilling Co. : | DID, WAPDA |
| Driller : | Nawaz |
| BOREHOLE No. : | BH-04 |
| Page : | 1 / 7 |
| Logged by: | Toqeer Ahmad |
| Checked By: | Umar Tariq |
| Date Started: | 10-10-2020 |
| Date Completed: | 29-10-2020 |
| RIG: | Longyear |

| DRILLING | | | | RECOVERY | | ROCK FABRIC | | | | DISCONTINUITIES | | | | | | | | | | | | | | GENERAL DESCRIPTION | Weathering | | | | Strength | | | | REMARKS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Drill run (m) | Drilling method | Water Loss % | % Core Recovery | % R.Q.D | Grain Size (mm) | Type | Inclination (°) * | Spacing (mm) | Type | Inclination (°) * | Spacing | Roughness | Wall Hardness | Fill Type | Fill Thickness (mm) | Fracture Frequency | FIELD TESTS | Results | Lugeon Test and Test level | PROFILE | | | Slightly | Moderately | Highly | Completely | Very Low | Low | Medium | High | | Elevation (masl) | Depth (m) |
| 1 | Open pit | | | | | | | | | | | | | | | | | | | | | SOIL: Soil Type: Colour, Consistency, Structure, Origin<br>ROCK: Rock Type: Weathering, Joint spacing, Colour, Fabric, Strength | | | | | | | | | | | |
| 2 | 1.00 | Rotary Drilling Method, 76 mm /NQ Diamond Bit with Single tube core barrel upto 04m | 05 | 14 | | | | | | | | | | | | | | | | | | **Overburden (0.00-6.00m):**<br>Overburden material consists of angular coarse gravel and cobbles of Granodiorite and Granitic Gneiss with light grey silty micaceous fine to medium sand. | | | | | | | | | Borehole stabilised with cement upto 07m | | 1 |
| 3 | 1.00 | | 05 | 12 | | | | | | | | | | | | | | | | | | | | | | | | | | | 22 cm wash sample of brown color, micaceous coarse to medium sand. | | 2 |
| 4 | 1.00 | | 70 | 12 | | | | | | | | | | | | | | | | | | | | | | | | | | | 23 cm wash sample of brown color, micaceous coarse to medium sand. | | 3 |
| 5 | 1.00 | | 100 | 18 | | | | | | | | | | | | | | | | | | | | | | | | | | | 20 cm wash sample of brown color, micaceous medium sand. | | 4 |
| 6 | 1.00 | | 100 | 15 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 |
| 7 | 2.00 | Rotary Drilling Method, 76 mm /NQ Diamond Bit with double tube core barrel from 04m to 80m | 20 | 91 | 41 | C | F | 45-55° | 1-4 | SJ<br>SJ<br>J<br>J<br>J | 55<br>50<br>60<br>50<br>50 | VC<br>VC<br>W<br>VC<br>VC | PVSm<br>PSm<br>PR<br>PSm<br>PVR | L<br>L<br>M<br>M<br>M | Clean<br>Clean<br>Stained<br>Stained<br>Clean | Nil<br>Nil<br>Nil<br>Nil<br>Nil | 15 | | | | | Top of rock at 6.00m<br>**Mylonised Granitic Gneiss (6.00-11.78m):**<br>It is grey and white in color, coarse grained, highly foliated, slightly weathered, highly jointed, mylonised and low to medium strong rock. Major mineral constituents include Feldspar, Quartz and Biotite. Shattered Garnet crystals are found at places. Abundance of mica forms weak planes and joint surfaces. Ductile deformation is superimposed by brittle deformation. From 6.53m to 6.66m, Pegmatite vein encountered with 50° angle | | | | | | | | | | | 7 |
| 8 | | | | | | | | | | SJ<br>J<br>SJ | 47<br>55<br>60 | C<br>C<br>W | UR<br>Usm<br>UR | M<br>L<br>M | Clean<br>Clean<br>Stained | Nil<br>Nil<br>Nil | 10 | | | | | | | | | | | | | | | | | | 8 |
| 9 | 2.00 | | 15 | 85 | 70 | | | | | SJ<br>J<br>SJ<br>J<br>J | 40<br>50<br>52<br>55<br>60 | VC<br>VC<br>M<br>C<br>C | PR<br>UR<br>PR<br>PSm<br>PR | L<br>L<br>M<br>L<br>M | Stained<br>Stained<br>Stained<br>Clean<br>Stained | Nil<br>Nil<br>Nil<br>Nil<br>Nil | 9 | | | | | At 8.24, 2 cm thick Pegmatite vein encountered with 52° angle | | | | | | | | | | | 9 |
| 10 | | | | | | | | | | J<br>J<br>J | 64<br>53<br>50<br>45 | VW<br>M<br>M<br>W | Usm<br>Usm<br>PR<br>UR | L<br>L<br>M<br>M | Stained<br>Stained<br>Stained<br>Stained | Nil<br>Nil<br>Nil<br>Nil | 3 | | | | | | | | | | | | | | | | | 10 |
| 11 | 3.00 cont. | | 15 | 99 | 97 | | | | | J<br>J<br>J<br>J<br>J<br>J<br>J | 50<br>52<br>45<br>35<br>60<br>50<br>40 | M<br>M<br>M<br>W<br>W<br>W<br>M | Usm<br>PR<br>Usm<br>Usm<br>StR<br>Usm<br>PSm | M<br>M<br>L<br>M<br>M<br>L<br>M | Stained<br>Stained<br>Stained<br>Stained<br>Stained<br>Stained<br>Clean | Nil<br>Nil<br>Nil<br>Nil<br>Nil<br>Nil<br>Nil | 5 | | | 2.56<br>1 Bar<br>2.65<br>2 Bar | | | | | | | | | | | | 11 |
| 12 | | | | | | | | | | J<br>J | 40<br>60<br>60 | VW<br>M<br>W | PR<br>PSm<br>PSm | M<br>L<br>H | Stained<br>Clean<br>Stained | Nil<br>Nil<br>Nil | 5 | | | | | At 11.60m,1 cm thick Pegmatite vein encountered with 40° angle. | | | | | | | | | | | 12 |

**Legend:** Overburden | Granitic Gneiss

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**BOREHOLE No.:** BH-04

**Project :** ATTABAD LAKE HYDROPOWER PROJECT

**Site:** POWER TUNNEL ALIGNMENT



| Depth (m) | Drill run (m) | Drilling method | Water Loss % | % Core Recovery | % R.Q.D | Grain Size (mm) | Type | Inclination (°) * | Spacing | Type | Inclination (°) * | Spacing | Roughness | Wall Hardness | Fill Type | Fill Thickness (mm) | Fracture Frequency | FIELD TESTS | Results | Lugeon Test and Test level | PROFILE | GENERAL DESCRIPTION<br>SOIL: Soil Type: Colour, Consistency, Structure, Origin<br>ROCK: Rock Type: Weathering, Joint spacing, Colour, Fabric, Strength | Weathering: Slightly | Moderately | Highly | Completely | Strength: Very Low | Low | Medium | High | REMARKS / GEOMECHANICS RMC | Elevation (masl) | Depth (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 | | Rotary Drilling Method, 76 mm /NQ Diamond Bit with double tube core barrel from 04m to 80m | | | | M | | | | J | 50 | M | UR | H | Stained | Nil | 1 | | | 2.48<br>3 Bar | | **Granite Gneiss (11.78-13.06m)**:<br>It is light grey in color, medium grained, unweathered, slightly foliated, sparsely jointed and strong rock. Amphibole, felspar and quartz are major mineral constituents. | | | | | | | | | | | 13 |
| | | | | | | | | | | J | 50 | VW | UVR | H | Stained | Nil | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | J | 85 | VW | PVR | H | Stained | Nil | | | | | | | | | | | | | | | | | |
| 14 | 2.00 | | 20 | 97 | 92 | | | | | J | 60 | W | UR | H | Stained | Nil | 3 | | | 2.42<br>2 Bar | | **Mylonised Granitic Gneiss (13.06-23.50m))**:<br>It is grey and white bands in color, coarse grained, schistosed, slightly weathered, mylonised, highly jointed and low to medium strong rock. Major mineral constituents include Quartz, Feldspar and Biotite. Shattered Garnet crystals are found at places. Abundance of mica forms weak planes and joint surfaces. Augen structure developed at places. Ductile deformation is superimposed by brittle deformation. | | | | | | | | | | | 14 |
| 15 | | | | | | | | | | SJ | 60 | M | Usm | L | Clean | Nil | 1 | | | 2.27<br>1 Bar | | | | | | | | | | | | | 15 |
| 16 | 1.00 | | 20 | 92 | 58 | | | 55-65° | | SJ<br>J<br>J<br>J<br>J | 40<br>50<br>85<br>63<br>60 | W<br>W<br>EW<br>C<br>W | PSm<br>PR<br>StVR<br>UR<br>PR | L<br>M<br>M<br>M<br>L | Clean<br>Stained<br>Stained<br>Stained<br>Stained | Nil<br>Nil<br>Nil<br>Nil<br>Nil | 6 | | | 1.17<br>1 Bar | | From 15.36m to 15.46m, Pegmatite vein found with 50° angle | | | | | | | | | | | 16 |
| 17 | 1.00 | | 20 | 93 | 63 | | | | | J<br>J<br>J<br>J<br>J | 70<br>40<br>70<br>52<br>55 | M<br>W<br>W<br>C<br>W | Usm<br>UR<br>PR<br>PR<br>Usm | L<br>M<br>L<br>M<br>M | Stained<br>Stained<br>Stained<br>Stained<br>Stained | Nil<br>Nil<br>Nil<br>Nil<br>Nil | 7 | | | 1.12<br>2 Bar | | From 16.31m to 16.37m, Pegmatite vein found with 40° angle | | | | | | | | | | | 17 |
| 18 | 2.00 | | 15 | 98 | 95 | C | F | | 1-4 | J<br>J<br>J<br>J<br>J | 75<br>60<br>40<br>60<br>60 | EW<br>C<br>w<br>VC<br>VW | PR<br>UR<br>StR<br>Usm<br>Usm | M<br>M<br>M<br>L<br>L | Stained<br>Stained<br>Stained<br>Stained<br>Stained | Nil<br>Nil<br>Nil<br>Nil<br>Nil | 5 | | | 1.22<br>3 Bar | | | | | | | | | | | 18 |
| 19 | | | | | | | | | | J | 45 | W | PR | M | Clean | Nil | 2 | | | 1.009<br>2 Bar | | From 18.28m to 18.32m, irregular Pegmatite vein encountered. | | | | | | | | | | | 19 |
| 20 | 1.00 | | 15 | 91 | 90 | | | | | J | 65 | W | StR | M | Stained | Nil | 1 | | | 0.84<br>1 Bar | | | | | | | | | | | | | 20 |
| 21 | | | | | | | | | | J<br>J | 55<br>45 | VW<br>VW | Usm<br>Usm | L<br>L | Stained<br>Stained | Nil<br>Nil | 2 | | | 1.42<br>1 Bar | | At 20.27m, 2 cm thick Quartz vein encountered. | | | | | | | | | | | 21 |
| 22 | 3.00 | | 15 | 97 | 89 | | | 50-60° | | J<br>J<br>J<br>J<br>J | 65<br>62<br>60<br>65<br>68 | M<br>C<br>C<br>M<br>W | Usm<br>StSm<br>UVSm<br>StSm<br>StSm | M<br>L<br>VL<br>VL<br>M | Stained<br>Stained<br>Stained<br>Stained<br>Stained | Nil<br>Nil<br>Nil<br>Nil<br>Nil | 4 | | | 1.39<br>2 Bar | | | | | | | | | | | 22 |
| 23 | | | | | | | | | | J | 50 | C | PSm | L | Stained | Nil | 2 | | | 1.45<br>3 Bar | | From 22.43m to 22.63m, Granitic Gneiss vein encountered. | | | | | | | | | | | 23 |
| 24 | 1.00 | | 15 | 92 | 60 | | | | | J<br>J<br>J<br>J<br>J | 50<br>70<br>40<br>48<br>45 | M<br>EW<br>C<br>M<br>VC | PSm<br>PR<br>PR<br>PR<br>PR | L<br>L<br>M<br>H<br>H | Stained<br>Stained<br>Clean<br>Clean<br>Clean | Nil<br>Nil<br>Nil<br>Nil<br>Nil | 9 | | | 1.14<br>2 Bar | | **Granitic Gneiss (23.50-80.00m)**:<br>It is grey in color, coarse to medium grained, foliated, unweathered, moderately jointed and medium to strong rock. Major mineral constituents are Quartz, Albite/ Plagioclase, K-feldspar and mica. At 24.26m, 2 cm thick Pegmatite vein encountered. | | | | | | | | | | | 24 |
| 25 | 1.00 | | 15 | 98 | 98 | | | | | J<br>J<br>J | 50<br>50<br>50 | M<br>W<br>W | PR<br>StR<br>StR | H<br>M<br>M | Clean<br>Stained<br>Stained | Nil<br>Nil<br>Nil | 2 | | | 1.03<br>1 Bar | | | | | | | | | | | | | 25 |

**Legend:** Overburden | Granitic Gneiss

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| BOREHOLE No.: | BH-04 | Project : | ATTABAD LAKE HYDROPOWER PROJECT | PAGE | 3 / 7 |
|---|---|---|---|---|---|
| | | Site: | POWER TUNNEL ALIGNMENT | | |

| DRILLING | | | | RECOVERY | | ROCK FABRIC | | | | DISCONTINUITIES | | | | | | | | FIELD TESTS | Results | Lugeon Test and Test level | PROFILE | GENERAL DESCRIPTION<br>SOIL: Soil Type: Colour, Consistency, Structure, Origin<br>ROCK: Rock Type: Weathering, Joint spacing, Colour, Fabric, Strength | Weathering | | | | Strength | | | | REMARKS / GEOMECHANICS RMC | Elevation (masl) | Depth (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Drill run (m) | Drilling method | Water Loss % | % Core Recovery | % R.Q.D | Grain Size (mm) | Type | Inclination (°) * | Spacing | Type | Inclination (°) * | Spacing | Roughness | Wall Hardness | Fill Type | Fill Thickness (mm) | Fracture Frequency | | | | | | Slightly | Moderately | Highly | Completely | Very Low | Low | Medium | High | | | |
| 26 | 2.00 | Rotary Drilling Method, 76 mm /NQ Diamond Bit with double tube core barrel from 04m to 80m | 10 | 96 | 94 | C-M | F | 50-60° | 1-4 | J | 45 | C | UR | H | Stained | Nil | Nil | | 1.72 | | **Granitic Gneiss (23.50-80.00m)**:<br>It is grey in color, medium to coarse grained, foliated, unweathered, moderately jointed and moderately strong to strong rock. Major mineral constituents are Quartz, Albite/ Plagioclase, K-feldspar and mica.<br>At 25.60m,1 cm thick Quartz vein found with 60° angle.<br>At 25.75m,1 cm thick Quartz vein found with 60° angle. | | | | | | | | | | | | 26 |
| | | | | | | | | | | J | 40 | C | PR | H | Stained | Nil | | | 1 Bar | | | | | | | | | | | | | |
| | | | | | | | | | | J | 40 | VW | PR | H | Clean | Nil | 5 | | 1.33 | | | | | | | | | | | | | |
| 27 | | | | | | | | | | J | 60 | W | PVR | H | Clean | Nil | | | 2 Bar | | | | | | | | | | | | | |
| | | | | | | | | | | J | 82 | VW | PSm | H | Stained | Nil | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | 1.68 | | | | | | | | | | | | | |
| 28 | | | | | | | | 45-55° | | J | 60 | C | PR | M | Stained | Nil | 2 | | **3 Bar** | | | | | | | | | | | | | |
| | | | | | | | | | | J | 60 | C | StR | L | Stained | Nil | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | 1.42 | | | | | | | | | | | | | |
| 29 | 3.00 | | 10 | 96 | 91 | | | | | J | 62 | VW | PR | H | Stained | Nil | 1 | | 2 Bar | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | 1.11 | | | | | | | | | | | | | |
| 30 | | | | | | C | | | | | | | | | | | Nil | | 1 Bar | | | | | | | | | | | | | |
| | | | | | | | | | | J | 83 | W | UR | M | Stained | Nil | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | 0.56 | | | | | | | | | | | | | |
| 31 | | | | | | | | | | SJ | 70 | C | PR | L | Stained | Nil | 3 | | 2 Bar | | | | | | | | | | | | | |
| | | | | | | | | | | SJ | 70 | C | PR | L | Stained | Nil | | | | | | | | | | | | | | | | |
| | | | | | | | | | | SJ | 70 | VC | PR | L | Stained | Nil | | | | | | | | | | | | | | | | |
| 32 | 2.50 | | 60 | 95 | 76 | | | 50-60° | | SJ | 70 | W | PR | L | Stained | Nil | 2 | | 0.69 | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | 3 Bar | | | | | | | | | | | | | |
| | | | | | | | | | | J | 50 | M | PR | M | Stained | Nil | | | | | | | | | | | | | | | | |
| | | | | | | | | | | J | 40 | VC | PR | M | Clean | Nil | | | | | | | | | | | | | | | | |
| | | | | | | M | | | | J | 40 | W | PR | M | Clean | Nil | 9 | | 0.64 | | | | | | | | | | | | | |
| 33 | | | | | | | | 35-40° | | J | 45 | C | PR | H | Clean | Nil | | | **5 Bar** | | | | | | | | | | | | | |
| | | | | | | | | | | J | 25 | EW | PR | M | Stained | Nil | | | | | | | | | | | | | | | | |
| | | | | | | | | | | J | 70 | W | PR | L | Stained | Nil | | | | | | | | | | | | | | | | |
| | | | | | | | | | | J | 40 | EW | PVR | M | Clean | Nil | 3 | | 0.66 | | | | | | | | | | | | | |
| 34 | 2.50 | | 50 | 96 | 83 | | | | | | | | | | | | | | 3 Bar | | | | | | | | | | | | | |
| | | | | | | | | | | J | 63 | W | UR | VL | Stained | Nil | | | | | | | | | | | | | | | | |
| | | | | | | | | | | J | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | J | 70 | W | PR | M | Stained | Nil | | | 0.46 | | | | | | | | | | | | | |
| | | | | | | | | | | | 60 | C | PR | L | Stained | Nil | 4 | | 2 Bar | | At 34.17m, 2 cm thick Pegmatite vein found with 60° angle. | | | | | | | | | | | | |
| 35 | | | | | | | | | | J | 50 | W | PSm | L | Stained | Nil | | | | | | | | | | | | | | | | |
| | | | | | | | | | | J | 60 | VW | PR | M | Stained | Nil | | | | | | | | | | | | | | | | |
| | | | | | | | | | | J | 70 | VW | UR | M | Clean | Nil | | | | | | | | | | | | | | | | |
| | | | | | | M-C | | | | J | 50 | M | PR | M | Stained | Nil | | | | | | | | | | | | | | | | |
| | | | | | | | | | | J | 55 | C | UR | M | Stained | Nil | 4 | | 2.1 | | | | | | | | | | | | | |
| 36 | | | | | | | | 50-60° | | | 50 | W | PSm | M | Stained | Nil | | | 2 Bar | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 3.00 | | 50 | 94 | 91 | | | | | | | | | | | | Nil | | 2.42 | | | | | | | | | | | | | |
| 37 | | | | | | | | | | | | | | | | | | | 3 Bar | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | From 37.07m to 37.13m, Pegmatite vein found with 30° angle. | | | | | | | | | | | | |
| | | | | | | | | | | J | 50 | W | PR | M | Stained | Nil | 1 | | 2.61 | | | | | | | | | | | | | |
| 38 | | | | | | | | | | | | | | | | | | | **5 Bar** | | | | | | | | | | | | | |

From 30.08 to 30.32m, Pegmatite vein found.

**Legend:** Overburden | Granitic Gneiss

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**Site:** POWER TUNNEL ALIGNMENT



| DRILLING | | | | RECOVERY | | ROCK FABRIC | | | | DISCONTINUITIES | | | | | | | Fracture Frequency | FIELD TESTS | Results | Lugeon Test and Test level | PROFILE | GENERAL DESCRIPTION | Weathering | | | | Strength | | | | REMARKS / GEOMECHANICS RMC | Elevation (masl) | Depth (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Drill run (m) | Drilling method | Water Loss % | % Core Recovery | % R.Q.D | Grain Size (mm) | Type | Inclination (°)* | Spacing | Type | Inclination (°)* | Spacing | Roughness | Wall Hardness | Fill Type | Fill Thickness (mm) | | | | | | SOIL: Soil Type: Colour, Consistency, Structure, Origin<br>ROCK: Rock Type: Weathering, Joint spacing, Colour, Fabric, Strength | Slightly | Moderately | Highly | Completely | Very Low | Low | Medium | High | | | |
| 39 | 2.00 | Rotary Drilling Method, 76 mm /NQ Diamond Bit with double tube core barrel from 04m to 80m | NIL | 97 | 94 | M-C | F | 50-60° | 1-4 | J<br>J | 50<br>50 | VC<br>W | US<br>US | M<br>M | Clean<br>Clean | Nil<br>Nil | 2 | | 2.28<br>3 Bar | | **Granitic Gneiss (23.50-80.00m)**:<br>It is grey in color, medium to coarse grained, foliated, unweathered, sparsely jointed and strong rock. Major mineral constituents are Quartz, Albite/ Plagioclase, K-feldspar and mica. | | | | | | | | | | 39 |
| 40 | | | | | | | | | | | | | | | | | Nil | | 1.95<br>2 Bar | | | From 39.64m to 39.90m, Pegmatite vein found with 30° angle | | | | | | | | | | 40 |
| 41 | 3.00 | | 40 | 98 | 98 | | | | | J<br>J | 60<br>50 | EW<br>W | PR<br>UR | H<br>H | Stained<br>Stained | Nil<br>Nil | 2 | | 3.34<br>2 Bar | | | | | | | | | | | | | | 41 |
| 42 | | | | | | | | | | J | 50 | W | PR | H | Stained | Nil | 1 | | 3.64<br>3 Bar | | | | | | | | | | | | | | 42 |
| 43 | | | | | | | | | | J | 45 | EW | UR | H | Clean | Nil | 1 | | 3.77<br>**5 Bar** | | | At 42.40m,1 cm thick Pegmatite vein found with 60° angle<br>At 42.60m,1 cm thick Pegmatite vein found with 27° angle | | | | | | | | | | 43 |
| 44 | 2.00 | | 20 | 98 | 97 | | | | | J<br>J | 30<br>40 | EW<br>EW | PR<br>UR | M<br>H | Clean<br>Clean | Nil<br>Nil | 2 | | 3.63<br>3 Bar | | | At 43.14m,1.5 cm thick Pegmatite vein found with 62° angle | | | | | | | | | | 44 |
| 45 | | | | | | | | | | | | | | | | | Nil | | 3.18<br>2 Bar | | | From 43.82m to 43.90m, Pegmatite vein found with 30° angle | | | | | | | | | | 45 |
| 46 | 2.60 | | 05 | 98 | 97 | | | | | J | 20 | EW | PR | H | Clean | Nil | 1 | | 0.43<br>3 Bar | | | | | | | | | | | | | | 46 |
| 47 | | | | | | | | | | | | | | | | | Nil | | 0.44<br>5 Bar | | | | | | | | | | | | | | 47 |
| 48 | | | | | | C | | 48-58° | 1-5 | | | | | | | | Nil | | 0.43<br>**7 Bar** | | | At 47.58m,1 cm thick Pegmatite vein found with 60° angle | | | | | | | | | | 48 |
| 49 | 2.40 | | NIL | 98 | 98 | | | | | | | | | | | | Nil | | 0.41<br>5 Bar | | | | | | | | | | | | | | 49 |
| 50 | | | | | | | | | | | | | | | | | Nil | | 0.43<br>3 Bar | | | From 49.85m to 49.93m, Pegmatite vein found. | | | | | | | | | | 50 |
| 51 | 2.00<br>cont. | | NIL | 100 | 100 | | | | | | | | | | | | Nil | | 0.08<br>3 Bar | | | | | | | | | | | | | | 51 |

**Legend:** Overburden | Granitic Gneiss

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| BOREHOLE No.: | BH-04 | Project : | ATTABAD LAKE HYDROPOWER PROJECT | PAGE | 5 / 7 |
|---|---|---|---|---|---|
| | | Site: | POWER TUNNEL ALIGNMENT | | |

| DRILLING | | | | RECOVERY | | ROCK FABRIC | | | | DISCONTINUITIES | | | | | | | | FIELD TESTS | Results | Lugeon Test and Test level | PROFILE | GENERAL DESCRIPTION<br>SOIL: Soil Type: Colour, Consistency, Structure, Origin<br>ROCK: Rock Type: Weathering, Joint spacing, Colour, Fabric, Strength | Weathering | | | | Strength | | | | REMARKS / GEOMECHANICS RMC | Elevation (masl) | Depth (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Drill run (m) | Drilling method | Water Loss % | % Core Recovery | % R.Q.D | Grain Size (mm) | Type | Inclination (°) * | Spacing | Type | Inclination (°) * | Spacing | Roughness | Wall Hardness | Fill Type | Fill Thickness (mm) | Fracture Frequency | | | | | | Slightly | Moderately | Highly | Completely | Very Low | Low | Medium | High | | | |
| 52 | | | | | | | | | | | | | | | | | Nil | | | 0.09<br>5 Bar | | **Granitic Gneiss (23.50-80.00m)**:<br>It is grey in color, coarse grained, foliated, unweathered, very sparsely jointed and strong rock. Major mineral constituents are Quartz, Albite/ Plagioclase, K-feldspar and mica. | | | | | | | | | | | 52 |
| 53 | 1.00 | Rotary Drilling Method, 76 mm /NQ Diamond Bit with double tube core barrel from 04m to 80m | NIL | 100 | 100 | | | 42-52° | | J | 23 | EW | PR | H | Clean | Nil | 1 | | | 0.12<br>**7 Bar** | | | | | | | | | | | | | 53 |
| 54 | 1.00 | | NIL | 100 | 100 | | | | | | | | | | | | Nil | | | 0.09<br>5 Bar | | | | | | | | | | | | | 54 |
| 55 | 1.00 | | 10 | 100 | 100 | | | | | J | 40 | EW | PR | H | Stained | Nil | 1 | | | 0.08<br>3 Bar | | | | | | | | | | | | | 55 |
| 56 | 1.00 | | NIL | 99 | 99 | | | | | | | | | | | | Nil | | | 0.01<br>3 Bar | | From 55.78m to 55.92m, Pegmatite vein found with 30° angle | | | | | | | | | | | 56 |
| 57 | 1.00 | | NIL | 98 | 96 | C | F | | 1-5 | | | | | | | | Nil | | | 0.03<br>5 Bar | | | | | | | | | | | | | 57 |
| 58 | 3.00 | | NIL | 99 | 99 | | | 42-52° | | | | | | | | | Nil | | | 0.05<br>**7 Bar** | | | | | | | | | | | | | 58 |
| 59 | | | | | | | | | | | | | | | | | Nil | | | 0.03<br>5 Bar | | From 58.39m to 58.46m, Granitic vein encountered. | | | | | | | | | | | 59 |
| 60 | | | | | | | | | | | | | | | | | Nil | | | 0.02<br>3 Bar | | | | | | | | | | | | | 60 |
| 61 | 3.00 | | NIL | 99 | 99 | | | | | J | 68 | EW | PR | M | Clean | Nil | 1 | | | | | From 60.08m to 61.37m, Pegmatite vein encountered.<br>From 60.25m to 60.39m, Pegmatite vein found with 28° angle<br>From 60.56m to 60.75m, Pegmatite vein found with 28° angle | | | | | | | | | | | 61 |
| 62 | | | | | | | | | | | | | | | | | Nil | | | | | | | | | | | | | | | 62 |
| 63 | | | | | | | | | | | | | | | | | Nil | | | | | From 62.18m to 62.76m, Pegmatite vein found. | | | | | | | | | | | 63 |
| 64 | 2.00 cont. | | 10 | 99 | 99 | | | | | | | | | | | | Nil | | | | | At 63.70m, 1 cm thick Quartz vein found. | | | | | | | | | Water Table encounterd at 63.70m | | 64 |

**Legend:** Overburden | Granitic Gneiss

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**BOREHOLE No.:** BH-04

**Project :** ATTABAD LAKE HYDROPOWER PROJECT

**Site:** POWER TUNNEL ALIGNMENT



| DRILLING | | | | RECOVERY | | ROCK FABRIC | | | DISCONTINUITIES | | | |

| BOREHOLE No.: | BH-04 | Project : | ATTABAD LAKE HYDROPOWER PROJECT | PAGE | 7 / 7 |
|---|---|---|---|---|---|
| | | Site: | POWER TUNNEL ALIGNMENT | | |

| DRILLING | | | | RECOVERY | | ROCK FABRIC | | | | DISCONTINUITIES | | | | | | | Fracture Frequency | FIELD TESTS | Results | Lugeon Test and Test level | PROFILE | GENERAL DESCRIPTION<br>SOIL: Soil Type: Colour, Consistency, Structure, Origin<br>ROCK: Rock Type: Weathering, Joint spacing, Colour, Fabric, Strength | Weathering | | | | Strength | | | | REMARKS / GEOMECHANICS RMC | Elevation (masl) | Depth (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Drill run (m) | Drilling method | Water Loss % | % Core Recovery | % R.Q.D | Grain Size (mm) | Type | Inclination (°) * | Spacing | Type | Inclination (°) * | Spacing | Roughness | Wall Hardness | Fill Type | Fill Thickness (mm) | | | | | | | Slightly | Moderately | Highly | Completely | Very Low | Low | Medium | High | | | |
| 78 | | Rotary Drilling, 76mm NQ Diamond Bit with double tube core barrel | | | | C | F | 45-50° | 1-5 | J | 50 | EW | USm | L | Clean | Nil | 1 | | | | | **Granitic Gneiss (23.50-80.00m):**<br>It is grey in color, coarse grained, foliated, unweathered, very sparsely jointed and strong rock. Major mineral constituents are Quartz, Albite/ Plagioclase, K-feldspar and mica. | | | | | | | | | | | | 78 |
| 79 | 2.00 | | NIL | 100 | 100 | | | | | | | | | | | | Nil | | | | | From 77.50m to 77.65m, Pegmatite vein found.<br>From 78.02m, 3 cm thick Pegmatite vein found. | | | | | | | | | | | | 79 |
| 80 | | | | | | | | | | J | 45 | EW | USm | L | Clean | Nil | 1 | | | | | **Bottom of Borehole at 80.00m** | | | | | | | | | | | | 80 |

**Legend:** Overburden | Granitic Gneiss

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# BH-05

| HYDRO PLANNING WAPDA | | |

| HYDRO PLANNING | BOREHOLE No. | BH-05 | Project: | ATTABAD LAKE HYDROPOWER PROJECT | Page | 2 of 7 |
|---|---|---|---|---|---|---|
| | | | Site: | Power House | | |

| DRILLING | | | | | RECOVERY | | Standared Penetration / Cone Penetration Test | | | | | | | | | PROFILE | GENERAL DESCRIPTION | Remarks | Elevation (masl) | Depth (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | % Core Recovery | Core pieces (cm) | Test # | Standard Penetration Blows per 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | Field Test | Permeability test Result | | SOIL: Soil Type: Colour, Consistency, Structure, ROCK: Rock Type: Weathering, Joint spacing, Colour, Fabric, Strength | | | | |
| 8 | 7 | 1.00 | Rotary Drilling method, 76 mm / NQ Diamond Bit with Double Tube Core barrel | NIL | NIL | | | | | | | | | | | | | **Overburden Clayey Silt (04.00-24.00 m)**: It consists of fine to very fine grained, light grey to brownish grey clayey silty. | Borehole is stabilized with HW casing from 0.00 to 33.30 m. | | 8 |
| 9 | 8 | 1.00 | | NIL | NIL | | | | | | | | | | | | | | A 18 cm wash sample consists of light grey to brownish grey, very fine to fine clayey silt is obtained. | | 9 |
| 10 | 9 | 1.00 | | NIL | NIL | | SPT-03 | 5 | 2 | 4 | 3 | 3 | 12 | 45 | | | | Grey to brownish grey, stiff, fine to very fine clayey Silt. | A 18 cm wash sample consists of light grey to brownish grey, very fine to fine clayey silt is obtained. | | 10 |
| 11 | 10 | 1.00 | | NIL | NIL | | | | | | | | | | | | | | A 18 cm wash sample consists of light grey to brownish grey, very fine to fine clayey silt is obtained. | | 11 |
| 12 | 11 | 1.00 | | NIL | NIL | | | | | | | | | | | | | | A 18 cm wash sample consists of light grey to brownish grey, very fine to fine clayey silt is obtained. | | 12 |
| 13 | 12 | 1.00 | | NIL | NIL | | SPT-04 | 4 | 2 | 3 | 3 | 3 | 11 | 45 | | | | Grey to brownish grey, stiff, fine to very fine clayey Silt. | A 18 cm wash sample consists of light grey to brownish grey, very fine to fine clayey silt is obtained. | | 13 |
| 14 | 13 | 1.00 | | NIL | NIL | | | | | | | | | | | | | | A 18 cm wash sample consists of light grey to brownish grey, very fine to fine clayey silt is obtained. | | 14 |
| 15 | 14 | 1.00 | | NIL | NIL | | | | | | | | | | | K=0.0277 cm/sec | | | A 18 cm wash sample consists of light grey to brownish grey, very fine to fine clayey silt is obtained. | | 15 |

**LEGEND:** Standard Penetration Test | Cone Penetration Test | Clayey Silt | Sandy Gravel/ /Cobbles/boulder

**Note:**
1. Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable
2. SOP for Refusal criteria: (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

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| HYDRO PLANNING | BOREHOLE No. | BH-05 | Project: | ATTABAD LAKE HYDROPOWER PROJECT | Page | 3 of 7 |
|---|---|---|---|---|---|---|
| | | | Site: | Power House | | |

| DRILLING | | | | | RECOVERY | | Standared Penetration / Cone Penetration Test | | | | | | | | | PROFILE | GENERAL DESCRIPTION | Remarks | Elevation (masl) | Depth (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | % Core Recovery | Core pieces (cm) | Test # | Standard Penetration Blows per 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | Field Test | Permeability test Result | | SOIL: Soil Type: Colour, Consistency, Structure, ROCK: Rock Type: Weathering, Joint spacing, Colour, Fabric, Strength | | | |
| 16 | 15 | 1.00 | Rotary Drilling method, 76 mm / NQ Diamond Bit with Double Tube Core barrel | NIL | NIL | | SPT-05 | 4 | 3 | 3 | 4 | 3 | 13 | 27 | | | | Grey to brownish grey, stiff, fine to very fine clayey Silt. | Borehole is stabilized with HW casing from 0.00 to 33.30 m. | | 16 |
| 17 | 16 | 1.00 | | NIL | NIL | | | | | | | | | | | | | **Overburden/ Clayey Silt (05.00-24.00 m):** It is consists of fine to very fine grained, light grey to brownish grey clayey silty. | 18cm wash sample consists of light grey to brownish grey, very fine to fine clayey silt is obtained. A 24 cm wash sample consists of light grey to brownish grey, very fine to fine clayey silt is obtained. Water table encountered at 16.50 m. | | 17 |
| 18 | 17 | 1.00 | | NIL | NIL | | | | | | | | | | | | | | A 18 cm wash sample consists of light grey to brownish grey, very fine to fine clayey silt is obtained. | | 18 |
| 19 | 18 | 1.00 | | NIL | NIL | | SPT-06 | 4 | 3 | 3 | 3 | 2 | 11 | 21 | | K=0.00945 cm/sec | | Grey to brownish grey, stiff, fine to very fine clayey Silt. | A 18 cm wash sample consists of light grey to brownish grey, very fine to fine clayey silt is obtained. | | 19 |
| 20 | 19 | 1.00 | | NIL | NIL | | | | | | | | | | | | | | A 18 cm wash sample consists of light grey to brownish grey, very fine to fine clayey silt is obtained. | | 20 |
| 21 | 20 | 1.00 | | NIL | NIL | | | | | | | | | | | | | | A 18 cm wash sample consists of light grey to brownish grey, very fine to fine clayey silt is obtained. | | 21 |
| 22 | 21 | 1.00 | | NIL | NIL | | SPT-07 | 8 | 6 | 5 | 5 | 5 | 21 | 37 | | K= 0.00685 cm/sec | | Grey to brownish grey, very stiff, fine to very fine clayey Silt. | A 18 cm wash sample consists of light grey to brownish grey, very fine to fine clayey silt is obtained. | | 22 |
| 23 | 22 | 1.00 | | NIL | NIL | | | | | | | | | | | | | | A 18 cm wash sample consists of light grey to brownish grey, very fine to fine clayey silt is obtained. | | 23 |

**LEGEND:** Standard Penetration Test | Cone Penetration Test | Clayey Silt | Sandy Gravel/ /Cobbles/boulder

**Note:**

1 Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable

2 Refusal criteria is adopted as (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

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| HYDRO PLANNING | BOREHOLE No. | BH-05 | Project: | ATTABAD LAKE HYDROPOWER PROJECT | Page | 4 of 7 |
|---|---|---|---|---|---|---|
| | | | Site: | Power House | | |

| DRILLING | | | | | RECOVERY | | Standared Penetration / Cone Penetration Test | | | | | | | | | PROFILE | GENERAL DESCRIPTION | Remarks | Elevation (masl) | Depth (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | % Core Recovery | Core pieces (cm) | Test # | Standard Penetration Blows per 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | Field Test | Permeability test Result | | SOIL: Soil Type: Colour, Consistency, Structure, ROCK: Rock Type: Weathering, Joint spacing, Colour, Fabric, Strength | | | |
| 24 | 23 | 1.00 | Rotary Drilling method, 76 mm / NQ Diamond Bit with Double Tube Core barrel | 10 | NIL | | | | | | | | | | | | | **Overburden/ Clayey Silt (05.00-24.00 m)**: It consists of fine to very fine grained, light grey to brownish grey clayey silty. | Borehole is stabilized with HW casing from 0.00 to 33.30 m. A 18 cm wash sample consists of light grey to brownish grey, very fine to fine clayey silt is obtained. | | 24 |
| 25 | 24 | 1.00 | | 20 | NIL | | SPT-08 | 7 | 5 | 5 | 2 | 2 | 14 | 21 | | K=0.006359 cm/sec | | Grey to brownish grey, stiff, fine to very fine clayey Silt. | A 24 cm wash sample consists of grey, very fine to fine clayey silt is obtained. | | 25 |
| 26 | 25 | 1.00 | | 20 | NIL | | | | | | | | | | | | | **Overburden/ Sand (24.00-30.00 m):** It is consists of fine to very fine grained, light grey silty sand. | A 24 cm wash sample consists of light grey, medium to coarse grained sand is obtained. A 24 cm wash sample consists of light grey, medium to coarse grained sand is obtained. | | 26 |
| 27 | 26 | 1.00 | | 20 | NIL | | | | | | | | | | | | | | A 24 cm wash sample consists of light grey, medium to coarse grained sand is obtained. | | 27 |
| 28 | 27 | 1.00 | | 20 | NIL | | SPT-09 | 10 | 6 | 8 | 8 | 8 | 30 | 43 | | K= 0.004969 cm/sec | | Light grey to grey, very stiff, fine to very fine Silty Sand. | A 24 cm wash sample consists of light grey, medium to coarse grained sand is obtained. | | 28 |
| 29 | 28 | 1.00 | | 20 | NIL | | | | | | | | | | | | | | A 24 cm wash sample consists of light grey, medium to coarse grained sand is obtained. | | 29 |
| 30 | 29 | 1.00 | | 20 | NIL | | | | | | | | | | | | | | A 24 cm wash sample consists of light grey, medium to coarse grained sand is obtained. | | 30 |
| 31 | 30 | 1.00 | | 100 | 44 | 14G,7,13,5,5 | CPT-01 | 7 | 5 | 5 | 3 | 4 | 17 | | | | | **Overburden (30.00-50.00 m):** It consists of angular to sub-angular pebble, cobble and boulders of granodiorite, granite gneiss, embeded into clayey silty sand. | | | 31 |

**LEGEND:** Standard Penetration Test | Cone Penetration Test | Clayey Silt | Sandy Gravel/ /Cobbles/boulder | Sand

**Note:**

1. Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable
2. Refusal criteria is adopted as (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

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| HYDRO PLANNING | BOREHOLE No. | BH-05 | Project: | ATTABAD LAKE HYDROPOWER PROJECT | Page | 5 of 7 |
|---|---|---|---|---|---|---|
| | | | Site: | Power House | | |

| DRILLING | | | | | RECOVERY | | Standared Penetration / Cone Penetration Test | | | | | | | Field Test | Permeability test Result | PROFILE | GENERAL DESCRIPTION | Remarks | Elevation (masl) | Depth (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | % Core Recovery | Core pieces (cm) | Test # | Standard Penetration Blows per 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | | | | SOIL: Soil Type: Colour, Consistency, Structure, ROCK: Rock Type: Weathering, Joint spacing, Colour, Fabric, Strength | | | |
| 32 | 31 | 1.00 | Rotary Drilling method, 76 mm / NQ Diamond Bit with Double Tube Core barrel | 100 | 93 | 2G,6,18 ,38,29 | | | | | | | | | | | **Overburden (30.00-50.00 m):** It consists of angular to sub-angular pebble, cobble and boulders of granodiorite, granite gneiss, embeded into clayey silty sand | Borehole is stabilized with HW casing from 0.00 to 33.30 m. | | 32 |
| 33 | 32 | 1.00 | | 100 | 36 | 16,3G,7 ,4,6G | | | | | | | | | | | | | | 33 |
| 34 | 33 | 1.00 | | 100 | 43 | 6,25,12 | CPT-02 | 10 | 10/0 | | | | Refusal | | | | | Borehole is stabilized with cement from 33.30 to 48.00 m. | | 34 |
| 35 | 34 | 1.00 | | 100 | 40 | 11G,7,4 ,10,8G | | | | | | | | | | | | | | 35 |
| 36 | 35 | 1.00 | | 100 | 49 | 13G,6,2 ,3,3,5,5, 4,6,2 | | | | | | | | | | | | | | 36 |
| 37 | 36 | 1.00 | | 100 | 47 | 13,9,8,1 7 | | | | | | | | | | | | | | 37 |
| 38 | 37 | 1.00 | | 100 | 41 | 3G,6,6, 22,1,3 | | | | | | | | | | | | | | 38 |
| 39 | 38 | 1.00 | | 100 | 90 | 32,31, 4G,23 | | | | | | | | | | | | | | 39 |

**LEGEND:** Standard Penetration Test | Cone Penetration Test | Gravelly Sand | Sandy Gravel/ /Cobbles/boulder

**Note:**
1. Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable
2. Refusal criteria is adopted as (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

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| HYDRO PLANNING | BOREHOLE No. | BH-05 | Project: | ATTABAD LAKE HYDROPOWER PROJECT | Page | 6 of 7 |
|---|---|---|---|---|---|---|
| | | | Site: | Power House | | |

| DRILLING | | | | | RECOVERY | | Standared Penetration / Cone Penetration Test | | | | | | | | | PROFILE | GENERAL DESCRIPTION | Remarks | Elevation (masl) | Depth (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | % Core Recovery | Core pieces (cm) | Test # | Standard Penetration Blows per 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | Field Test | Permeability test Result | | SOIL: Soil Type: Colour, Consistency, Structure, ROCK: Rock Type: Weathering, Joint spacing, Colour, Fabric, Strength | | | | |
| 40 | 39 | 1.00 | Rotary Drilling method, 76 mm / NQ Diamond Bit with Double Tube Core barrel | 100 | 94 | 14,16,4, 5G,55 | | | | | | | | | | | **Overburden (30.00-50.00 m):** It consists of angular to sub-angular pebble, cobble and boulders of granodiorite, granite gneiss, embeded into clayey silty sand | Borehole is stabilized with cement from 33.30 to 48.00 m. | | 40 |
| 41 | 40 | 1.00 | | 100 | 94 | 31,17,4 0,2,4 | | | | | | | | | | | | | | 41 |
| 42 | 41 | 1.00 | | 100 | 92 | 5,28,4,1 6,35,4 | | | | | | | | | | | | | | 42 |
| 43 | 42 | 1.00 | | 100 | 83 | 9,3,13,1 1,12,10, 5, 4G,10, 7G | | | | | | | | | | | | | | 43 |
| 44 | 43 | 1.00 | | 100 | 50 | 10G,5,1 6,5,14 | | | | | | | | | | | | | | 44 |
| 45 | 44 | 1.00 | | 100 | 11 | 9,2 | | | | | | | | | | | | | | 45 |
| 46 | 45 | 1.00 | | 100 | NIL | | | | | | | | | | | | | | | 46 |
| 47 | 46 | 1.00 | | 100 | NIL | | | | | | | | | | | | | | | 47 |

**LEGEND:** Standard Penetration Test | Cone Penetration Test | Gravelly Sand | Sandy Gravel/ /Cobbles/boulder

**Note:**

1. Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable
2. Refusal criteria is adopted as (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

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| HYDRO PLANNING | BOREHOLE No. | BH-05 | Project: | ATTABAD LAKE HYDROPOWER PROJECT | Page | 7 of 7 |
|---|---|---|---|---|---|---|
| | | | Site: | Power House | | |

| DRILLING | | | | | RECOVERY | | Standared Penetration / Cone Penetration Test | | | | | | | | | | GENERAL DESCRIPTION | Remarks | Elevation (masl) | Depth (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | % Core Recovery | Core pieces (cm) | Test # | Standard Penetration Blows per 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | Field Test | Permeability test Result | PROFILE | SOIL: Soil Type: Colour, Consistency, Structure, ROCK: Rock Type: Weathering, Joint spacing, Colour, Fabric, Strength | | | |
| 48 | 47 | 1.00 | Rotary Drilling method, 76 mm / NQ Diamond Bit with Double Tube Core barrel | 100 | 8 | 8G | | | | | | | | | | | | **Overburden (30.00-50.00 m):** It consists of angular to sub-angular pebble, cobble and boulders of granodiorite, granite gneiss, embeded into clayey silty sand | Borehole is stabilized with cement from 33.30 to 48.00 m. | | 48 |
| 49 | 48 | 1.00 | | 100 | 13 | 13G | | | | | | | | | | | | | | 49 |
| 50 | 49 | 1.00 | | 100 | 7 | 7G | | | | | | | | | | | | **Bottom of Borehole at 50.00 m.** | | 50 |
| 51 | | | | | | | | | | | | | | | | | | | | 51 |
| 52 | | | | | | | | | | | | | | | | | | | | 52 |
| 53 | | | | | | | | | | | | | | | | | | | | 53 |
| 54 | | | | | | | | | | | | | | | | | | | | 54 |
| 55 | | | | | | | | | | | | | | | | | | | | 55 |

**LEGEND:** Standard Penetration Test | Cone Penetration Test | Gravelly Sand | Sandy Gravel/ /Cobbles/boulder

**Note:**

1. Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable
2. Refusal criteria is adopted as (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

# BH-06

| HYDRO PLANNING WAPDA | GRAIN SIZE (ASTM D2487) | | | CONSISTENCY | | | | Project : | ATTABAD LAKE HYDROPOWER PROJECT | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Silt and clay | | < 75 µm | CLAY / SILT | | SAND / GRAVEL | | Site: | Power House | | |
| | | | | N Value | | | | Easting : | 481605.02 | Borehole No. : | BH-06 |
| | Sand | Fine | 75 µm - 425 µm | very soft | <2 | <4 | very loose | Northing: | 4017906.55 | Page : | 1 of 8 |
| | | Medium | 425 µm - 2 mm | Soft | 2-4 | 4-10 | Loose | Elevation : | 2313.84 m | Logged by: | Nauman Nazir/Naseer Ahmad |
| | | Coarse | 2 mm - 4.75 mm | Firm | 4-8 | 10-30 | Medium Dense | Dip : | 90° | Checked By: | Umar Tariq |
| BOREHOLE NO. | Gravels | Fine | 4.75 m - 19 mm | Stiff | 8-15 | 30-50 | Dense | Final Depth : | 60 m | Date Started: | 22-09-2020 |
| BH-06 | | Coarse | 19 mm - 75 mm | Very Stiff | 15-30 | >50 | Very Dense | Bearing : | Nil | Date Completed: | 15-10-2020 |
| | Cobbles | | 75 mm -300 mm | Hard | >30 | | | Drilling Co. : | DD, WAPDA | Water Table: | 15.50 m |
| | Boulders | | > 300 mm | | | | | Driller : | Mr. Maqbool | RIG: | Longyear |

| DRILLING | | | | | RECOVERY | | Standared Penetration Test / Cone Penetration Test | | | | | | | | Field Test | Permeability test Result | Profile | GENERAL DESCRIPTION | Remarks | Elevation (masl) | Depth (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | Core Recovery % | Core pieces (cm) | Test # | Penetration Blows 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | | | | SOIL: Soil Type: Colour, Consistency, Structure, | | | |
| 1 | 1 | 1.00 | Rotary Drilling method, 96 mm / HQ Diamond Bit with Single Tube Core barrel | Nil | NIL | | | | | | | | | | | | | **Overburden/ clayey Silt (00.00-15.00 m)**: It consists grey to brownish grey, fine to very fine grained, clayey Silt. | Borehole is stabilized with HW casing from 0.00 to 15.12 m. | | 1 |
| 2 | 2 | 1.00 | | NIl | NIL | | | | | | | | | | | | | | A 18 cm wash sample consists of grey to brownish grey, very fine to fine clayey silt is obtained. | | 2 |
| 3 | 3 | 1.00 | | Nil | NIL | | | | | | | | | | | | | | A 18 cm wash sample consists of grey to brownish grey, very fine to fine clayey silt is obtained. | | 3 |
| 4 | 4 | 1.00 | | 100 | NIL | | SPT-1 | 6 | 4 | 3 | 3 | 3 | 13 | 27 | | | | Grey to brownish grey, stiff, fine to very fine clayey Silt. | | | 4 |
| 5 | 5 | 1.00 | Rotary Drilling method, 96 mm / HQ Diamond Bit with Double Tube Core barrel | 100 | NIL | | | | | | | | | | | | | | | | 5 |
| 6 | 6 | 1.00 | | 100 | NIL | | | | | | | | | | | | | | | | 6 |
| 7 | 7 | 1.00 | | 100 | NIL | | SPT-2 | 5 | 3 | 5 | 5 | 7 | 20 | 27 | | | | Grey to brownish grey, very stiff, fine to very fine clayey Silt. | | | 7 |

**LEGEND:** Standard Penetration Test | Cone Penetration Test | Clayey Silt | Sandy Gravel/ Cobble/boulder | Boulder/ Gravel

**Note:**
1. Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable
2. SOP for Refusal criteria: (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

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| HYDRO PLANNING | BOREHOLE No. | BH-06 | Project: | ATTABAD LAKE HYDROPOWER PROJECT | Page | 2 of 8 |
|---|---|---|---|---|---|---|
| | | | Site: | Power House | | |

| DRILLING | | | | | RECOVERY | | Standared Penetration Test / Cone Penetration Test | | | | | | | | | | GENERAL DESCRIPTION | Remarks | Elevation (masl) | Depth (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | Core Recovery % | Core pieces (cm) | Test # | Penetration Blows 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | Field Test | Permeability test Result | Profile | SOIL: Soil Type: Colour, Consistency, Structure, | | | |
| 8 | 8 | 1.00 | Rotary Drilling method, 96 mm / HQ Diamond Bit with Double Tube Core barrel | 100 | NIL | | | | | | | | | | | | | **Overburden/ Clayey Silt (00.00-15.00 m)**: It consists grey to brownish grey, fine to very fine grained, clayey Silt. | Borehole is stabilized with HW casing from 0.00 to 15.12 m. | | 8 |
| 9 | 9 | 1.00 | | 100 | NIL | | | | | | | | | | | | | | | | 9 |
| 10 | 10 | 1.00 | | 100 | NIL | | SPT-3 | 6 | 5 | 4 | 5 | 7 | 21 | 12 | | | | Grey to brownish grey, very stiff, fine to very fine clayey Silt. | | | 10 |
| 11 | 11 | 1.00 | | 100 | NIL | | | | | | | | | | | | | | | | 11 |
| 12 | 12 | 1.00 | | 100 | NIL | | | | | | | | | | | | | | | | 12 |
| 13 | 13 | 1.00 | | 100 | NIL | | SPT-4 | 6 | 4 | 5 | 5 | 6 | 20 | 27 | | | | Grey to brownish grey, very stiff, fine to very fine clayey Silt. | | | 13 |
| 14 | 14 | 1.00 | | 100 | NIL | | | | | | | | | | | | | | | | 14 |
| 15 | 15 | 1.00 | | 100 | NIL | | | | | | | | | | | | | | | | 15 |

**LEGEND:** Standard Penetration Test | Cone Penetration Test | Clayey Silt | Sandy Gravel/ Cobble/boulder | Boulder/ Gravel

**Note:**

1 Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable

2 SOP for Refusal criteria: (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

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| HYDRO PLANNING | BOREHOLE No. | BH-06 | Project: | ATTABAD LAKE HYDROPOWER PROJECT | Page | 3 of 8 |
|---|---|---|---|---|---|---|
| | | | Site: | Power House | | |

| DRILLING | | | | | RECOVERY | | Standard Penetration Test / Cone Penetration Test | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | Core Recovery % | Core pieces (cm) | Test # | Penetration Blows 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | Field Test | Permeability test Result | Profile | GENERAL DESCRIPTION<br>SOIL: Soil Type: Colour, Consistency, Structure, | Remarks | Elevation (masl) | Depth (m) |
| 16 | 16 | 0.50 | Rotary Drilling method, 96 mm / HQ Diamond Bit with Double Tube Core barrel | 100 | 27 | 5,5,7G,8,26 | CPT-1 | 10 | 10/0 | | | | Refusal | | | K= 0.00241 cm/sec | | **Overburden/ Gravels (15.00-60.00 m)**:<br>It consists of light grey to grey coloured, angular to sub-angular pebble, cobble and boulders of granite gneiss, granodiorite, and marble embeded into silty sand. | Borehole is stabilized with NW casing from 15.12 to 30.0m.<br>**Water Table at 15.50 m** | | 16 |
| 17 | 17 | 1.00 | | 100 | 77 | 13,22,12,14G, 14,2G | | | | | | | | | | | | | | | 17 |
| 18 | 18 | 1.40 | | 100 | 71 | 24G,47, 9G | | | | | | | | | | | | | | | 18 |
| 19 | | | | | | | CPT-2 | 10 | 10/0 | | | | Refusal | | | K= 0.00289 cm/sec | | | | | 19 |
| 20 | 19 | 1.60 | | 100 | 74 | 96,22 | | | | | | | | | | | | | | | 20 |
| 21 | 20 | 1.00 | | 100 | 60 | 60G | | | | | | | | | | | | | | | 21 |
| 22 | 21 | 1.00 | | 100 | 67 | 11,5G,25,7G,19 | CPT-3 | 8 | 10 | 10/0 | | | Refusal | | | K=0.00392 cm/sec | | | | | 22 |
| 23 | 22 | 1.00 | | 100 | 41 | 34,7G | | | | | | | | | | | | | | | 23 |

**LEGEND:** Standard Penetration Test | Cone Penetration Test | Clayey Silt | Sandy Gravel/ Cobble/ boulder | Boulder/ Gravel

**Note:**

1. Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable
2. Refusal criteria is adopted as (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

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| HYDRO PLANNING | BOREHOLE No. | BH-06 | Project: | ATTABAD LAKE HYDROPOWER PROJECT | Page | 4 of 8 |
|---|---|---|---|---|---|---|
| | | | Site: | Power House | | |

| DRILLING | | | | | RECOVERY | | Standared Penetration Test / Cone Penetration Test | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | Core Recovery % | Core pieces (cm) | Test # | Penetration Blows 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | Field Test | Permeability test Result | Profile | GENERAL DESCRIPTION<br>SOIL: Soil Type: Colour, Consistency, Structure, | Remarks | Elevation (masl) | Depth (m) |
| 24 | 23 | 1.00 | Rotary Drilling method, 96 mm / HQ Diamond Bit with Double Tube Core barrel | 100 | 81 | 6G,75 | | | | | | | | | | | | **Overburden/ Gravels (15.00-60.00 m):**<br>It is consists of light grey to grey coloured, angular to sub-angular pebble, cobble and boulders of granite gneiss, granodiorite, and marble embeded into silty sand. | Borehole is stabilized with NW casing from 15.12 to 30.0m. | | 24 |
| 25 | 24 | 1.00 | | 100 | 62 | 62 | CPT-4 | 10 | 10/0 | | | | Refusal | | | | | | | | 25 |
| 26 | 25 | 1.00 | | 100 | 37 | 12,25G | | | | | | | | | | K=0.00286 cm/sec | | | | | 26 |
| 27 | 26 | 1.00 | | 100 | 68 | 23G,45 | | | | | | | | | | | | | | | 27 |
| 28 | 27 | 1.00 | | 100 | 77 | 21G,7, 32,5, 12G | CPT-5 | 10/0 | | | | | Refusal | | | | | | | | 28 |
| 29 | 28 | 1.00 | | 100 | 77 | 3G,4,13, 8,24G,6, 4,2,5,8 | | | | | | | | | | Head could not be maintained. | | | | | 29 |
| 30 | 29 | 1.00 | | 100 | 94 | 7,16G, 10,24,14 ,3G,20 | | | | | | | | | | | | | | | 30 |
| 31 | 30 | 1.00 | NQ Bit with double tube | 100 | 19 | 19G | CPT-6 | 10/0 | | | | | Refusal | | | | | | | | 31 |

**LEGEND:** Standard Penetration Test | Cone Penetration Test | Clayey Silt | Sandy Gravel /Cobble/boulder | Boulder/ Gravel

**Note:**
1. Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable
2. Refusal criteria is adopted as (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

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| HYDRO PLANNING | BOREHOLE No. | BH-06 | Project: | ATTABAD LAKE HYDROPOWER PROJECT | Page | 5 of 8 |
|---|---|---|---|---|---|---|
| | | | Site: | Power House | | |

| DRILLING | | | | | RECOVERY | | Standared Penetration Test / Cone Penetration Test | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | Core Recovery % | Core pieces (cm) | Test # | Penetration Blows 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | Field Test | Permeability test Result | Profile | GENERAL DESCRIPTION<br>SOIL: Soil Type: Colour, Consistency, Structure, | Remarks | Elevation (masl) | Depth (m) |
| 32 | 31 | 1.00 | Rotary Drilling method, 76 mm / NQ Diamond Bit with Double Tube Core barrel | 100 | 13 | 4G,3,6 | | | | | | | | | | K=0.00338 cm/sec | | **Overburden/ Gravels (15.00-60.00 m):**<br>It is consists of light grey to grey coloured, angular to sub-angular pebble, cobble and boulders of granite gneiss, granodiorite and marble embeded into silty sand. | Borehole is stabilized with cement from 30.0 to 58.0m. | | 32 |
| 33 | 32 | 1.00 | | 100 | 23 | 12,11 | | | | | | | | | | | | | | | 33 |
| 34 | 33 | 1.00 | | 100 | 24 | 4,11,5,4 | | | | | | | | | | Head could not be maintained. | | | | | 34 |
| 35 | 34 | 1.00 | | 100 | 69 | 2,9,13G, 13,7,4,7, 14 | | | | | | | | | | | | | | | 35 |
| 36 | 35 | 1.00 | | 100 | 40 | 15G,9, 16 | | | | | | | | | | | | | | | 36 |
| 37 | 36 | 1.00 | | 100 | 34 | 22G,6,6 | | | | | | | | | | | | | | | 37 |
| 38 | 37 | 1.00 | | 100 | 86 | 3G,5,62, 8,4G,4 | | | | | | | | | | | | | | | 38 |
| 39 | 38 | 1.00 | | 100 | 83 | 5,21G,4, 7,9,9,4,3 ,3,2 | | | | | | | | | | K=0.00279 cm/sec | | | | | 39 |

**LEGEND:** Standard Penetration Test | Cone Penetration Test | Clayey Silt | Sandy Gravel /Cobble/boulder | Boulder/ Gravel

**Note:**

1 Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable

2 Refusal criteria is adopted as (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

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| HYDRO PLANNING | BOREHOLE No. | BH-06 | Project: | ATTABAD LAKE HYDROPOWER PROJECT | Page | 6 of 8 |
|---|---|---|---|---|---|---|
| | | | Site: | Power House | | |

| DRILLING | | | | | RECOVERY | | Standared Penetration Test / Cone Penetration Test | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | Core Recovery % | Core pieces (cm) | Test # | Penetration Blows 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | Field Test | Permeability test Result | Profile | GENERAL DESCRIPTION<br>SOIL: Soil Type: Colour, Consistency, Structure, | Remarks | Elevation (masl) | Depth (m) |
| 40 | 39 | 1.00 | Rotary Drilling method, 76 mm / NQ Diamond Bit with Double Tube Core barrel | 100 | 68 | 7,6,4,29, 14,6,2 | | | | | | | | | | | | **Overburden/ Gravels (15.00-60.00 m):**<br>It consists of light grey to grey coloured, angular to sub-angular pebble, cobble and boulders of granite gneiss, granodiorite, and marble embeded into silty sand. | Hole is stabilized with cement from 30.0 to 58.0m. | | 40 |
| 41 | 40 | 1.00 | | 100 | 16 | 16G | | | | | | | | | | | | | No wsah sample is collected from 39.0 to 50.0m due to 100% water loss. | | 41 |
| 42 | 41 | 1.00 | | 100 | 61 | 19,21, 11,10 | | | | | | | | | | | | | | | 42 |
| 43 | 42 | 1.00 | | 100 | 29 | 7,22 | | | | | | | | | | | | | | | 43 |
| 44 | 43 | 1.00 | | 20 | 68 | 6,10G,1 3,18,21 | | | | | | | | | | | | | | | 44 |
| 45 | 44 | 1.00 | | 20 | 43 | 14,18,6, 5 | | | | | | | | | | | | | | | 45 |
| 46 | 45 | 1.00 | | 15 | 47 | 14,13G, 20 | | | | | | | | | | | | | | | 46 |
| 47 | 46 | 1.00 | | 20 | 39 | 8,3,6, 20G | | | | | | | | | | | | | | | 47 |

**LEGEND:** Standard Penetration Test | Cone Penetration Test | Clayey Silt | Sandy Gravel /Cobble/boulder | Boulder/ Gravel

**Note:**

1 Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable

2 Refusal criteria is adopted as (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

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| HYDRO PLANNING | BOREHOLE No. | BH-06 | Project: | ATTABAD LAKE HYDROPOWER PROJECT | Page | 7 of 8 |
|---|---|---|---|---|---|---|
| | | | Site: | Power House | | |

| DRILLING | | | | | RECOVERY | | Standared Penetration Test / Cone Penetration Test | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | Core Recovery % | Core pieces (cm) | Test # | Penetration Blows 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | Field Test | Permeability test Result | Profile | GENERAL DESCRIPTION<br>SOIL: Soil Type: Colour, Consistency, Structure, | Remarks | Elevation (masl) | Depth (m) |
| 48 | 47 | 1.00 | Rotary Drilling method, 76 mm / NQ Diamond Bit with Double Tube Core barrel | 20 | 42 | 42G | | | | | | | | | | | | **Overburden/ Gravels (15.00-60.00 m):**<br>It is consists of light grey to grey coloured, angular to sub-angular pebble, cobble and boulders of granite gneiss, granodiorite, and marble embeded into silty sand. | Hole is stabilized with cement from 30.0 to 58.0m. | | 48 |
| 49 | 48 | 1.00 | | 10 | 92 | 43,8,30, 9 | | | | | | | | | | | | | | | 49 |
| 50 | 49 | 1.00 | | 10 | 93 | 61,6,26 | | | | | | | | | | | | | A 19 cm wash sample consists of grey, silty fine sand is obtained. | | 50 |
| 51 | 50 | 1.00 | | 40 | 6 | 6G | | | | | | | | | | | | | A 19 cm wash sample consists of grey, fine sand is obtained. | | 51 |
| 52 | 51 | 1.00 | | 45 | 19 | 2,17 | | | | | | | | | | | | | A 19 cm wash sample consists of grey, silty sand is obtained. | | 52 |
| 53 | 52 | 1.00 | | 50 | 22 | 20,2 | | | | | | | | | | | | | A 19 cm wash sample consists of grey, medium to fine sand is obtained.<br>A 19 cm wash sample consists of grey, silty sand is obtained. | | 53 |
| 54 | 53 | 1.00 | | 35 | NIL | NIL | | | | | | | | | | K=0.000781 cm/sec | | | A 19 cm wash sample consists of grey, silty fine sand is obtained. | | 54 |
| 55 | 54 | 1.00 | | 35 | 17 | 2,11,4G | | | | | | | | | | | | | A 19 cm wash sample consists of grey, silty fine sand is obtained. | | 55 |

**LEGEND:** Standard Penetration Test | Cone Penetration Test | Clayey Silt | Sandy Gravel /Cobble/boulder | Boulder/ Gravel

**Note:**

1. Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable
2. Refusal criteria is adopted as (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

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| HYDRO PLANNING | BOREHOLE No. | BH-06 | Project: | ATTABAD LAKE HYDROPOWER PROJECT | Page | 8 of 8 |
|---|---|---|---|---|---|---|
| | | | Site: | Power House | | |

| DRILLING | | | | | RECOVERY | | Standared Penetration Test / Cone Penetration Test | | | | | | | | | | | | GENERAL DESCRIPTION | Remarks | Elevation (masl) | Depth (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run # | Drill run (m) | Drilling method | Water Loss % | Core Recovery % | Core pieces (cm) | Test # | Penetration Blows 6" | 3" | 3" | 3" | 3" | N Value | Sample length (cm) | Field Test | Permeability test Result | Profile | SOIL: Soil Type: Colour, Consistency, Structure, | | | |
| 56 | 55 | 1.00 | Rotary Drilling method, 76 mm / NQ Diamond Bit with Double Tube Core barrel | 30 | 80 | 12,50,3, 15 | | | | | | | | | | K=0.00298 cm/sec | | **Overburden/ Gravels (15.00-60.00 m):** It is consists of light grey to grey coloured, angular to sub-angular pebble, cobble and boulders of granite gneiss, granodiorite, and marble embeded into silty sand. | Hole is stabilized with cement from 30.0 to 58.0m. | | 56 |
| 57 | 56 | 1.00 | | 30 | 52 | 5,5,3,6, 6G,17,6 G,4 | | | | | | | | | | | | | A 18 cm wash sample consists of light grey, micaceous, medium to fine sand is obtained. | | 57 |
| 58 | 57 | 1.00 | | 35 | 59 | 4G,17, 38 | | | | | | | | | | | | | A 20 cm wash sample consists of light grey, micaceous, medium to fine sand is obtained. | | 58 |
| 59 | 58 | 1.00 | | NIL | 100 | 100 | | | | | | | | | | | | | | | 59 |
| 60 | 59 | 1.00 | | NIL | 100 | 100 | | | | | | | | | | | | **Bottom of Borehole at 60.00 m.** | | | 60 |
| 61 | | | | | | | | | | | | | | | | | | | | | 61 |
| 62 | | | | | | | | | | | | | | | | | | | | | 62 |
| 63 | | | | | | | | | | | | | | | | | | | | | 63 |

**LEGEND:** Standard Penetration Test | Cone Penetration Test | Clayey Silt | Sandy Gravel /Cobble/boulder | Boulder/ Gravel

**Note:**

1. Core recoveries are measured in addition to gravel recovered in Split Spoon Sampler if applicable
2. Refusal criteria is adopted as (a) 50 blows for any 6 inches penetration (b)100 blows for 12 inches or N=100 (c)10 blows for zero penetration

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# TEST PIT LOGS

| HYDRO PLANNING WAPDA | Grain Size (ASTM D2487) | | | Project : | ATTABAD LAKE HYDROPOWER PROJECT | | |
|---|---|---|---|---|---|---|---|
| | Boulders | | ≥ 300 mm | Site: | Shishkat Bridge (Sand Aggregate) | | |
| | Cobbles | | <300 mm - ≥75 mm | | | | |
| TEST PIT # 1 | Gravel | Coarse | <75 mm - ≥19 mm | Easting: | 487919.20m | Page : | 1 of 1 |
| | | Fine | <19 mm - ≥4.75 mm | Northing: | 4025427.54m | Water Table | 1.30m |
| | Sand | Coarse | <4.75 mm - ≥2 mm | Elevation: | 2414.09m | Date Started: | 15.12.2020 |
| | | Medium | <2 mm - ≥425 µm | Final Depth: | 3.0 m | Date Completed: | 15.12.2020 |
| | | Fine | <425 µm - ≥75 µm | Logged by: | Naseer/Nauman | Operating Agency: | DD, WAPDA |
| | Silt / Clay | | < 75 µm | Checked By: | Umar Tariq | Excavation Method: | Mannual |

| Depth (m) | Elevation (masl) | Cobble/ Boulder size (cmxcmxcm) | Sample Type | Profile | GENERAL DESCRIPTION | Remarks |
|---|---|---|---|---|---|---|
| 1 | | | | | **SAND with subordinate Gravels (0.0-0.50 m)**: It is light grey to grey coloured, loose, moist, unconsolidated coarse to very coarse grained, SAND with subordinate cobble, pebble of varigated origin. A 3cm seem 50 cm to 53 cm of very fine grained, smooth, semi consolidated moist Clayey SILT is present. | Soil is easy to excavate. |
| 2 | | | | | **SAND (0.50-3.0 m)**: It is light grey to grey coloured, loose, very moist, unconsolidated coarse grained, SAND. | Water Table encountered |
| 3 | | | | | **BOTTOM OF PIT** | |

LEGEND: Sand, Gravelly Sand, Sandy Silt, Undisturbed Sample, Bulk Sample, Block Sample

| HYDRO PLANNING WAPDA | Grain Size (ASTM D2487) | | | Project : | ATTABAD LAKE HYDROPOWER PROJECT | | |
|---|---|---|---|---|---|---|---|
| | Boulders | | ≥ 300 mm | Site: | Power House Area (Aggregate) | | |
| | Cobbles | | <300 mm - ≥75 mm | | | | |
| TEST PIT # 2 | Gravel | Coarse | <75 mm - ≥19 mm | Easting: | 481753.897m | Page : | 1 of 1 |
| | | Fine | <19 mm - ≥4.75 mm | Northing: | 4017946.520m | Water Table | NIL |
| | Sand | Coarse | <4.75 mm - ≥2 mm | Elevation: | 2338.10m | Date Started: | 16.12.2020 |
| | | Medium | <2 mm - ≥425 µm | Final Depth: | 3.0 m | Date Completed: | 16.12.2020 |
| | | Fine | <425 µm - ≥75 µm | Logged by: | Naseer/Nauman | Operating Agency: | DD, WAPDA |
| | Silt / Clay | | < 75 µm | Checked By: | Umar Tariq | Excavation Method: | Excavator |

| Depth (m) | Elevation (masl) | Cobble/ Boulder size (cmxcmxcm) | Sample Type | Profile | GENERAL DESCRIPTION | Remarks |
|---|---|---|---|---|---|---|
| 1 | | | | | **RBGM (0.00-2.00 m):** It consist of Boulders, Gravels, Cobble and Pebbles of varigated origin, embeded into SAND of grey to dark grey in color, moist and loose. first 0.0 to 0.50m is moderatly moist with some Silty SAND. | Bulk composite sample is collected. |
| 2 | | | | | **Clayey SILT (2.0 to 3.00):** It is grey to brownish grey in color, damped/highly moist, fine grained, flocculated, and smooth. | Bulk composite sample is collected. |
| 3 | | | | | | |

LEGEND: Sand, Clayey Silty, Silty Sand, Undisturbed Sample, Bulk Sample, Block Sample

PROCUREMENT REGULATORY AUTHORITY PUBLIC (PPRA) EPADS

| HYDRO PLANNING WAPDA | Grain Size (ASTM D2487) | | | Project : | ATTABAD LAKE HYDROPOWER PROJECT | | |
|---|---|---|---|---|---|---|---|
| | Boulders | | ≥ 300 mm | Site: | Power House Area (Fine Aggregate/Clay) | | |
| | Cobbles | | <300 mm - ≥75 mm | | | | |
| TEST PIT # 3 | Gravel | Coarse | <75 mm - ≥19 mm | Easting: | 481677.321m | Page : | 1 of 1 |
| | | Fine | <19 mm - ≥4.75 mm | Northing: | 4017944.585m | Water Table | NIL |
| | Sand | Coarse | <4.75 mm - ≥2 mm | Elevation: | 2337.31m | Date Started: | 16.12.2020 |
| | | Medium | <2 mm - ≥425 µm | Final Depth: | 3.0 m | Date Completed: | 16.12.2020 |
| | | Fine | <425 µm - ≥75 µm | Logged by: | Naseer/Nauman | Operating Agency: | DD, WAPDA |
| | Silt / Clay | | < 75 µm | Checked By: | Umar Tariq | Excavation Method: | Excavator |

| Depth (m) | Elevation (masl) | Cobble/ Boulder size (cmxcmxcm) | Sample Type | Profile | GENERAL DESCRIPTION | Remarks |
|---|---|---|---|---|---|---|
| 1 | | | | | **Clayey SILT (0.0-3.0 m)**: It is light grey to brownish grey in colour, loose, moist, fine to very fine grained, Clayey SILT with plant roots. | |
| 2 | | | | | From 0.50 to 1.20m, it is light grey, soft, loose, highly moist, moderatly plastic with plant roots. | |
| 3 | | | | | From 1.20 to 3.0m, it is light grey, soft to stiff, highly moist. | |

| LEGEND: | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sand | | | | | | | | |
| Clayey Silty | | | | | | | | |
| Block Sample | | Undisturbed Sample | | Bulk Sample | | | | |

| HYDRO PLANNING WAPDA | Grain Size (ASTM D2487) | | | Project : | ATTABAD LAKE HYDROPOWER PROJECT | | |
|---|---|---|---|---|---|---|---|
| | Boulders | | ≥ 300 mm | Site: | Power House Area (Fine Aggregate) | | |
| | Cobbles | | <300 mm - ≥75 mm | | | | |
| TEST PIT # 2 | Gravel | Coarse | <75 mm - ≥19 mm | Easting: | 481727.344m | Page : | 1 of 1 |
| | | Fine | <19 mm - ≥4.75 mm | Northing: | 4017728.434m | Water Table | NIL |
| | Sand | Coarse | <4.75 mm - ≥2 mm | Elevation: | 2388.99m | Date Started: | 16.12.2020 |
| | | Medium | <2 mm - ≥425 µm | Final Depth: | 3.0 m | Date Completed: | 16.12.2020 |
| | | Fine | <425 µm - ≥75 µm | Logged by: | Naseer/Nauman | Operating Agency: | DD, WAPDA |
| | Silt / Clay | | < 75 µm | Checked By: | Umar Tariq | Excavation Method: | Excavator |

| Depth (m) | Elevation (masl) | Cobble/ Boulder size (cmxcmxcm) | Sample Type | Profile | GENERAL DESCRIPTION | Remarks |
|---|---|---|---|---|---|---|
| 1 | | | | | **SAND (0.00-0.7m):** It consist of light grey to grey, medium to coarse grained, dry, very loose SAND with plant roots. | |
| 2 | | | | | **Clayey Sandy SILT (0.7 to 3.0m):** It is grey to brownish grey in color, dry, fine to very fine grained, unconsolidated. | Bulk composite sample is collected. |
| 3 | | | | | | |

| LEGEND: | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sand | | | | | | | | |
| Clayey Silty | | | | | | | | |
| Block Sample | | Undisturbed Sample | | Bulk Sample | | | | |

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

| TP- 5,6 | | Grain Size (ASTM D2487) | | Project : | ATTABAD LAKE HYDROPOWER PROJECT | | |
|---|---|---|---|---|---|---|---|
| | | Boulders | ≥ 300 mm | Site: | OUTLET OF SEDIMENT FLUSHING CHANNEL ALIGNMENT (Left Side) | | |
| | | Cobbles | <300 mm - ≥75 mm | | | | |
| | | Gravel Coarse | <75 mm - ≥19 mm | Easting: | 483433.611m | Page : | 1 of 1 |
| | | Gravel Fine | <19 mm - ≥4.75 mm | Northing: | 4018077.262m | Water Table | NIL |
| TEST PIT # | 5 | Sand Coarse | <4.75 mm - ≥2 mm | Elevation: | 2443.0m | Date Started: | 16.12.2020 |
| | | Sand Medium | <2 mm - ≥425 µm | Final Depth: | 3.0 m | Date Completed: | 16.12.2020 |
| | | Sand Fine | <425 µm - ≥75 µm | Logged by: | Naseer/Nauman | Operating Agency: | DD, WAPDA |
| | | Silt / Clay | < 75 µm | Checked By: | Umar Tariq | Excavation Method: | Excavator |

| Depth (m) | Elevation (masl) | Cobble/ Boulder size (cmxcmxcm) | Sample Type | Profile | GENERAL DESCRIPTION | Remarks |
|---|---|---|---|---|---|---|
| 1 | | | | | **Clayey Silty SAND with Gravels (0.0-0.20 m)**: It is brownish coloured, loose to very loose, dry, unconsolidated Clayey Silty SAND with subordinate cobble, pebble of varigated origin with plant roots.<br><br>From **0.20m to 1.50m**, it is grey to brownish grey in color, fine grained , having RBGM and ABGM embeded into Clayey Silty Sand. The RBGM and ABGM are of varigated origin. It is low to moderatly moist, unconsolidated and soft. | Bulk composite sample is collected. |
| 2 | | | | | **Clayey SITY (1.50 to 3.0)m:**<br>It is grey to brownish grey in color, fine to very fine grained damped/highly moist, flocculated, and smooth. | Bulk composite sample is collected. |
| 3 | | | | | | |

| LEGEND: | | | | | | | |
|---|---|---|---|---|---|---|---|
| Sand | | Clayey Silty Sand with Gravel | | | | | |
| Clayey Silt | | | | | | | |
| Block Sample | | Undisturbed Sample | | Bulk Sample | | | |

| HYDRO PLANNING WAPDA | | Grain Size (ASTM D2487) | | Project : | ATTABAD LAKE HYDROPOWER PROJECT | | |
|---|---|---|---|---|---|---|---|
| | | Boulders | ≥ 300 mm | Site: | FLUSHING CHANNEL SLOPE ALIGNMENT (Left Side) | | |
| | | Cobbles | <300 mm - ≥75 mm | | | | |
| | | Gravel Coarse | <75 mm - ≥19 mm | Easting: | 483661.468m | Page : | 1 of 1 |
| | | Gravel Fine | <19 mm - ≥4.75 mm | Northing: | 4018060.061m | Water Table | NIL |
| TEST PIT # | 6 | Sand Coarse | <4.75 mm - ≥2 mm | Elevation: | 2514.80m | Date Started: | 16.12.2020 |
| | | Sand Medium | <2 mm - ≥425 µm | Final Depth: | 3.0 m | Date Completed: | 16.12.2020 |
| | | Sand Fine | <425 µm - ≥75 µm | Logged by: | Naseer/Nauman | Operating Agency: | DD, WAPDA |
| | | Silt / Clay | < 75 µm | Checked By: | Umar Tariq | Excavation Method: | Excavator |

| Depth (m) | Elevation (masl) | Cobble/ Boulder size (cmxcmxcm) | Sample Type | Profile | GENERAL DESCRIPTION | Remarks |
|---|---|---|---|---|---|---|
| 1 | | 2×1.2×1.5<br>0.64×.72×.55<br>0.8×0.6×0.4<br>0.47×.53×.35<br>1.6×0.5×0.6<br>2.5×1×0.80 | | | **Gravelly Sand (0.0-0.4 m):**<br>It consist of greyish brown Silty SAND with boulders and Gravels. It is loose, unconsolidated and dry. | |
| 2 | | | | | **ABGM (0.4-3.00 m):**<br>It consist of Boulder and Gravels mostly of Granodiorite, with subordinate clay and silt. it is loose, unconsolidated, dry with cavities. It is excavated into slided mass. | Bulk composite sample is collected. |
| 3 | | | | | | Bulk composite sample is collected. |

| LEGEND: | | | | | | | |
|---|---|---|---|---|---|---|---|
| Sand | | | | | | | |
| Gravelly Sand | | | | | | | |
| Block Sample | | Undisturbed Sample | | Bulk Sample | | | |

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

| HYDRO PLANNING WAPDA | Grain Size (ASTM D2487) | | | Project : | ATTABAD LAKE HYDROPOWER PROJECT | | |
|---|---|---|---|---|---|---|---|
| | Boulders | | ≥ 300 mm | Site: | INLET OF SEDIMENT FLUSHING CHANNEL ALIGNMENT (Left Side) | | |
| | Cobbles | | <300 mm - ≥75 mm | | | | |
| TEST PIT # 7 | Gravel | Coarse | <75 mm - ≥19 mm | Easting: | 484127.262m | Page : | 1 of 1 |
| | | Fine | <19 mm - ≥4.75 mm | Northing: | 4018014.833m | Water Table | NIL |
| | Sand | Coarse | <4.75 mm - ≥2 mm | Elevation: | 2417.37m | Date Started: | 16.12.2020 |
| | | Medium | <2 mm - ≥425 µm | Final Depth: | 3.0 m | Date Completed: | 16.12.2020 |
| | | Fine | <425 µm - ≥75 µm | Logged by: | Naseer/Nauman | Operating Agency: | DD, WAPDA |
| | Silt / Clay | | < 75 µm | Checked By: | Umar Tariq | Excavation Method: | Excavator |

| Depth (m) | Elevation (masl) | Cobble/ Boulder size (cmxcmxcm) | Sample Type | Profile | GENERAL DESCRIPTION | Remarks |
|---|---|---|---|---|---|---|
| 1 | | 3×1.8×2<br>1.4×0.6×0.4<br>1×0.6×0.3<br>0.3×0.7×0.4<br>0.40×1×0.7<br>0.6×0.7×0.9<br>1.3×.70×.50<br>1×0.6×0.48<br>0.6×0.25×0.7<br>1×0.6×0.5 | | | **Silty SAND with RBGM (0.0-0.50 m)**:<br>It is grey coloured, loose, moist, unconsolidated coarse to very coarse , Silty SAND with subordinate Gravels of variegated origin embeded init. RBGM seems to be utalized for stabilization of slope after sliding.<br><br>**ABGM (0.50-3.0)**<br>It consists of boulders and Gravels having cavities in it, subordinate silty sand is also encounterd in small quantity. The boulders belongs to slided mass and mostly consist of Granodiorite. | Many cavities encountered in slided mass.<br><br>A Bulk composite sample was collected. |
| 2 | | | | | | |
| 3 | | | | | | |

| LEGEND: | | | | | | | |
|---|---|---|---|---|---|---|---|
| Sand | | ABGM | | | | | |
| Silty Sand with RBGM | | | | | | | |
| Block Sample | | Undisturbed Sample | | Bulk Sample | | | |

| HYDRO PLANNING WAPDA | Grain Size (ASTM D2487) | | | Project : | ATTABAD LAKE HYDROPOWER PROJECT | | |
|---|---|---|---|---|---|---|---|
| | Boulders | | ≥ 300 mm | Site: | SLOPE AREA ABOVE SPILLWAY (Right Side) | | |
| | Cobbles | | <300 mm - ≥75 mm | | | | |
| TEST PIT # 8 | Gravel | Coarse | <75 mm - ≥19 mm | Easting: | 484038.170m | Page : | 1 of 1 |
| | | Fine | <19 mm - ≥4.75 mm | Northing: | 4018352.560m | Water Table | NIL |
| | Sand | Coarse | <4.75 mm - ≥2 mm | Elevation: | 2488.25m | Date Started: | 17.12.2020 |
| | | Medium | <2 mm - ≥425 µm | Final Depth: | 3.0 m | Date Completed: | 18.12.2020 |
| | | Fine | <425 µm - ≥75 µm | Logged by: | Naseer/Nauman | Operating Agency: | DD, WAPDA |
| | Silt / Clay | | < 75 µm | Checked By: | Umar Tariq | Excavation Method: | Mannual |

| Depth (m) | Elevation (masl) | Cobble/ Boulder size (cmxcmxcm) | Sample Type | Profile | GENERAL DESCRIPTION | Remarks |
|---|---|---|---|---|---|---|
| 1 | | 0.3×0.8×0.2<br>0.4×0.3×0.4<br>1×0.4×0.3<br>0.3×0.4×0.4<br>0.4×1×0.7<br>0.6×0.7×0.9<br>0.3×0.25×0.4 | | | **ABGM (0.00-3.00 m):**<br>It consist of angular Boulders, Gravels, Cobble and Pebbles mostly of granodiorite, some crushed rock grinded to Silty/Sandy mateial. | Bulk composite sample is collected. |
| 2 | | | | | | |
| 3 | | | | | | |

| LEGEND: | | | | | | | |
|---|---|---|---|---|---|---|---|
| ABGM | | | | | | | |
| | | | | | | | |
| Block Sample | | Undisturbed Sample | | Bulk Sample | | | |

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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Grain Size (ASTM D2487) | | | Project : | ATTABAD LAKE HYDROPOWER PROJECT | | |
| | Boulders | | ≥ 300 mm | Site: | SLOPE AREA ABOVE SPILLWAY (Right Side) | | |
| | Cobbles | | <300 mm - ≥75 mm | | | | |
| | Gravel | Coarse | <75 mm - ≥19 mm | Easting: | 483755.940m | Page : | 1 of 1 |
| | | Fine | <19 mm - ≥4.75 mm | Northing: | 4018415.090m | Water Table | NIL |
| | Sand | Coarse | <4.75 mm - ≥2 mm | Elevation: | 2504.980m | Date Started: | 17.12.2020 |
| | | Medium | <2 mm - ≥425 µm | Final Depth: | 3.0 m | Date Completed: | 18.12.2020 |
| | | Fine | <425 µm - ≥75 µm | Logged by: | Naseer/Nauman | Operating Agency: | DD, WAPDA |
| TEST PIT # 9 | Silt / Clay | | < 75 µm | Checked By: | Umar Tariq | Excavation Method: | Mannual |

| Depth (m) | Elevation (masl) | Cobble/ Boulder size (cmxcmxcm) | Sample Type | Profile | GENERAL DESCRIPTION | Remarks |
|---|---|---|---|---|---|---|
| 1 | | 0.3×0.8×0.5<br>0.4×0.5×0.4<br>0.3×0.6×0.3<br>0.3×0.5×0.4<br>0.4×0.5×0.7<br>0.4×0.7×0.5 | | | **ABGM (0.00-3.00 m):**<br>It consist of angular Boulders, Gravels, Cobble and Pebbles mostly of granodiorite, some crushed rock grinded to Silty/Sandy mateial. | A Bulk composite sample was collected. |
| 2 | | 0.3×0.2×0.5<br>0.5×0.4×0.2<br>0.2×0.2×0.3<br>0.6×0.3×0.5 | | | | |
| 3 | | | | | | |

LEGEND: ABGM; Block Sample; Undisturbed Sample; Bulk Sample

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| HYDRO PLANNING WAPDA | Grain Size (ASTM D2487) | | | Project : | ATTABAD LAKE HYDROPOWER PROJECT | | |
| | Boulders | | ≥ 300 mm | Site: | SLOPE AREA ABOVE SPILLWAY (Right Side) | | |
| | Cobbles | | <300 mm - ≥75 mm | | | | |
| | Gravel | Coarse | <75 mm - ≥19 mm | Easting: | 471821.13m | Page : | 1 of 1 |
| | | Fine | <19 mm - ≥4.75 mm | Northing: | 4018520.38m | Water Table | NIL |
| | Sand | Coarse | <4.75 mm - ≥2 mm | Elevation: | 2185.25m | Date Started: | 17.12.2020 |
| | | Medium | <2 mm - ≥425 µm | Final Depth: | 3.0 m | Date Completed: | 17.12.2020 |
| | | Fine | <425 µm - ≥75 µm | Logged by: | Naseer/Nauman | Operating Agency: | DD, WAPDA |
| TEST PIT # 10 | Silt / Clay | | < 75 µm | Checked By: | Umar Tariq | Excavation Method: | Excavator |

| Depth (m) | Elevation (masl) | Cobble/ Boulder size (cmxcmxcm) | Sample Type | Profile | GENERAL DESCRIPTION | Remarks |
|---|---|---|---|---|---|---|
| 1 | | | | | **Clayey SILT (0.0 to 3.0m):**<br>It is light brown to brownish grey in color, fine to very fine grained, dry, Loose, flocculated, smooth and unconsolidated Clayey SILT. | Bulk composite sample is collected.<br>Block Sample is collected. |
| 2 | | | | | | Block Sample is collected. |
| 3 | | | | | | |

LEGEND: Clayey Silt; Block Sample; Undisturbed Sample; Bulk Sample

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# PAKISTAN

## WATER AND POWER DEVELOPMENT AUTHORITY

# ATTABAD LAKE HYDROPOWER PROJECT

# FEASIBILITY STUDY

# VOLUME 6

# ENVIRONMENTAL AND SOCIOECONOMIC IMPACT ASSESSMENT

**June 2021**

## HYDRO PLANNING ORGANIZATION

WAPDA, SUNNY VIEW ESTATE, LAHORE ☎ 99202717 🖷 99202722 ✉ gmhydroplanning@gmail.com

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# ATTABAD LAKE HYDROPOWER PROJECT
# LIST OF VOLUMES

VOLUME – 1 MAIN REPORT

VOLUME – 2 DRAWINGS

VOLUME – 3 GEOLOGICAL AND GEOTECHNICAL STUDIES

VOLUME – 4 NEOTECTONICS STUDIES & SESIMIC HAZARDSN ANALYSIS

VOLUME – 5 BOREHOLE LOGS AND LABORTORY TESTING

**VOLUME – 6 ENVIRONOMENTAL AND SOCIAL IMPACT ASSESSMENT**

VOLUME – 7 APPENDICES



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# LIST OF ABBREVIATION

| | |
|---|---|
| **A** | |
| ADB | Asian Development Bank |
| AKCSP | Aga Khan Cultural Service Pakistan |
| AKDN | Aga Khan Development Net Work |
| AKF | Aga Khan Foundation |
| AKHS | Aga Khan Health Service |
| AKRSP | Aga Khan Rural Support Programme |
| **C** | ` |
| CBM | Confidence-building measure |
| CBOs- | Community-based organizations |
| CPEC | China Pakistan Economic Corridor |
| DLP | Defect Liability Period |
| **E** | |
| EIA | Environmental Impact Assessment |
| EL | Elevation Level |
| EMMP | Environment Monitoring Management Plan |
| EOT | Electric Overhead Bridge Type Traveling |
| EPA | Environment Protection Agency |
| ESIA | Environmental Impact Assessment |
| **G** | |
| GB | Gilgit-Baltistan |
| GEF | Global Environment Facility |
| GHG | Green House Gases |
| GLOF | Glacial Lake Outburst Floods |
| GSP | Geological Survey of Pakistan |
| **H** | |
| ha | Hectare |
| HPO- | Hydro Planning Organization |
| HPP | Hydropower Project |
| **I** | |
| ICT- | Information and Communication Technologies |
| IEE | Initial Environmental Examination |
| IRS | Indus River System |
| IUCN | International Union for Conservation of Nature |
| **K** | |
| KKH | Karakoram Highway |



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# LIST OF ABBREVIATION

| | |
|---|---|
| KNP- | Khunjerab National Park |
| KPK- | Khyber Pakhtunkhwa |
| **L** | |
| LAA | Land Acquisition Act |
| LGO | Local Government Ordinance |
| **M** | |
| MASL | Meters Above Sea Level |
| MBT | Main Boundary Thrust |
| MKT | Main Karakoram Thrust |
| MMM | Mitigation Management Matrix |
| MMT | Main Mantle Thrust |
| MW | Mega Watt |
| **N** | |
| NA | Northern Areas |
| NCS | National Conservation Strategy |
| NEQS | National Environment Quality Standards |
| NGO | Non- Governmental Organizations |
| NOC | No Objection Certificate |
| **P** | |
| PAP | Project Implementation and Resettlement of the Affected Persons |
| PEPA | Pakistan Environmental Protection Act |
| PEPC | Pakistan Environmental Protection Council |
| PMAC | Program for Mountain Areas Conservation |
| PPC | Pakistan Penal Code |
| **R** | |
| RAP | Resettlement Action Plan |
| RNR | Renewable Natural Resources |
| **S** | |
| SC | Supervisory Consultants |
| SWHP | Surface Water Hydrology Project |
| **T** | |
| TOR | Terms of Reference |
| **U** | |
| UNDP | United Nations Development Program |
| **V** | |
| VO | Village Organizations |



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# LIST OF ABBREVIATION

**W**

| | |
|---|---|
| WAPDA | Water and Power Development Authority |
| WCSDO | Wildlife Conservation and Social Development Organizations |
| WCS | Wildlife Conservation Society |
| WHO | World Health Organization |
| WUO | Water Users' Organizations |
| WWF | World Wide Fund |

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## UNITS: CONVERSION FACTORS: SI TO FPS

| Length | To convert from | to | Multiply by |
|---|---|---|---|
| | m | ft | 3.281 |
| | cm | ft | 0.0328 |
| | km | ft | 3,280.84 |
| | m | mi | 0.0006214 |
| | km | mi | 0.6214 |
| **Area** | $m^2$ | $ft^2$ | 10.764 |
| | $km^2$ | $mi^2$ | 0.3861 |
| | $m^2$ | acre | 0.0002471 |
| | $km^2$ | acre | 247.105 |
| | hectare | acre | 2.471 |
| **Volume** | $m^3$ | $ft^3$ | 35.315 |
| | $m^3$ | US gal | 264.172 |
| | $m^3$ | UK gal | 219.969 |
| | L | $ft^3$ | 0.035315 |
| | $m^3$ | Acre Feet | 0.000810714 |
| **Velocity** | m/s | ft/s | 3.281 |
| | cm/s | ft/s | 0.03281 |
| | m/s | mi/h | 2.237 |
| | km/h | mi/h | 0.622 |
| **Acceleration** | $m/s^2$ | $ft/s^2$ | 3.281 |
| **Mass** | kg | $lb_m$ | 2.205 |
| | kg | ton | 0.00110 |
| **Pressure and Stress** | Pa or $N/m^2$ | psi | 0.000145 |
| **Discharge** | $m^3/s$ | $ft^3/s$ | 35.315 |
| | L/s | $ft^3/s$ | 0.035315 |
| | $m^3/s$ | US gal/min | 15850.3 |
| | $m^3/s$ | UK gal/min | 13198.2 |
| | L/s | US gal/min | 15.850 |
| | L/s | UK gal/min | 13.198 |



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# TABLES OF CONTENTS

**1 INTRODUCTION ..... 1-1**
1.1 GENERAL ..... 1-1
1.2 LOCATION ..... 1-3
1.3 Environmental AND SOCIAL Impact Assessment (ESIA) ..... 1-3
1.4 Project Categorization ..... 1-4
1.5 SCOPE AND LIMITATIONS OF ESIA ..... 1-5
1.5.1 Scope ..... 1-5
1.5.2 Limitations ..... 1-5
1.6 APPROACH AND METHODOLOGY ..... 1-5
1.6.1 Review of Previous Studies ..... 1-5
1.6.2 Acquisition of Secondary Data ..... 1-6
1.6.3 Collection of Primary Data ..... 1-6
**2 PROJECT DESCRIPTION ..... 2-1**
2.1 Background ..... 2-1
2.2 Project Introduction ..... 2-1
2.3 Project Components ..... 2-2
2.3.1 Civil Works ..... 2-2
2.3.2 Mechanical Works ..... 2-4
2.3.3 Electrical Works ..... 2-5
2.4 Salient Features of the Project ..... 2-6
**3 REGULATORY LAWS AND THE INSTITUTIONAL FRAMEWORK ..... 3-1**
3.1 GENERAL ..... 3-1
3.2 NATIONAL POLICY FRAMEWORK ..... 3-1
3.2.1 National Conservation Strategy, 1992 ..... 3-1
3.2.2 National Environmental Policy, 2005 ..... 3-2
3.2.3 National Forest Policy Pakistan, 2001 ..... 3-2
3.2.4 National Power Policy, 2013 ..... 3-3
3.2.5 National Electricity Policy, 2005 ..... 3-3
3.2.6 Federal Government Institutions ..... 3-3
3.2.7 Pakistan Environmental Protection Agency Regulations 2000 ..... 3-4
3.2.8 Functions of Federal Environmental Protection Agency (PAK EPA) ..... 3-4
3.2.9 Functions of Provincial EPAs ..... 3-5



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3.3 PAKISTAN ENVIRONMENTAL IMPACT ASSESSMENT (EIA) APPROVAL PROCEDURES ....3-6
3.3.1 Guidelines for Environmental Assessment....3-6
3.4 FEDERAL STATUTORY FRAMEWORKS FOR ENVIRONMENT MANAGEMENT AND ASSESSMENT ....3-7
3.4.1 Land Acquisition Act (LAA), 1894 ....3-7
3.4.2 Project Implementation and Resettlement of the Affected Persons Ordinance ....3-8
3.4.3 Antiquities Act 1975....3-8
3.4.4 Pakistan Water and Power Development Authority Act 1958....3-8
3.4.5 The Telegraphy Act 1910 ....3-8
3.4.6 Labor Laws....3-9
3.4.7 Penal Code 1860....3-9
3.4.8 Local Government Ordinance 2001 ....3-9
3.4.9 Regulations of Mines and Oil Fields and Mineral Development Act, 1948....3-9
3.4.10 Motor Vehicle Ordinance 1965 ....3-10
3.4.11 Factories Act, 1934....3-10
3.4.12 Highways Safety Ordinance 2000....3-10
3.4.13 Explosive Act, 1884 ....3-10
3.4.14 Wild Life Act 1975....3-10
3.4.15 Private Forest Regulation 1970 ....3-10
3.4.16 The Forest Act, 1927 and later amendments ....3-11
3.4.17 Protection of Trees and Brushwood Act, 1949....3-11
3.4.18 Gilgit-Baltistan Customary Laws ....3-11
3.4.19 Gilgit-Baltistan Forest Rules 1983 ....3-11
3.4.20 Gilgit-Baltistan Strategy for Sustainable Development 2003 ....3-11
3.4.21 Draft National Forest Policy 2001 ....3-11
**4 BASELINE CONDITIONS....4-12**
4.1 PHYSICAL ENVIRONMENT ....4-12
4.1.1 Physiography....4-12
4.1.2 Demography....4-12
4.1.3 Climate ....4-13
4.1.4 Precipitation....4-13
4.1.5 Temperature....4-13
4.1.6 Wind Speed and Direction ....4-14



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4.1.7 Geology ..... 4-15
4.1.8 Seismology ..... 4-15
4.1.9 Landslides, Erosion and Sedimentation ..... 4-15
4.1.10 Land Use ..... 4-16
4.1.11 Mining ..... 4-17
4.1.12 Soil Pollution and Contamination ..... 4-17
4.1.13 Agriculture ..... 4-17
4.1.14 Fruits ..... 4-19
4.1.15 Livestock ..... 4-22
4.1.16 Hydrology ..... 4-25
4.1.17 Flooding ..... 4-26
4.1.18 Surface Water ..... 4-26
4.1.19 Tributaries ..... 4-29
4.1.20 Groundwater ..... 4-29
4.1.21 Water Availability & Quality ..... 4-29
4.1.22 Air Quality and Noise ..... 4-30
4.1.23 Greenhouse gases ..... 4-30
4.1.24 Waste ..... 4-30
4.2 BIOLOGICAL ENVIRONMENT ..... 4-31
4.2.1 Flora ..... 4-31
4.2.2 Medicinal Plants ..... 4-32
4.2.3 Forestry ..... 4-33
4.2.4 Fauna ..... 4-35
4.2.5 Insects ..... 4-36
4.2.6 Endangered, Threatened or Vulnerable Species of Fauna ..... 4-36
4.2.7 Community Controlled Hunting Areas ..... 4-37
4.2.8 Protected Area ..... 4-37
4.2.9 CONSERVATION AND SUSTAINABLE USE OF BIODIVERSITY ..... 4-38
4.2.10 GAME RESERVES ..... 4-38
4.2.11 Aquatic Ecology ..... 4-39
4.2.12 Fisheries ..... 4-39
4.3 Social and Economic Environment ..... 4-40
4.3.1 Population ..... 4-40
4.3.2 Languages ..... 4-43



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4.3.3 Ethnic Groups and Religions ....4-43
4.3.4 Administrative Setup....4-43
4.3.5 Aga Khan Development Network (AKDN)....4-44
4.3.6 Housing Characteristics....4-44
4.3.7 Health Facilities and Common Diseases....4-44
4.3.8 Education and Literacy ....4-45
4.3.9 Infrastructure and Recreation ....4-45
4.3.10 Professions and Source of Income ....4-45
4.3.11 Social Organizations and NGO Involvement....4-45
4.3.12 Tourism and Cultural Heritage ....4-46
4.3.13 Status of Women....4-46
**5 ESIA AND MITIGATION MEASURES ....5-1**
5.1 General ....5-1
5.2 Impact Assessment Procedure....5-1
5.2.1 Sensitivity ....5-1
5.2.2 Magnitude....5-1
5.3 Impacts during Construction....5-2
5.3.1 Impacts on Topography....5-2
5.3.2 Impact on Seismicity....5-3
5.3.3 Impact on Geology ....5-3
5.3.4 Impacts on Landslides....5-3
5.3.5 Impacts on Land Use....5-4
5.3.6 Impacts of Excavated Material....5-4
5.3.7 Impacts on Infrastructure....5-4
5.3.8 Impact on Climate....5-4
5.3.9 Impacts on Hydrology....5-5
5.3.10 Impacts on Surface Water ....5-5
5.3.11 Impacts on Sedimentation ....5-5
5.3.12 Impacts on Flooding ....5-5
5.3.13 Impacts on Groundwater ....5-6
5.3.14 Impacts on Air Quality....5-6
5.3.15 Impacts on Agriculture and Vegetation ....5-6
5.3.16 Impacts on Terrestrial Flora....5-6
5.3.17 Impact on Terrestrial Fauna....5-7



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5.3.18 Impacts on Aquatic Life ....5-7
5.3.19 Involuntary Resettlement ....5-7
5.3.20 Impacts on Employment Opportunities ....5-7
5.3.21 Impacts on Regional Safety and Health ....5-7
5.3.22 Impacts on Occupational Health and Safety ....5-8
5.3.23 Impacts on Resources ....5-8
5.3.24 Impact on Roads Traffic ....5-8
5.3.25 Impacts on Communication ....5-9
5.3.26 Impacts on Cultural Heritage and Archaeology ....5-9
5.3.27 Impacts on Tourism ....5-9
5.3.28 Impacts on Women and Indigenous People ....5-9
5.4 Impacts During Operational Stage ....5-10
5.4.1 Impact on Seismicity ....5-10
5.4.2 Impacts on Geology ....5-10
5.4.3 Impacts on Landslides ....5-10
5.4.4 Impacts on Land Use ....5-11
5.4.5 Impacts of Dismantling Material ....5-11
5.4.6 Impacts on Infrastructure ....5-11
5.4.7 Impacts on Climate ....5-11
5.4.8 Impacts on Hydrology ....5-11
5.4.9 Impacts on Surface Water ....5-12
5.4.10 Impacts on Sedimentation ....5-12
5.4.11 Impacts on Flooding ....5-12
5.4.12 Impacts on Groundwater ....5-13
5.4.13 Impacts on Air Quality ....5-13
5.4.14 Impacts on Agriculture and Terrestrial Vegetation ....5-13
5.4.15 Impacts on Flora and Fauna ....5-13
5.4.16 Aquatic Life and Fish Stocks ....5-13
5.4.17 Impacts on Power ....5-14
5.4.18 Impacts on Employment Opportunities ....5-15
5.4.19 Impacts on Social Services ....5-15
5.4.20 Impacts on Tourism, Landscaping and Visual Amenity ....5-15
5.4.21 Impact on Women ....5-15
**6 ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN ....6-1**



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6.1 Objectives of Environmental Management and Monitoring ..... 6-1
6.2 Mitigation Management Matrix ..... 6-1
6.3 Management of Direct Construction Impacts ..... 6-2
6.4 Site Restoration Plan ..... 6-2
6.5 Reservoir Management Plan ..... 6-2
6.6 Impact Monitoring Program ..... 6-3
6.6.1 Objectives of the Impact Monitoring Plan ..... 6-3
6.6.2 Monitoring Strategy ..... 6-3
6.6.3 Monitoring Parameters and Frequency ..... 6-4
6.7 Constitution of Project Environment Management Committee ..... 6-4
6.8 Land Requirements for the Project ..... 6-5
6.9 Constitution of Project Environment Management Committee ..... 6-5



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# LIST OF FIGURES

Figure 1-1: District and Tehsil Boundaries of GB.....1-1

Figure 1-2: Affected Area of Attabad Village .....1-2

Figure 1-3 Extent of Attabad Lake showing Villages .....1-9

Figure 3-1: Environmental Approval Procedure.....3-6

Figure 4-1: Mean Monthly Flows .....4-25

Figure 4-2: Instantaneous Peak Flows at Attabad Lake HPP Site .....4-26

Figure 4-3: Plantation site Khuramand & Zarabad, Hunza .....4-34



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# LIST OF TABLES

Table 2-1: Salient Features of Attabad Hydropower Project ..... 2-6
Table 4-1: Average Max & Min Monthly Temperature and Mean Precipitation at Gilgit ..... 4-14
Table 4-2: Wind Speed and Direction ..... 4-14
Table 4-3: Summary of Land Use in Gilgit-Baltistan ..... 4-16
Table 4-4: District Wise Agriculture Land of GB ..... 4-18
Table 4-5: Cropping Pattern in Hunza valley ..... 4-18
Table 4-6: Cropped Area and Production ..... 4-19
Table 4-7: Area and Production of Fruit in Sub division Hunza ..... 4-20
Table 4-8: Utilization of Fruits on District Sub division Hunza ..... 4-21
Table 4-9: Detail of Nurseries and Seed Farms ..... 4-21
Table 4-10: List of Veterinary Units ..... 4-23
Table 4-11: Livestock Census 2017 ..... 4-24
Table 4-12: Chemical Parameters Results of the Samples (Surface Water) ..... 4-27
Table 4-13: Bacteriological and Physical Parameters Results of the Samples ..... 4-28
Table 4-14: Range of Gaseous Pollutant Concentration & Noise Emission Level ..... 4-30
Table 4-15: Important medicinal plants report in GB Forests ..... 4-32
Table 4-16: Fauna available in Gilgit Baltistan ..... 4-36
Table 4-17: Game Reserves Areas ..... 4-38
Table 4-18: Potential Fisheries Resources in District Hunza ..... 4-40
Table 4-19: Population of the Area (2017) ..... 4-41
Table 4-20: Jamatkhana Wise Population Information Summary 2016 ..... 4-42
Table 6-1: Land Requirements for Attabad Lake HPP ..... 6-5
Table 6-2: Cost Estimate for Land Acquisition and Environmental Mitigation ..... 6-6



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# LIST OF APPENDICES

A. List of Respondents of Socio-Economic Survey

B. Questionnaire for Socio-Environmental Survey

C. Water Sample Laboratory Testing (ALHPP)

# LIST OF DRAWINGS

1. Drawing-I Project Layout
2. Drawing-II Land Requirement for the Project



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# 1 INTRODUCTION

## 1.1 GENERAL

Gilgit-Baltistan, formerly part of the Northern Areas, is the northern most administrative territory of Pakistan. Gilgit-Baltistan lies at the extreme north of the country with borders joining Xinjiang Province of China in the north, Chitral in the west and Kalam, Kohistan and Kaghan valleys in the south. Towards the east are the Indian occupied territories of Ladakh and Kashmir. Gilgit-Baltistan is linked via the Silk Route: i.e. the Karakoram Highway which starts from Mansehra district of Khyber Pakhtunkhwa and ends at the Khunjerab Pass of Hunza District where the road continues into China.

Administratively, the Gilgit-Baltistan is divided into 10 districts: Gilgit, Ghizer, Hunza, Nagar, Skardu, Ghanche, Shigar, Kharmang, Diamer and Astore. Previously there were seven districts in the region. In 2016, the number rose from seven to ten after the addition of 2 districts in Baltistan region and the bifurcation of the Hunza-Nagar district. As of 2021, there are 10 districts in the entire region, four in the Baltistan Division, four in the Gilgit Division and two in the Diamer Division. In 2019, Darel, Tangir, Gupis–Yasin and Roundu were announced as new districts by the GB Cabinet, but so far these districts are not notified officially.

**Figure 1-1: District and Tehsil Boundaries of GB**

Tourism in Pakistan is a growing rapidly. One renowned travel guide book termed Pakistan "tourism's next big thing". Pakistan was also ranked “the best holiday destination for 2020” and



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was also declared the third-highest potential adventure destination in the world for 2020 by a travel magazine.

Gilgit-Baltistan is home to five of the "eight-thousanders" out of fourteen and to more than fifty peaks above 7,000 meters (23,000 ft). The region is home to some of the world's highest mountain ranges. The main ranges are the Karakoram and the western Himalayas. The Pamir Mountains lies at the north, and the Hindu Kush lies to the west. Amongst the highest mountains are World's 2nd highest peak 'K2' (Mount Godwin-Austen) and World's 9th highest peak 'Nanga Parbat'. Three of the world's longest glaciers outside the polar regions are located in Gilgit-Baltistan: the Biafo Glacier, the Baltoro Glacier, and the Batura Glacier. There are, in addition, several high-altitude lakes in Gilgit-Baltistan

Hunza Valley was composed of two independent kingdoms: Hunza and Nager in the early 1600s. Hunza is located on the branch of the ancient Silk Route from Kashgar to Kashmir and is linked to Turkistan/western China since ancient times.

Hunza is one of the primary destinations in Pakistan and is the center piece of tourism in the northern region. The major valleys in Hunza are Nilt, Nagar, Shimshal, Morkhun, Chapursan and Hanging Glacier in high Karakoram Range. The climate varies widely from monsoon-influenced moist temperate to arid and semi-arid cold deserts in the north. Below 3000 m.a.s.l, precipitation is less than 200 mm per annum while there is a sharp precipitation gradient along the altitude, and over 2,000 mm annual snow fall above 6000 m.a.s.l. Climate of the area is cold arid with moderate dry summers and severe winters.

**Figure 1-2: Affected Area of Attabad Village**



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Attabad Lake was created due to a massive land slide in January, 2010. Water and Power Department of Gilgit Baltistan intends to utilize this storage as an opportunity to develop Hydropower Project of appropriate capacity utilizing this potential in order to meet the ever increasing demand of Hunza district and its suburbs.

## 1.2 LOCATION

The Attabad Lake HPP is located in the Gilgit-Baltistan. The site of the project is located on Hunza River at Attabad Lake about 15 km upstream from Ganish Bridge of Hunza. Its distance is about 20 km from Hunza, 115 km from Gilgit. The powerhouse location is on the left bank of river and easily accessible from Karakoram Highway. The intake weir/dam site is selected at current exit point of Attabad Lake which was formed in the year 2010 due to a huge slide from right bank mountain.

The Hunza River is joined by several tributaries like Chapursan, Khunjerab, Ghujerab, Shimshal and Hisper Rivers. Nagar is the nearest district to Hunza and its capital is 25 km from the project site.

## 1.3 ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT (ESIA)

The ESIA is the planning tool developed in recent years to foresee the environmental and social impacts of human intervention in nature arising from development projects. Major hydropower and storage dam projects invariably result in many far-reaching environmental, ecological and socio-cultural changes. Some of these changes benefit human population, while others threaten the natural resource base on a short or long term basis.

The undesirable changes are not solely restricted to increasing pollution or loss of natural resources and habitats for native flora and fauna, but they cover the entire range of environmental and social components, such as soil, water, air, and socio-economic and cultural system. It is now accepted fact that for sustainable economic development, strategies must be compatible with environmental goals. This requires the incorporation of environmental consideration into the process of development. It is important to make choices and decisions that will eventually promote sound development by understanding the environmental functions under the exercise of power conferred by Section 33 of PEPA, 1997, EPA, Pakistan with the approval of the Federal Cabinet has promulgated EPA Regulations, 2000. These regulations provide the basis for the screening of a Project as per Project size and magnitude. The subject Project falls under the Schedule II of category E, which is related to Water Management, Dams, Irrigation and Flood Protection with criteria that dams and reservoir with storage volume of 50 $Mm^3$ and above or surface area greater than 8 $km^2$ and hydro projects above 50 MW of installed capacity requires an EIA. Attabad Lake Hydropower Project has installed capacity of 54 MW having reservoir surface area of 4.5 $km^2$, therefore, it requires an EIA for the issuance of NOC from the concerned EPA.



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The negative environmental and social impacts of a development project are avoided or minimized through the ESIA and where adverse impacts cannot be avoided, the mitigation measures and resettlement activities are conceived and executed as part of the project.

The overall objectives of an Environmental and Social Impact Assessment in accordance with the Pakistan Environment Protection Act (PEPA 1997), and the World Bank guidelines (OP 4.0) include the following:

- Help ensure the environmental and social soundness and sustainability of projects.
- Support integration of environmental and social aspects of projects into the decision making process.
- Promote environmentally sustainable development by supporting the protection, conservation, maintenance, and rehabilitation of natural habitats and their functions
- Avoid or minimize involuntary resettlement and if not feasible, to assist displaced persons in improving or at least restoring their livelihoods and standards of living in real terms relative to pre-displacement levels or to levels prevailing prior to the beginning of project implementation, whichever is higher.
- Design and implement projects in a way that fosters full respect for indigenous peoples' dignity, human rights, and cultural uniqueness and so that they: (a) receive culturally compatible social and economic benefits; and (b) do not suffer adverse effects during the development process.
- Assist in preserving physical cultural resources and avoiding their destruction or damage.
- Assure quality, health and safety in the design and construction of new dams and the rehabilitation of existing dams, and in carrying out activities that may be affected by an existing dam.
- Enable vulnerable and disadvantaged stakeholder groups to participate in an informed manner.

## 1.4 PROJECT CATEGORIZATION

According to Pakistan Environment Protection Agency regulations for review of IEE and EIA, hydroelectric projects with a generation capacity of over 50 MW and power transmission lines with a capacity more than 11 kV fall into Schedule-II, i.e. projects requiring EIA. Similarly, in accordance with the guidelines of the World Bank, the Asian Development Bank and the Japan Bank for International Cooperation Environmental guidelines, the Attabad Lake HPP (with a planned generating capacity of 54 MW and 132 kV power transmission lines) would fall within the category 'A' projects could be having significant impacts on the environment and requiring a full scale EIA.



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## 1.5 SCOPE AND LIMITATIONS OF ESIA

### 1.5.1 Scope

The scope of the study proposed by WAPDA in the Terms of Reference (TOR) for this feasibility study includes this ESIA which only covers the dam site, reservoir, powerhouse areas and transmission systems. Resettlement Action Plan (RAP) is not under consideration as there is no displacement of people involved. Team of Engineers from Hydro planning have envisaged the following Statement of Work related to environmental studies:

a. Review of national and local guidelines, laws and policies;
b. Review of all relevant existing data, studies, reports and drawings;
c. Avoid, minimize, mitigate and the potential significant environmental and social impacts due to the proposed intervention;
d. Collection of baseline data related to Physical, Ecological and Social environmental aspects;
e. Identification, evaluation and categorization of the potentially significant adverse physical, ecological and socio-economic impacts on the local environment during the construction and operational stages of the proposed Hydropower Project;
f. Recommend appropriate environmental and social mitigation measures for the identified adverse impacts and monitoring plans to address them;
g. Preparation of Environment Monitoring Management Plan (EMMP);
h. Cost estimate for environmental setup;
i. Public consultation and disclosure;

### 1.5.2 Limitations

The baseline information documented in the present report reflects the prevailing physical, biological and socio-economic conditions of the project area. The project is at feasibility stage and the detailed design and tender documents preparation stages will follow during the execution. If the project is implemented after two years of completion of the feasibility stage then certain variables such as development of infrastructure, population growth, increase or decrease in the forest, land use, cropping patterns and economic conditions could be changed significantly.

## 1.6 APPROACH AND METHODOLOGY

### 1.6.1 Review of Previous Studies

Attabad Lake Hydropower Project was conceived by Water and Power Department, Govt. of GB for 32.5 MW. Consequently, a Feasibility Study was conducted by the Water & Power Department Gilgit Baltistan through Consultants. No detailed EIA was required for less than 50 MW installed capacity. Only Initial Environmental Examination was carried out to fulfill the requirement of the Pakistan Environmental Protection Agency (PEPA) by the consultants engaged by Govt. of GB. Later on the request of Govt. of GB, WAPDA updated the feasibility study of the project with



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enhanced capacity of 54 MW and for such project, detailed environmental and social impact assessment study was required.

The following earlier project reports have been reviewed to assess their applicability in the prevailing environmental conditions specially in Gilgit Baltistan region:

- Bunji Hydropower Project: Feasibility Study Report (Vol-III), Environmental Impact Assessment by Bunji Hydropower Consultants (March 2005).
- Detailed Engineering Design Report of Phander Hydropower Project.
- Feasibility Study Report of Shyok Dam Project, Environmental Impact Assessment Study.
- And Various Other Reports Related to Gilgit Baltistan.

### 1.6.2 Acquisition of Secondary Data

The secondary data was collected from various offices and published reports of different organizations in the Gilgit Baltistan. These organizations included Water & Power, Education, Forest, Agriculture, Fisheries, Sanitation, Wildlife, Environmental Protection Agency, District Administration, Tehsil Offices, Local Councils and others. The studies are carried out on the information received during field visits of Project area, data received from some NGOs, water samples collected from project area at various places and tested in Gilgit-Baltistan Environmental Protection Agency Laboratory, Gilgit, climate data received from Metrological department, and other data taken from earlier conducted feasibility study and other reports of projects.

### 1.6.3 Collection of Primary Data

The primary data were collected and assessed with reference to different project components, i.e. dam site, reservoir area, powerhouse, construction camps etc. The data regarding climate, hydrology, geology, seismology, neo-tectonics and other physical features of the project area were also obtained as part of the preparation of this feasibility study. Data collected from the villages as shown in the Figure1-3

#### i. Vegetation Studies

The assessment area for terrestrial flora and fauna encompasses the terrestrial environments upstream and downstream of the dam and adjacent areas that may be affected by the project activities, specifically from the dam to the upper end of the reservoir impoundment and from the dam to the powerhouse.

Since the lake was formed in January 2010 and no new area would be submerged with the project except the powerhouse site, therefore, there would be no new threat to plants with the construction of hydropower project. However, concentration was given to study the rare species and special emphasis was given to the economic species such as medicinal plants.



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### ii. Wildlife Fauna Studies

Information on wildlife fauna species (mammals, amphibians, reptiles, birds etc.) in the assessment area was compiled based on opportunistic observation, gathering the existing information and consultation with local experts, community members and government and non-government organizations.

### iii. Aquatic Ecology

Generally Northern Area are blessed with great water resources comprised of rivers, streams, and alpine lakes fed by the snowmelt and glacier waters. These freshwater resources harbor several fish species, which are the important component of the biological diversity. The fish fauna in Hunza Valley is relatively poor due to high turbidity, low water temperature and high water speed.

### iv. Environmental Flow Study

An environmental flow study was carried out to determine the optimum environmental flow downstream of the proposed dam for sustainability of the aquatic ecosystem. The study is based on the hydrological data 50 years obtain from Surface Water Hydrology Department WAPDA that involves analysis of river flow data coupled with aquatic ecosystem analysis.

### v. Social Surveys

The purpose of social survey was to record the present conditions of the people living in the project area and to assess the expected project impacts on their life, subsistence systems, and social and cultural conditions. Prior to conducting the field surveys, the following steps were taken:

- Geographic boundaries of the project area were identified and existing villages and settlements were listed.
- Decided the sampling procedure in order to draw a representative sample size of the target population and households
- Developed the tools for data collection i.e. questionnaires for household sample survey, village profile, women sample survey, community participation and water use.

In order to obtain comprehensive and detailed information, the following techniques and tools of data collection were used.

### vi. Sampling Design

A stratified proportionate random sampling technique was applied to select adequate and representative samples to generalize survey findings at the project level. The stratification variables were taken into consideration for enhancing the representation level for adopting appropriate sampling design.



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### vii. Stratification Variables

The major objective of the study was to establish baseline socio-economic conditions for the inhabitants near the existing reservoir upto original extent of lake formed in 2010, powerhouse and adjacent areas of the project. The following factors were taken into consideration for enhancing the probability of every household being selected in the sample size:

Each village was included in the sampling frame because of the heterogeneity of socio-economic characteristics between villages and relatively homogeneity within a village.

### viii. Sampling Unit

The primary sampling unit for the socio-economic survey was the head (male or female) of the household falling within the nine sample villages of proposed Attabad Lake Project area.

### ix. Basic Unit of Study

The basic unit of study and analysis for the purpose of socio-economic investigation is nine villages of project area for Attabad Lake Hydropower Project.

### x. Questionnaires

In order to test the validity and reliability of the proposed questionnaires, interviewing guides were pre-tested in the area and then the questionnaires were reviewed to assess whether questions needed to be clarified, changed or re-sequenced and then a final editing of questionnaires was conducted prior to their subsequent application in the real sample areas.

List of Respondents of socio-economic survey is attached at **Appendix-A** The different questionnaires used for the social survey are included in **Appendix-B** of this volume.

### xi. Field Investigators

A team of experts of Hydro Planning Organization moved to project area for field investigations. The team hired services of one local graduate lady and one local graduate man for questioning and answering with local people in their language. The team spent more than three weeks to visit seven villages of upstream and two villages of downstream side of the project area. In this exercise both genders were covered in field visits of project area. The role playing exercises provided the field investigators with the ability and confidence to establish a rapport with the respondents as well as other interviewing skills in order to minimize the no sampling error, wrongly asked or interpreted or recorded answers. The services of a local well educated female were hired for the data collection on the subjects of gender and women empowerment.

### xii. Interviewing Guide for Community Participation

Well informed persons in the village were interviewed by using a questionnaire to obtain information about village and their perceptions about the project.



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### xiii. Household Sample Survey

Household heads of total sample size from each sample village of the project area were interviewed by using structured questionnaires. Detailed information about the socio-economic status of the family and household was obtained from the respondents.

### xiv. Village Profile

A comprehensive village profile was prepared to document the socio-economic and demographic data of each sample village in project area.

### xv. Gender Survey

The experts developed a separate questionnaire covering various aspects and issues of women in the area. The services of a qualified local female were hired for this survey. Women from all the villages were interviewed. Respondent women were selected by applying the same technique as used for socioeconomic survey.

### xvi. Data Editing

The filled-in questionnaires and interviewing guides were edited by the same field investigators, who were involved in the data collection. This was done immediately after completing the field investigations.

### xvii. Data Analysis

Data sets were processed after the completion of the field survey and editing of socio-economic information. Analysis of this diversified data and preparation of conclusions in the minimum possible time was achieved using statistical techniques of data analysis.

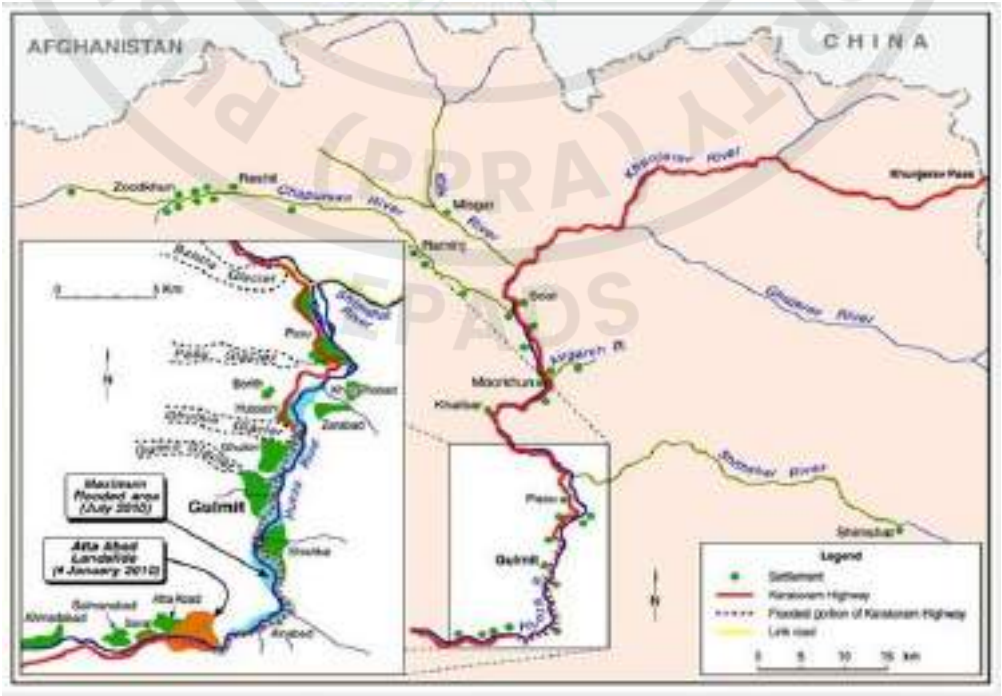


**Figure 1-3: Extent of Attabad Lake showing Villages**



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# 2 Project Description

## 2.1 BACKGROUND

The Hunza region is facing acute shortage of power resulting in long hours Load Shedding in the area, especially the conditions become worse in winter season, due to low flows in streams. Presently, there is high supply and demand gap; therefore, load shedding is common in summer, while it becomes very acute in winter. The commercial and industrial demand is partly fulfilled from privately owned diesel generators. The diesel generators are mainly used by the hotels, small businesses, banks and other consumers which can afford the high running cost. Apart from the cost the use of these diesel generators is creating environmental pollution (i.e., noise and air), which is also affecting the tourism in the area. The expected fast growth in tourism industry will immensely increase the electricity demand in future, if not planned properly and addressed timely, it will most likely create a crisis like situation in the near future.

## 2.2 PROJECT INTRODUCTION

Attabad Lake Hydropower Project is proposed on Attabad Lake which is located on the Hunza River in the Hunza District of the Gilgit-Baltistan. Attabad Lake was created due to land slide dam formed in January, 2010 due to a huge landslide from right bank of Hunza River at Attabad about 15 kilometers upstream of Ganish Bridge and about 111 kilometers upstream of Gilgit.

The project has been sized as per flows availability, size of conveyance system and surface powerhouse executable under prevailing topographic and geological features. The plant size of 54 MW will provide the installed power during peak hours throughout the years. The off-peak power would remain from 20 to 54 MW in six winter months, while in six summer months, 54 MW would be available for 24 hours.

A weir/dam will be constructed to divert the flow of Hunza River into Head Race channel, 2300 m long nearby Karakoram Highway. Before construction of weir, a deep flushing channel/ under sluices structure would be constructed in order to lower down the level of lake and to evacuate the water from lake on the left side of existing outlet. The under sluices structure will also act as flushing of sediment from the lake once project comes into operation. The diverted water enters into the head race tunnel 2300 m long. The tunnel is followed by surge shaft. Water will enter into 450 m long penstock pipe branching into three units at the end through manifold. These high-pressure penstock pipes and feed three turbines, for the generation of 54 MW hydropower. Layout of the Project is attached at **Drawing-I**.

The project is proposed to be developed on Hunza River at Attabad Lake with design discharge 60$m^3$/s to generate the rated power round the year. This project will enhance the generation capacity and augment the power supply network of entire Hunza-Nagar Valleys and Gilgit Town. Once completed and operational this project will help improve the power supply situation in the region.



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The salient features of the envisaged power supply project are given as follows;

- Type of Development: High Head Run of River with Peaking
- Gross Head: 111.7 m
- Net Head: 105.5 m
- Installed Capacity: 54MW
- Type of Turbine: Francis (Vertical)
- No. of Units: 03
- Design Discharge ($Q_d$): 60.00 $m^3/s$ (20 $m^3/s$ to each unit)
- Overflow Weir Length: 60 m
- No. of Undersluices: Three (03)
- Undersluice Gate Size: 5m x 5m
- Power Tunnel Length: 2300 m
- Penstock Length: 450 m
- Type of Powerhouse: External
- Annual Energy: 373.69 GWh
- Plant Factor: 79 %

## 2.3 PROJECT COMPONENTS

### 2.3.1 Civil Works

#### 2.3.1.1 Main Weir

The weir is located on the natural spillway of Attabad Lake. It will be an overflow type weir having 60 m width. Crest of weir is located at 2414 m.a.s.l. and has been designed to pass the flood of 3,250 $m^3/s$ along with undersluice. The existing spillway will be treated and given a proper shape of a weir. Grouting and cutoff wall will be provided to keep the structure safe from any kind of seepage.

#### 2.3.1.2 Undersluice

The undersluice channel is provided for the diversion of flow during the execution stage and for sediment flushing during operation stage of the project. Life of Attabad Lake will be maintained by flushing the sediments during most months of the year. A rectangular shaped Undersluice channel has been proposed at an elevation of 2402 m.a.s.l having width of 20 m.



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#### 2.3.1.3 Power Intake

The Intake will be the structure built to divert the design flow from the lake towards the headrace for onward transmission to the proposed power house. The intake would ensure proper & efficient working besides adherence to the hydrology of the River during low flows, normal flows and maximum possible flows.

Intake structure has been proposed at the point where the earthen embankment meets the face of left bank mountain in the rocks exposed on left bank just closed to lake boundary. The sill level of intake structure has been proposed as 2404 m.a.s.l. The maximum and minimum operation levels of water have been kept as 2414 m.a.s.l. and 2412 m.a.s.l. respectively. A trash rack will also be provided at the front of intake structure to avoid the entering of unwanted materials.

#### 2.3.1.4 Low Pressure Headrace Tunnel

A horse shoe type low pressure power tunnel of 5.2 m width has been proposed on the left bank of the river with diversion intake to cater the 60 $m^3$/sec design discharge for the power generation. Power Tunnel having 2300 m length passes through the stable rock portion on the left side.

#### 2.3.1.5 Surge Shaft

Surge tank has been proposed to accommodate surges to facilitate maintaining water level in headrace tunnel.

The surge shaft is proposed have an internal diameter of 8.0 m and maximum surge level reaches upto 2440 m.a.s.l.

#### 2.3.1.6 Penstock

One penstock will be laid down at the end of power tunnel to convey flow to powerhouse. The length of the penstock is about 450 m with diameter of 3.6 m. The thickness of steel is kept as 20 mm to withstand the water pressure. The initial 80 m penstock from surge tank would be pressure tunnel.

#### 2.3.1.7 Power House

The external type powerhouse is proposed near the old Chinese camp at 2 km downstream of existing spillway of Attabad Lake. It will be constructed in front of Sarat village near the bridge on Hunza river. It is designed for three vertical Francis units. The approximate dimensions of the power house will be L x W x H are 45 m x 18 m x 22 m. The turbine level in powerhouse has been kept as 2300 m.a.s.l., and the level for draft tube has been proposed as 2293 m.a.s.l.

#### 2.3.1.8 Tailrace channel

Tailrace Channel consists of an open channel forming part of power house structure and connecting to river Hunza. Tailwater levels varies for different situations. For normal operation when all three units are running the tailwater level reaches upto 2302.3 m.a.s.l. and during off



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peaking it reaches to as minimum as 2301.5 m.a.s.l. The maximum tailwater level reaches at around 2307 m.a.s.l.

### 2.3.2 Mechanical Works

#### 2.3.2.1 Turbines

The installed capacity of the Attabad Lake HPP shall be 54 MW with three units each having rated turbine output of 19 MW. Based on the technical and economical consideration and range of the head, Vertical Francis turbine have been selected for the Attabad Lake HPP due to the reasons that their part load operation is stable and the efficiency is high. The Vertical Shaft Francis turbines are selected for Attabad Lake HPP.

Each turbine shall be equipped with modern digital governor consisting of solid-state programmable microprocessor system of the electric-hydraulic PID type.

#### 2.3.2.2 Inlet Valves

Butterfly valve is suggested for Attabad Lake HPP. The valve diameter as worked out shall be 1.83 m, operated by servomotors.

#### 2.3.2.3 Cranes

One electric overhead bridge type traveling (EOT) crane of 100-ton capacity has been proposed for unloading and handling the powerhouse equipment at the loading/erection bay. Besides, the same crane shall be used for assemblies at the loading bay and for erection of plant.

#### 2.3.2.4 Cooling Water System

Independent closed loop system for each unit has been provided for turbine and generator coolers.

#### 2.3.2.5 Drainage System

The drainage system shall be designed to collect the Seepage water from different floors of the powerhouse. & leakage of oil from various components.

#### 2.3.2.6 Mechanical & Electrical Workshops

For the day-to-day maintenance jobs of the power plant, mechanical and electrical workshops along with storage areas for essential tools will be provided under the erection bay of the powerhouse.



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### 2.3.3 Electrical Works

#### 2.3.3.1 Generators

Three Generators with rated output of 21.2 MVA each, rated power factor of 0.85 & rated Voltage of 11kV will be coupled with the Turbines.

#### 2.3.3.2 Transformers

Three Unit step up Transformers be installed with Rated power of 22 MVA & Rated Voltage of 11 kV/132 kV each.

#### 2.3.3.3 Control Panels

Digital Control panels be installed for overall control of the power house and auxiliary systems.

#### 2.3.3.4 132 kV Transmission Lines

132 kV Transmission line of 27km (double circuit) will be constructed from Attabad Lake HPP to Aliabad. And 132 kV Transmission line of 70 km (single circuit) will be constructed from Attabad Lake HPP to Sost.

#### 2.3.3.5 Grid Stations

132 kV switchyard will be constructed at Attabad Lake HPP.

#### 2.3.3.6 Protections

Digital type Relays of latest version will be used for protection of turbines, generators and transformers.



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## 2.4 SALIENT FEATURES OF THE PROJECT

**Table 2-1: Salient Features of Attabad Hydropower Project**

| | | | |
|---|---|---|---|
| Location | Attabad village, Hunza District, Gilgit-Baltistan of Pakistan, 130 km west of Gilgit & 740 km north- of Islamabad | Design Discharge<br>Gross head<br>Installed Capacity<br>Mean Annual Energy<br>Plant Factor | 60 $m^3/s$<br>111.7 m<br>54 MW<br>373.69 GWh<br>79 % |
| River<br>Catchment Area<br>Mean Annual Discharge<br>Total annual volume | Hunza<br>8920 $km^2$<br>209 $m^3/s$<br>6591 mill $m^3$ | Penstock<br>Length<br>Diameter<br>Thickness | 1 no. Embedded<br>450 m<br>3.6 m<br>20 mm |
| Weir<br>Crest elevation<br>Crest length<br>Weir height<br>Stone Pitching length | Lateral weir<br>2414 m.a.s.l<br>60 m<br>2.0 m<br>30 m u/s and 20 m d/s | Powerhouse<br>Size<br>Height<br>Type of units<br>No. of units | External slope type<br>45 m x 18 m<br>22 m<br>Francis<br>3 |
| Attabad Lake length<br>Lake width<br>Lake depth | 14000 m<br>100 m<br>50 to 60 m | Tailrace<br>Turbine level<br>Max. Flood level | 20 m, concrete lined<br>2300 m.a.s.l<br>2307 m.a.s.l |
| Tunnel length<br>Size<br>Type | 2300 m<br>5.2 m diameter<br>Horse Shoe | Firm Power<br>Off peak winter<br>Peak Summer | 26 MW<br>18 MW<br>54 MW |
| Peaking Storage<br>Full supply level<br>Minimum supply level<br>Gross Storage | 5 Million $m^3$<br>2414 m.a.s.l<br>2412 m.a.s.l<br>123 Million $m^3$ | Distance up to Gilgit<br>Transmission Line upto<br>Voltage level<br>Areas to be served | 130 km<br>70 km single circuit and 27 km double circuit<br>132 k V<br>Hunza-Nagar, Gilgit, and Ghizar valleys |



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# 3 REGULATORY LAWS AND THE INSTITUTIONAL FRAMEWORK

## 3.1 GENERAL

This chapter deals with the National Policy, Regulatory Framework related to environmental protection, preservation and environmental assessment and approval procedures.

## 3.2 NATIONAL POLICY FRAMEWORK

The Federal Ministry of Environment (now called the Ministry of Climate Change) was established in Pakistan in 1975 as a follow up to the Stockholm Declaration of 1972. The Ministry was instrumental in the promulgation of the Environmental Protection Ordinance of Pakistan in 1983. The National Conservation Strategy (NCS) was formulated in 1992 which provides a broad framework for addressing various environmental issues and environmental conservation in the country. The Pakistan Environmental Protection Act (PEPA) was enacted in 1997 repealing the Ordinance of 1983. The Environmental Quality Standards (NEQS) were promulgated in December 28, 1999 after the approval of the Pakistan Environmental Protection Council (PEPC). The IEE/EIA Regulations were promulgated by the Pakistan Environmental Protection Agency (under Section 12, PEPA Act of 1997) in 2000. A revised version of NEQS was enforced in 2000. The Ministry of Climate Change was created in 2010 to deal with the threats posed by global warming and for environmental protection in the country. However, after the approval of 18th amendment in 2010, the matters related to environment became a provincial subject. The role of the Federal EPA is now limited to the federal capital and matters related to environment in each province has to be dealt by their own EPAs which are made more independent having their own laws related to the protection of the environment and procedures for the issuance of NOC for the development Projects.

The National Policy Framework encompasses the environmental issues which Pakistan is currently facing, especially pollution of fresh water bodies and coastal waters, air pollution, lack of proper waste management, deforestation and degradation of forest cover, loss of biodiversity, desertification, natural calamities and climate change.

### 3.2.1 National Conservation Strategy, 1992

The Pakistan National Conservation Strategy (NCS) was approved by the federal cabinet in March 1992 and as such formulates the principal policy document dealing with environmental conservation issues in the country. The NCS outlines the country's primary approach towards encouraging sustainable development, conserving natural resources, and improving efficiency in the use and management of natural resources.

The NCS has 68 specific programs in 14 core areas in which policy intervention is considered crucial for the preservation of Pakistan's natural and physical environment. The core areas that are relevant in the context of the proposed Project are pollution prevention and abatement,



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restoration of rangelands, increasing energy production, conserving biodiversity, supporting forestry and plantation, and preservation of cultural heritage.

### 3.2.2 National Environmental Policy, 2005

The National Environment Policy while recognizing the goals and objectives of the National Conservation Strategy, National Environmental Action Plan and other existing environment related national policies, strategies and action plans, provides broad guidelines to the Federal Government Provincial Governments, Federally Administrated Territories and Local Governments for addressing environmental concerns and ensuring effective management of their environmental resources.

The main objectives of the Policy are:

a. Conservation, restoration and efficient management of the environmental resources;
b. Integration of the environmental considerations in policy making and planning process;
c. Capacity building of public sector agencies and other stakeholders at all levels for better environmental management;
d. Meeting international obligations effectively in line with the national aspirations; and
e. Creation of an atmosphere for environmental protection through mass awareness and community involvement.

### 3.2.3 National Forest Policy Pakistan, 2001

The goal of this policy is to foster the sustainable development of Renewable Natural Resources (RNR) of Pakistan, through maintenance and rehabilitation of these essential resources and enhancement of sustainable livelihoods of rural masses particularly women, children and other deserving groups.

The various components of the policy include the following:

a. Reducing poverty, powerlessness and unemployment;
b. Population planning in critical eco-systems;
c. Reducing the impact of socio-economic factors;
d. Providing substitutes to firewood in the mountain-woods;
e. Reducing political interferences in Forestry and Wildlife Departments;
f. Renovating and invigorating the institutions of RNR;
g. Supporting Local Governments in the sustainable development of their RNR;
h. Policies for fragile eco-systems;
i. Riverside forests;
j. Irrigated plantations;
k. Preservation of sensitive and unique forests;



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l. Wildlife conservation;

m. Rangelands and desert eco-systems; and

n. Planting trees and fodder on farmlands.

### 3.2.4 National Power Policy, 2013

Then Ministry of Water and Power of the Government of Pakistan developed an ambitious power policy to support the current and future energy needs of the country. This bold strategy will set Pakistan on a trajectory of rapid economic growth and social development. Simultaneously, it will address the key challenges of the power sector in order to provide much needed relief to the citizens of Pakistan. This document will frame the broad contours of the energy policy articulating the vision for the power sector, highlighting its key challenges, setting major goals, summarizing policy principles, and highlighting the strategy devised to achieve Pakistan's aspirations.

### 3.2.5 National Electricity Policy, 2005

The National Electricity Policy is one of the key instruments for providing policy guidance to the Electricity Regulatory Commissions in discharge of their functions and to the Central Electricity Authority for preparation of the National Electricity Plan. The Policy aims at accelerated development of the power sector, providing supply of electricity to all areas and protecting interests of consumers and other stakeholders keeping in view availability of energy resources, technology available to exploit them, economics of generation using different resources and energy security issues. This also involves development of National Grid, development of Rural Electrification Distribution, reliability and quality of power supply to be monitored by State Electricity Commissions, measures to promote competition, exploitation of small hydro, solar, biomass and wind resources / opportunities for additional power generation, emphasis on achieving higher efficiency levels through renovation and modernization, speedy implementation of stringent measures against theft of electricity, full emphasis on augmentation of R&D base and appointing Ombudsman for redressed of consumers grievances among various others.

### 3.2.6 Federal Government Institutions

The Federal Ministry of Climate Change deals with the issues of environmental preservation and climate change at the federal level. Within the Ministry, the NCS Resource Center (RC) is responsible for using the Information and Communication Technologies (ICTs) by setting up a decision support system in the field of environment. In addition to serving as an information and knowledge repository for all stakeholders of environmental protection and sustainable development in the country, it also aims to co-relate / restore environmental information / data, Project EIA reports, research publications, grey literature and documentaries to create accessibility among all the stakeholders, especially the public-sector agencies. This data base also contributes and facilitates decision making in the sectors of industry, health, energy, physical communication and tourism etc.

The Pakistan Environmental Protection Council (PEPC) and the PAK-EPA were primarily responsible for administering the provisions of PEPA 1997. The PEPC oversees the functioning



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of PAK-EPA. Its members include representatives of the Federal Govt. industry and Non-Governmental Organizations (NGOs).

The Pakistan Environmental Protection Agency (PAK-EPA) was required to ensure compliance with the NEQS, establish monitoring and evaluation system, and identify the need as well as initiate necessary legislation whenever required.

PAK-EPA has delegated powers to its provincial counterparts for environmental monitoring and enforcement. One of the functions delegated by the PAK-EPA to the provincial EPAs is the review and approval of environmental assessment reports (EIA's) and the issuance of No Objection Certificates (NOCs).

### 3.2.7 Pakistan Environmental Protection Agency (Review of IEE/EIA) Regulations 2000

These regulations / schedules present the policy and procedures for the filing / review and approval of environmental assessment reports. The Projects falling under Schedule-I of these regulations require an IEE Report while Projects falling under Schedule-II require an EIA for the issuance of NOC by the concerned agency prior to the construction of the Project.

According to the PAK-EPA Regulations 2000 for Review of IEE and EIA, the proposed Attabad HPP falls under Schedule-II Projects, (water management, dams, irrigation and flood protection). Therefore, this EIA study was carried out for the Attabad HPP. The IEE / EIA regulations 2000 stipulate that within ten (10) working days of the IEE or EIA having been submitted, the federal/provincial agency will confirm that the document submitted is complete for the purpose of review. During this time, should the agency require the proponent to submit additional information, it will return the IEE or EIA to the proponent for revision, clearly listing those aspects that need further discussion. Subsequently, the Federal EPA / concerned Provincial EPA would make every effort to complete an IEE review within forty-five (45) days and an EIA review within ninety (90) days of filing.

### 3.2.8 Functions of Federal Environmental Protection Agency (PAK EPA)

The functions and responsibilities of the Pak EPA is now restricted to the only for Federal Capital and it adjoin areas. The functions and responsibilities of the Pak EPA are as follows:

a. Implement and administer the Pakistan Environmental Protection Act (PEPA)-1997;
b. Adopt effective measures for implementation of national environmental policies;
c. Enforcement of the NEQS;
d. Publish annual report on status of national environment;
e. Promote research in science and technology which may contribute to the prevention of pollution and protection of environment;
f. Promote public awareness and education in the environment sector;
g. Pak EPA can inquire or investigate any environmental issue at its own or upon complaint from any person or community.



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### 3.2.9 Functions of Provincial EPAs

a) The EPAs can advise the potential proponent(s) for taking up environment assessment studies according to Schedule I and II of the PEPA 1997;

b) Issuance of NOC for an Initial Environmental Examination (IEE) or Environmental Impact Assessment (EIA).

c) The EPA can impose penalties on the violators of the applicable laws / environmental polluters;

d) The Provincial EPA can inquire or investigate any environmental issue at its own or upon complaint from any person or community within its jurisdiction.

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS



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## 3.3 PAKISTAN ENVIRONMENTAL IMPACT ASSESSMENT (EIA) APPROVAL PROCEDURES

Various steps encountered in the submission, review and approval of an IEE or EIA Report under Schedule-I and Schedule-II are shown in Figure 2.1.

### 3.3.1 Guidelines for Environmental Assessment

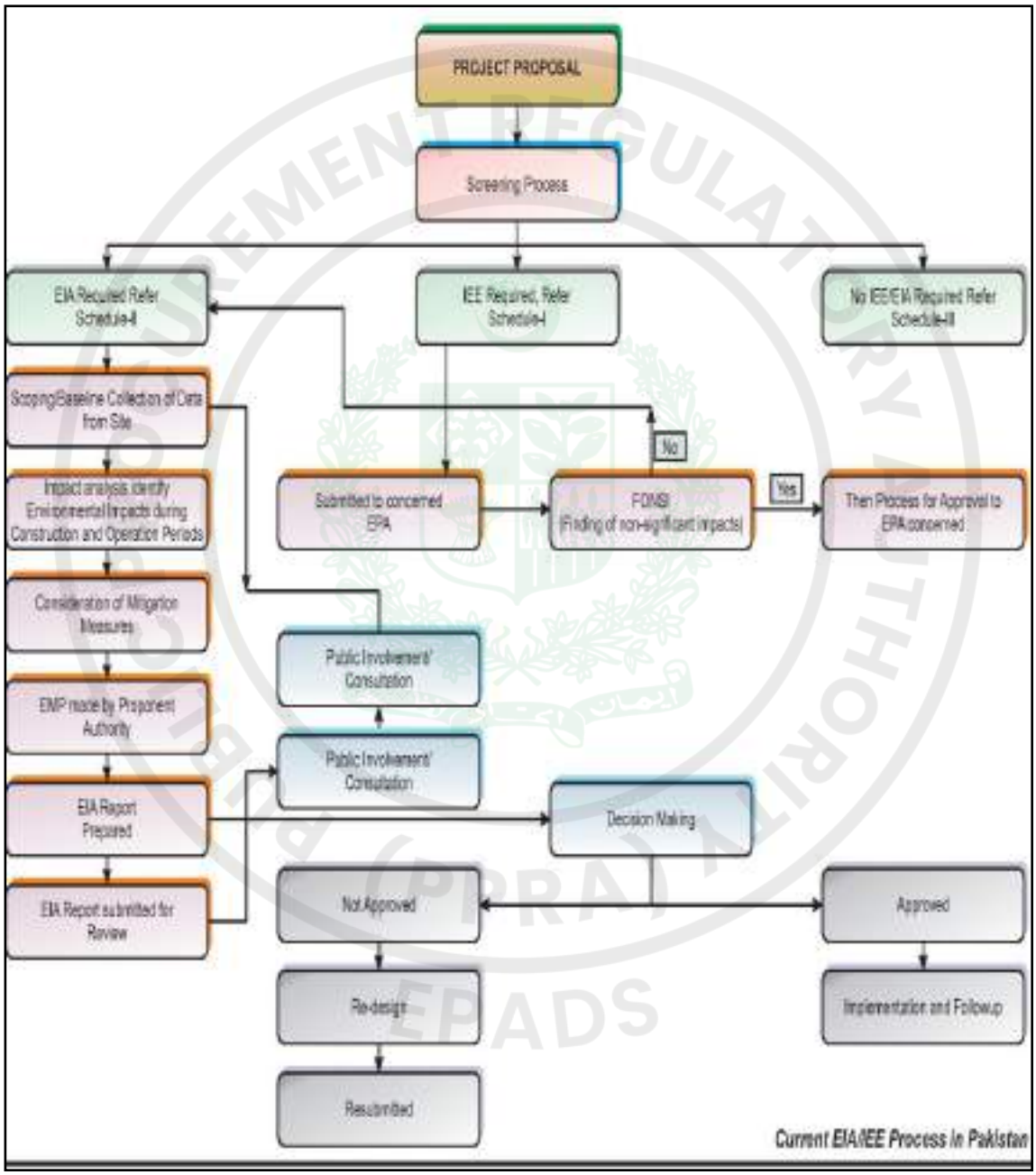


**Figure 3-1: Environmental Approval Procedure**

Pak-EPA has published a set of environmental guidelines for conducting the environmental assessments and the environmental management of different types for the development Projects.

The guidelines are relevant to the proposed Projects are listed below.



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a) Guidelines for the Preparation and Review of Environmental Reports, Pakistan Environmental Protection Agency, 1997

b) Guidelines for Public Consultation, Pakistan Environmental Protection Agency, May 1997.

c) Sectorial Guidelines: Pakistan Environmental Assessment Procedures, Pakistan Environmental Protection Agency, October 1997.

**Required Permits** This section describes the procedure for obtaining NOCs for EIA from concerned authorities and for working in sensitive and critical areas, as shown in Figure 3.1

## 3.4 FEDERAL STATUTORY FRAMEWORKS FOR ENVIRONMENT MANAGEMENT AND ASSESSMENT

This section outlines the important statutes apart from Pakistan Environmental Protection Act, 1997, which are relevant to the Project.

### 3.4.1 Land Acquisition Act (LAA), 1894

This Act is the primary law for acquisition of land and built-up properties for public interest in Pakistan and also sets out the procedure and rules for acquisition and compensating the owners, as well as for compensating owners for damage caused to their properties, crops and trees by a project but it lacks the mechanism to address the complex issues of resettlement. It comprises 55 sections dealing with area notifications, surveys, acquisition, compensation, appointment awards, disputes resolution, penalties and exemptions. The latest revisions and amendments including Land Acquisition Rules were made in 1983. Presently, the Land Acquisition Act 1894 is applicable throughout Pakistan including Gilgit Baltistan. The valuation of land for compensation is governed by sections 23 and 24 of the Act, which include the following provisions:

- Market value of the land at the time of notification of Section 6
- Damage sustained by a person interested in taking of compensation of standing crops or trees
- Damage sustained by the person at the time of Collector's taking possession of land
- Damage sustained by the person at the time of acquisition of land injuriously affecting his other property, movable or immovable.

For the Attabad Hydropower Project compensation for acquisition of land for project operations and hearing of complaints will be carried out primarily in the light of this Act, supported by other measures (to be decided in the particular circumstances to suit the requirements). However, in case a need arises, this Act will be used for this purpose, supported by other measures as warranted, to fulfill requirements of the World Bank Guidelines. In the project area mostly land ownership belongs to the community, people living in valleys have ownership rights on the local rangelands. The community has unwritten traditional laws for possession, distribution and transfer of assets or the income of the assets to the original inhabitants of these valleys.



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### 3.4.2 Project Implementation and Resettlement of the Affected Persons Ordinance 2000

The Government of Pakistan has proclaimed an ordinance entitled "Project Implementation and Resettlement of the Affected Persons Ordinance 2001", later referred to as the “Resettlement Ordinance". This ordinance will be used to safeguard the interests of persons and groups involuntarily displaced from the existing places to new resettlement areas. This ordinance establishes that the resettlement of the involuntarily displaced persons is done as a matter of right and not by way of charity or any such sentiment, also the PAPs will be accepted as special groups, who in the interest of the project have accepted and undergone involuntary displacement. However, as far as Attabad Lake HPP is concerned, there is no displacement involved for the project there will no resettlement.

### 3.4.3 Antiquities Act 1975

The Antiquities Act of 1975 ensures the protection of the cultural resources of Pakistan. All the archaeological sites, artefacts, historical carvings, historical monuments, temples, shrines, old graveyards etc. come under the cultural property. The Act is designed to protect "antiquities" from destruction, theft, negligence, unlawful excavation, trade and export. The law prohibits new construction in the proximity of a protected antiquity and empowers the Government of Pakistan to prohibit excavation in any area which is of archaeological significance. Under this Act, it is understood that all project proponents are obliged to:

- Ensure that no activity is undertaken in the proximity of a protected areas without permission of the competent authority
- In case any antiquities have been found or reported in any project area it will be the responsibility of the proponent to report to the Department of Archaeology, Government of Pakistan

### 3.4.4 Pakistan Water and Power Development Authority Act 1958

The Act provides for the unified and coordinated development of the water and power resources of Pakistan. This Act authorizes WAPDA to develop water and power resources in the country through construction and operation of water storages and power houses and erecting electrical transmission lines with powers and obligations of a licensee under the Telegraphy Act of 1910. This act also establishes policy for land acquisition and compensation, as well as the degree of liability of WAPDA for damages sustained by landowners or others.

### 3.4.5 The Telegraphy Act 1910

This act was promulgated for the installation of telegraph poles and lines. This Act makes provision of installing poles and towers without acquiring any land. However, provision is also made for temporary acquisition of land during the construction period. As such, compensation is made for the loss of crops for a specific period.



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### 3.4.6 Labor Laws

Labor laws in Pakistan are governed by several legislative tools. However, the principal labor rights are provided by the constitution of Pakistan. The following articles enforce key labor rights.

- **Article 11** of the constitution prohibits all forms of slavery, forced labor and child labor
- **Article 17** provides for a fundamental right to exercise the freedom of association and the right to form union
- **Article 18** prescribes the right of its citizen to enter upon any lawful profession or occupation and to conduct any lawful trade or business
- **Article 25** lays down the right to equality
- **Article 37 (e)** makes provisions for securing human conditions of work, ensuring that children and women are not employed in vacations unsuited to their age or sex, and for maternity benefits for women employment.

In addition to constitutional rights, Acts and Ordinances have been enforced for limiting working hours, minimum working age, and conditions of employment.

### 3.4.7 Penal Code 1860

The Pakistan Penal Code deals with offences where public or private property and/or human lives are affected due to the intentional or accidental misconduct of an individual or body of people. In the context of the environment, the Penal Code empowers local authorities to control noise, toxic emissions and disposal of effluents.

### 3.4.8 Local Government Ordinance 2001

This Act empowers the Government of Pakistan and provincial governments to enforce laws for land use; conservation of natural vegetation; air, water, and land pollution; disposal of solid waste and wastewater effluents; and public health and safety, including some provisions for environmental protection. Section 93 of this Ordinance pertains to environmental pollution, under which the local councils are authorized to restrict causing pollution to air, water or land. They may also initiate schemes for improving the environment. The Local Councils of the project area have been consulted for their views on the project interventions, and mitigation being proposed for the likely impacts.

### 3.4.9 Regulations of Mines and Oil Fields and Mineral Development Act, 1948

This Act provides regulatory procedures for the quarrying and mining of construction material on public as well as private lands.



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### 3.4.10 Motor Vehicle Ordinance 1965

The Motor Vehicles Ordinance of 1965 of Punjab was extended to the whole of Pakistan in 1978. The ordinance deals with the powers of the Motor Vehicle Licensing Authorities and empowers other related agencies to regulate traffic rules, vehicle speed and weight limits, and vehicle use, to erect traffic signs, and to prescribe special duties of drivers in case of accidents. It also prescribes powers of police officers to check and penalize traffic offenders. At the same time, the ordinance also empowers the regional transport authority to operate as a quasi-judicial body at district level to monitor road transport, licensing requirements, and compensations for deaths or injuries to passengers on public carriers.

### 3.4.11 Factories Act, 1934

The clauses relevant to the project are those which concern health, safety and welfare of workers, disposal of solid wastes and effluents, and damage to private and public property. The Factories Act also provides regulations for handling and disposal of toxic and hazardous materials. As construction activity is classified as 'industry', these regulations will be applicable to the project construction contractor.

### 3.4.12 Highways Safety Ordinance 2000

This ordinance includes provisions for licensing and registration of vehicles and construction equipment; maintenance of road vehicles; traffic control offences, penalties and procedures; and the establishment of a police force for motorways and national highways to regulate and control the traffic as well as keep the highways clear of encroachments.

### 3.4.13 Explosive Act, 1884

Under the Explosives Act, the project contractors are bound by regulations on licensing, handling, transportation, storage and using explosives during quarrying, blasting, and other purposes.

### 3.4.14 Wild Life Act 1975

The Wild Life Act is an Act to amend and consolidate the law relating to protection, preservation, conservation and management of wildlife in the country.

### 3.4.15 Private Forest Regulation 1970

Forests in state ownership in the Gilgit-Baltistan have been designated as "protected forests" under the Pakistan Forest Act (1927). The other legal category of forests here is "private forest" which are owned by the local communities. These forests are legally covered under the Gilgit Private Forests Regulations (1970) and the rules framed thereafter.



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### 3.4.16 The Forest Act, 1927 and later amendments

This Act establishes the right of the Government to designate areas for reserved forest, village forest and protected forest, and may acquire such areas for prohibiting or restricting the public use of the resources or other activities.

### 3.4.17 Protection of Trees and Brushwood Act, 1949

This Act prohibits cutting or lopping of trees along roads and canals planted by the Forest Department, without permission of the Forest Department.

### 3.4.18 Gilgit-Baltistan Customary Laws

In NA customary laws are also practiced besides national laws. This system provides for at least one authority, chosen by the community either by nomination or election, with responsibility for managing natural resources and enforcing customary laws. This customary normative framework includes provisions for: community and individual ownership; resource use fees; and fines as penalties for violations of these laws. Most of the occupants, who claim to be the owner, do not have any written tenancy agreement. For such cases in the non-settled area, confirmation by the village jirgas on land possession is accepted at community, court and local administration levels. Adoption of current 'Gilgit-Baltistan Neuter Rule' (1980) envisages that the occupant of land will be treated as its owner. All other land beyond the settlements, mostly barren, will belong to the Gilgit-Baltistan Administration. This position was also reaffirmed by the Courts of NA.

### 3.4.19 Gilgit-Baltistan Forest Rules 1983

The Gilgit-Baltistan Forest Rules protected forests which are either the property of the government or have property rights to the whole or part of the forest produce. However local people may have some concessions and user rights. They may be able to use these forests for grazing and collection of fuel wood and other non-timber products.

### 3.4.20 Gilgit-Baltistan Strategy for Sustainable Development 2003

The Gilgit-Baltistan Strategy for Sustainable Development presents a vision and a strategic framework for economic, social, cultural, and ecological well-being of the people of the Gilgit-Baltistan. It provides a road map to improve governance, integrated gender, environment and sustainability, prioritized development needs, and creation of an enabling environment by improving policies and legislation.

### 3.4.21 Draft National Forest Policy 2001

A draft of the National Forest Policy was prepared in 2001 which is also applicable to the Gilgit-Baltistan. It emphasizes the sustainable use of natural resources with community participation and recommends that timber harvesting be used for poverty alleviation. It also aims to rehabilitate the environment.



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# 4 BASELINE CONDITIONS

This section provides baseline data (physical, biological and socio-economic parameters) related to the project area. Information provided is both quantitative and qualitative and is based on secondary and primary data collected, site field visits and desk studies. A baseline consists of the existing environmental and socio-economic and cultural status of the project area. The baseline information and indigenous knowledge is required for scoping potential environmental issues associated with the implementation of the project. On the basis of baseline information, the project interventions are assessed and mitigation measures are proposed. The baseline information also helps to indicate the specific issues to be monitored during project execution as well as during operational phase.

## 4.1 PHYSICAL ENVIRONMENT

### 4.1.1 Physiography

The project area is located in Gilgit-Baltistan (N.A) of Pakistan in district Hunza. Hunza is a mountainous region forming the western part of the Karakoram and Eastern Pamir mountain range. The area generally consists of rugged and precipitous terrain classified as alpine scrub zone and is characterized by heavy snowfall at higher altitudes in winter.

The site of the project is located on Hunza River at Attabad Lake about 15km upstream from Ganish Bridge of Hunza. Its distance is about 20 km from Hunza, 115 km from Gilgit. The powerhouse location is on the left bank of river and easily accessible from Karakoram Highway. The intake weir/dam site is selected at current exit point of Attabad Lake which is was formed in the year 2010 due to a huge slide from right bank mountain, however, some portion of left bank mountain was also damaged.

People of all the nine villages within the project area are mostly dependent on agriculture and livestock. The dam and reservoir fall into the jurisdiction of Hunza district.

The Hunza River in the study area is the principal river of Hunza and Nagar Districts in Gilgit-Baltistan. It is formed by the confluence of the Chapursan and Khunjerab Nullahs (gorges) which are fed by glaciers. It is joined by the Gilgit River and the Naltar River, before it flows into the Indus River near Juglot.

### 4.1.2 Demography

Hunza valley is mainly divided in three parts with different tribal structure. The people living in Gojal had migrated to this part of Hunza from Wakhan, Pamir, and Badakhshan before the end of 18th century. They are mostly Wakhis (from Wakhan, a strip of land between Central Asia and Pakistan), an ethic group staying in the mountainous areas of the Karakoram and the Pamirs in the border land of Pakistan, China and Afghanistan. The language and culture distinguish them from Brush and Shina speaking people, who live in central and lower Hunza.



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### 4.1.3 Climate

The climatic parameters that influence the climate of an area include temperature, precipitation, humidity and evaporation. Situated in the western most arm of Karakoram range, Hunza is found within semi-arid and rugged mountain landscape (mountain desert). The climate varies widely from monsoon-influenced moist temperate to arid and semi-arid cold deserts in the north. In general, two seasons prevail in the project area: winter (October to March) and summer (April to September). The Northern Areas have the high mountain ranges of the Himalayas, Karakoram and Hindukush ranges with elevations rising to over 8,000 m, which result in altitude being the dominant influence on the climate of the region. These ranges act as climate barriers between the Indus basin and Central Asia to the North, and the main part of the sub-continent to the South.

### 4.1.4 Precipitation

Rarefied air, intense solar radiation, strong winds, and vast ranges of temperature are the characteristic climate of the area. Below 3000 m, precipitation is less than 200 mm per annum while there is a sharp precipitation gradient along the altitude, and over 2,000 mm annual snow fall above 6000 masl. Precipitation in the form of rainfall is not sufficient to contribute significantly in meeting either crop water requirements or stream flows. The snow- and ice-melt are the major sources of precipitation contributing to the available water resources in the GB. Irrigation is based on water resources from glaciers, rivers and streams. Average Monthly and annual rainfall recorded at WAPDA High Altitude Weather Station has been given in Table-4.1.

The Hunza River catchment upstream of the dam site is highly mountainous generally with low precipitation. The low precipitation particularly during the hot (monsoon) season coupled with less catchment area likely to experience rainfall are the factors responsible for low runoff or poor contribution to flood producing mechanism source.

### 4.1.5 Temperature

The Northern Areas of Pakistan are dominated by one of the most mountainous landscapes on earth, with an arm of the Hindu Kush to the west, the lesser Himalaya to the south, the Karakoram to the east and the Pamir to the north. More than half of the Northern Areas is located above 4,500 meters. Temperatures in the valley bottoms can vary from extremes of 35°C in summer to less than –15°C in winter.

The summer season in Hunza Valley is cool while winter is chilly. Wide spread snow fall occurs in winter. During winter the northern winds blow constantly bringing the temperature down considerably. At Hunza, the mean temperature is 30.20 °C in July, the hottest month and the coldest month is January with an average temperature of -3.5 °C. The mean minimum temperatures are 21.9 °C in July and -7.3 °C in January respectively. Hunza like other areas in extreme north-west of Pakistan receives only 136 mm precipitation of which 40% occurs in Winter and Spring.



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The Gilgit Meteorological Station is the nearest station to Hunza valley that has a sound historical record covering more than five decades.

**Table 4-1: Average Max & Min Monthly Temperature and Mean Precipitation at Gilgit**

| Month | Mean Min Temp (°C) | Mean Max Temp (°C) | Mean Prec. (mm) |
|---|---|---|---|
| Jan | 2.4 | 9.4 | 4 |
| Feb | 0.7 | 12.6 | 6.8 |
| Mar | 5.7 | 18.2 | 0.14 |
| Apr | 9.5 | 24.1 | 23.8 |
| May | 12.1 | 28.6 | 24.5 |
| Jun | 15.1 | 34 | 8.8 |
| Jul | 18.4 | 36.1 | 14.6 |
| Aug | 17.8 | 35.3 | 14.6 |
| Sep | 12.7 | 31.7 | 7.6 |
| Oct | 6.8 | 25.5 | 6.9 |
| Nov | 0.9 | 18.2 | 2.4 |
| Dec | -1.9 | 11.5 | 5.1 |
| **Annual** | **7.9** | **23.8** | **133.1** |

### 4.1.6 Wind Speed and Direction

Wind speed is a highly variable parameter especially at high altitudes complex terrains and depends on the local conditions of the specific catchment. Computation of realistic wind speed is therefore very difficult due to its temporal and spatially varying nature in the mountainous regions.

The speed and direction data of Hunza Valley is not being recorded, however, data of some adjacent stations to project area are given in Table 4.2.

**Table 4-2: Wind Speed and Direction**

| Station | Calm | N | NE | E | SE | S | SW | W | NW | Mean Wind Speed | Maximum Observed Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Percent of Total Time (%) | | | | | | | | | | Knots | |
| Astore | 50 | 17 | 1 | 0 | 0 | 29 | 1 | 0 | 1 | 3.0 | 29.0 |
| Gilgit | 74 | 0 | 1 | 4 | 7 | 1 | 1 | 9 | 2 | 2.0 | 28.0 |
| Skardu | 80 | 0 | 2 | 2 | 0 | 9 | 5 | 3 | 0 | 2.9 | 69.0 |



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Wind speeds tend to be higher between April and September and lowest from November to January. However, these averages conceal the fact that often the wind is accumulated over short bursts of gusty convectional wind especially during the late spring and summer when heating effects cause strong but short lived convectional winds.

### 4.1.7 Geology

Tectonically, project area lies in the Karakoram Block towards the north of the Karakoram Thrust (MKT) and Main Mantle Thrust (MMT) which are considered to be the manifestation of the tectonic collision between Indian Plate (Continent) with the Kohistan Island Arc and then with the Eurasian plate (Continent). This continent to continent collision has given rise to three most famous orogenies in the world. The Himalaya, Karakorum and Hindokush are considered to be the highest mountainous ranges in the world.

The Glacio fluvial deposits forming the site of Attabad village consist of boulders, cobbles and gravels with some silt and sand as cementing material. The rocks exposed at the crown and toe; are highly fractured, sheared, jointed and weathered. A fault on the eastern side of the village is passing through Hunza River trending almost North-South. The re- sediment till deposits flank both sides of Hunza River in the power house area. These tills comprise extremely fine grained (powder) soapy-touch clays.

### 4.1.8 Seismology

The project area lies in the region of Northern Pakistan which has high frequency of earthquakes especially in the Himalayan orogenic belt. This belt represents the contact between Indo-Pak and Eurasian plates, which has always been the source of moderate to large earthquakes including Kangra (1905), Bihar-Nepal (1934), Assam (1897) and 2005 Kashmir earthquakes with significance consequences. The presence of some of the active faults like Main Karakorum Thrust (MKT), Main Mantle Thrust (MMT), Raikot Fault, Riwat Fault, Panjal Khairabad Fault, Jhelum Fault and Main Boundary Thrust (MBT) etc make the northern Pakistan region tectonically very active.

In October 2005, an earthquake of very high intensity (7.8) hit the area near Muzaffarabad and disturbed the ground to a significant extent in that area. The geological, tectonic and geodynamic conditions of the project area have been assessed and detailed mapping of the ground surface has been done to define the geology and tectonic features of the area.

### 4.1.9 Landslides, Erosion and Sedimentation

The glaciers of the Gilgit Baltistan and KPK have very high “activity indices”, an index for the total amount of water passing through the glacier system per annum. As a result, they have high flow rates in terms of the glacier melt, ranging between 100 and 1,000 meters/year. As a result of these high rates of flow, these glaciers aggressively erode their beds and transport the eroded materials to the headwaters of rivers, which causes the transport of sediments into the major rivers of the region. The exact proportion of sediment due to glacial erosion is still not measured;



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however, it could be stated that these account for the huge load of the sediments passing through the upper Indus system especially Hunza River, Shyok River and Shiger River.

Landslides are very common features in the project area because of the high steep terrain. Erosion and sediment input to the river is a function of landslides and riparian erosion processes. There are frequent talus accumulations along the side slopes of the river. These are typically in a state of stable equilibrium at their current slope angle and environment but become unstable when the equilibrium is disturbed. Excess water and earthquakes often trigger landslides.

### 4.1.10 Land Use

There are nine villages located on alluvial fans and terraces on both sides of the Hunza River and its tributaries where water is available for human consumption and agriculture. The mountains on both sides of the reservoir have steep slopes and many streams and nallahs join the river in this length. The nallahs span out near the confluence of the river, forming some cultivable land masses as can be witnessed near Passu village. The alluvial fans contain clay silt layer with an undulated topography over hard bedrock. The available flat land is used for residential purposes as well as for agriculture, orchards and grazing for cattle, goats and sheep etc. The total geographic area of the Hunza valley is about 8,920 $Km^2$. Summary of land use in the Gilgit Baltistan is shown in Table 4.3.

**Table 4-3: Summary of Land Use in Gilgit-Baltistan**

| S.No. | Type of land | Area Million (Hectares) | Percentage (%) |
|---|---|---|---|
| **1** | Mountain/Lakes/Rivers/Glaciers | 4.810 | 66.3 |
| **2** | Protective Forests | 0.065 | 0.89 |
| **3** | Private Forests | 0.219 | 1.78 |
| **4** | Social/agri Forests | 0.368 | 5.07 |
| **5** | Range lands | 1.626 | 22.4 |
| **6** | Cultivable Area | 0.078 | 1.1 |
| **7** | Cultivable Waste | 0.090 | 1.2 |
| **Total** | | 7.250 | 100% |

Source: Statistical Unit GBP & DD 2013

A land use survey was carried out in the villages falling in the reservoir, dam site and power house areas.

The area is rugged and mountainous. The cultivated lands are concentrated in alluvial fans near habitation. Rest of the area is either under Forests/Pastures and the remaining is barren land belonging to the Government/Communities.



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### 4.1.11 Mining

Mining is one of the common professions in small parts of the project area. Local people have developed mining at their own level with their own resources. Small horizontal mines have been excavated by local explorers. The area near the lake is rich in mineral resources however their exploitation as commercial use is still not being done. There are archeological sites were observed and reported during field investigations. People use to explorers the Mines by their own resources without any support of Government.

### 4.1.12 Soil Pollution and Contamination

There is no industry, commercial area, poultry farm, vehicular washing lines or any other source of contaminants in the project area which could cause soil pollution or contamination through liquid and solid waste generation. The agriculture is practiced on a limited area and limited farm yard manure is used for crop production. Use of chemical fertilizers, pesticides and insecticides is also limited.

### 4.1.13 Agriculture

The area under agriculture is approximately 112,688 ha or 1.6% of the total area Gilgit Baltistan. Because the climate is arid, agriculture depends on irrigation through water channels locally known as (kuhls)-that bring water through gravity flow from streams fed by glacier or snow melt. It is estimated that another 90,000 ha can be brought under farming by irrigation. Almost 80 per cent of the GB's population is engaged in subsistence agriculture. While GB exports fruits and potato to other parts of the country, it has to import of cereals, poultry and other food products to meet the needs of growing population Agricultural in GB has can be divided into two broad cropping zones depending on the elevation. At elevations between 1200 and 2000 m.s.a.l both summer and winter crops are grown, however, in areas situated in between 2000 m.s.a.l and 3000 m.s.a.l a single summer crop can be grown.

In Hunza District, a mixture of different activities is followed in the farming system. There may be some variation in the farm size or in the status of minor crops in the overall cropping practices but the general combination of crops, livestock and other farm related activities are more or less the same. Wheat, barley and vegetables are the main Rabi crops. Whereas Maize, potato, millet and pulses are Kharif crops. Shaftall and Lucerne or Alfalfa is grown as a perennial crop which is the most popular fodder for livestock throughout the year. Majority of the trees are grown on the field boundaries.



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**Table 4-4: District Wise Agriculture Land of GB**

| District | Agriculture Land (ha) | Percentage Cover |
|---|---|---|
| Astore | 8133.43 | 1.51% |
| Diamer | 9058.52 | 1.26% |
| Ghanche | 11966.75 | 1.35% |
| Ghizer | 16431.94 | 1.34% |
| Gilgit | 10167.94 | 2.44% |
| Hunza-Nagar | 12013.87 | 0.8% |
| Skardu | 30589.88 | 1.56% |
| **Total** | **98362.33** | **10.26%** |

Most of the agricultural activities in Hunza are carried out on the terraces prepared in the vicinity of settlements.

**Table 4-5: Cropping Pattern in Hunza valley**

| Date of Land Preparation | Crops/Vegetables | Fruits | Fodder |
|---|---|---|---|
| May | Wheat, Potato, Peas | Apples, Apricot | Alfalfa |
| March-April | Wheat, Barley, Potato, Peas, Turnip, Buckwheat | Apples, Apricot Walnut, Mulbery | Alfalfa |
| March-April | Wheat, Maize Barley, Potato, Peas, Turnip, Buckwheat. | Apples, Apricot, Walnut, Mulbery | Alfalfa |
| March-April | Wheat, Barley, Potato, Peas, Turnip, Buckwheat | Apples, Apricot, Walnut, Mulbery | Alfalfa |
| March-April | Wheat, Barley, Maize, Potato, Peas, Turnip, Buckwheat | Apples, Apricot, Walnut, Mulbery Almonds, Grapes | Alfalfa |
| March-April | Wheat, Barley, Potato, Peas, Turnip, Buckwheat | Apples, Apricot, Walnut, Mulbery | Alfalfa |

Average land per household for wheat is 10 kanals. Average wheat production in the area is 1.8 monds per kanal. Average barley production is 1.5 monds per kanal, which is grown for cereals and barley has short duration. As a yield of wheat straw is 3.3 monds per kanal and barley 2.2 monds per kanal. After harvesting the first crop, both maize is gown for fodder, or turnip and cereals are enough for 4 months and straw sufficient for 5 months.

Grass and fodder are stored during autumn for long winter. On average every household has 9 kanals of land allocated for grass. About 75% households rely on traditional grass, where as 17%



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for maize or grass. Average production of fodder per kanal has been 4.5 monds. Each household collects and stores at least 30 monds of grass per year, to feed animals in winter.

**Table 4-6: Cropped Area and Production**

| Crop | Wheat | Maize | Barley | Potato | Vegetable | Fruits | Fodder | Total |
|---|---|---|---|---|---|---|---|---|
| **Area (hectare)** | 886 | 970 | 223 | 3267 | 128 | 3578 | 1572 | 10633 |
| **Production (Ton)** | 1570 | 2713 | 361 | 48285 | 1455 | 30483 | 7449 | 92316 |

Very little chemical fertilizer is applied to wheat. However, chemical fertilizer is normally applied to potato crop. Application of fertilizer is conditional with the availability of money at the time of planting the crops. The total crop area of Hunza Nagar is 9344 Hectare, 0.73 Hectare per family and about 0.081 per capita.

Irrigation intervals reported for maize were 10 to 15 days depending on the rise in temperature and grain filling periods. Harvesting is done by a serrated sickle and threshing is done either by hand or trampling of grain by oxen.

The agriculture undertaken in the project area is mainly subsistence farming, as land does not produce enough to feed the family. The estimated average yield of crops per household is estimated as 10 mounds (1 mound = 40 kg) of wheat, 15 mounds of maize and 5 monds of Barley per year. The extended family system ensures sharing of the field produce and none is marketed. It was also reported that cereals are only sufficient for four months in most cases and for eight months in few other cases. Agricultural Department and AKRSP are introducing new varieties of cereals but it has not yet been adopted fully.

The cultivated lands and orchards are irrigated from the nallas. These nallas are the only source of water to irrigate all the surrounding villages. Therefore, the village faces scarcity of irrigation water during cropping season.

### 4.1.14 Fruits

Gilgit Baltistan is producing many fruits like apple, cheery, walnut, and apricot. But apricot is more famous for its test and quality. Pakistan produces approximately 300,000 tons of fresh apricot, making it the world's fourth largest producer. Gilgit Baltistan (GB) and Baluchistan are the two main apricot growing regions in Pakistan, with GB alone producing 114,286 tons in 2007. Planting density is only 230 trees/ha, which is much less than the recommended 750 trees/ha, due to apricots being planted around field edges, rather than orchards. Average yields of fresh fruit are 38kg/tree which are good considering the limited use of inputs, although yields of 50kg/tree can be achieved through improved management.

Special importance is given to the cultivation of fruits. Fruits are grown for household consumption as well as for sale in the dry form. Various fruits are grown in Hunza valley. At higher altitudes



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there are no fruit trees, but in lower portion of Hunza valley several types of fruit are grown. Major fruits are apricot, apple, mulberry, grapes, almond and walnut. It has been calculated on average that every household has 22 trees out of which 15 are fruit bearing trees. The average production of fruit by each tree is 50 kg. Average fruit available to each household is 20 monds. Fresh fruit is consumed at home and there is no marketing of fruit.

Table 4.7 shows Area and Production of Fruit in Sub division Hunza.

**Table 4-7: Area and Production of Fruit in Sub division Hunza**

| Fruits | Fruit Bearing Trees | Non Fruit Bearing Trees | Total Trees | Area (ha) | Production (Ton) |
|---|---|---|---|---|---|
| Apricot | 140078 | 59755 | 199833 | 869 | 9629 |
| Apple | 68660 | 23515 | 92175 | 401 | 2321 |
| Grapes | 4789 | 915 | 5704 | 25 | 171 |
| Pears | 3659 | 2960 | 6619 | 29 | 147 |
| Peaches | 11838 | 1453 | 13291 | 58 | 395 |
| Pomegranate | 2064 | 323 | 2386 | 10 | 39 |
| Cherry | 21685 | 10493 | 32178 | 140 | 399 |
| Mulberry | 5058 | 1614 | 6672 | 29 | 322 |
| Walnut | 6830 | 4472 | 11302 | 49 | 102 |
| Almond | 8224 | 4987 | 13211 | 57 | 55 |
| **Total** | **2722885** | **110486** | **383371** | **1667** | **13582** |

Data Source: GIS Lab, WWF-Pakistan (2013)



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Table 4.8 shows utilization of fruits on district sub division Hunza.

**Table 4-8: Utilization of Fruits on District Sub division Hunza**

| Fruits | Production (Ton) | Wastage (Ton) | %age Losses | Consumption | | Marketed | |
|---|---|---|---|---|---|---|---|
| | | | | Fresh (Ton) | Dry (Ton) | Fresh (Ton) | Dry (Ton) |
| Apricot | 9629 | 3298 | 34 | 240 | 378 | 75 | 694 |
| Apple | 2321 | 451 | 19 | 797 | 0 | 1074 | 0 |
| Grapes | 171 | 49 | 29 | 118 | 0 | 4 | 0 |
| Pears | 147 | 28 | 19 | 86 | 0 | 33 | 0 |
| Peaches | 395 | 165 | 42 | 228 | 0 | 2 | 0 |
| Pomegranate | 39 | 3 | 7 | 33 | 0 | 3 | 0 |
| Cherry | 399 | 55 | 14 | 128 | 0 | 216 | 0 |
| Mulberry | 322 | 231 | 72 | 74 | 11 | 0 | 11 |
| Walnut | 102 | 0 | 0 | 0 | 95 | 0 | 5 |
| Almond | 55 | 0 | 0 | 0 | 36 | 0 | 19 |
| **Total** | **13582** | **4280** | **32** | **1703** | **521** | **1407** | **729** |

Data Source: GIS Lab, WWF-Pakistan (2013)

Detail of nurseries and seed farms is given in Table 4.9 below.

**Table 4-9: Detail of Nurseries and Seed Farms**

| Sr. No | Nursery/Seed Farm | Location | Area (kanal) | Stock Position For the Year 2020 | | |
|---|---|---|---|---|---|---|
| | | | | Issue able Plants | Non-Issue able Plants | Total Stock |
| 1 | Fruit Nursery | Murtazabad | 10 | 3200 | 3700 | 6900 |
| 2 | Fruit Nursery | Khanabad | 20 | Development in progress however 1600 issue able and 2500 non-issue bale plants are available in some developed plots | | |
| 3 | Fruit Nursery | Shishkat | 23.4 | 5300 | 3500 | 8800 |
| 4 | Seed Farm | Khudabad | 10 | Sown 30000 Invetro Tuber under an area of 6 kanal | | |



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### 4.1.15 Livestock

The people of entire Hunza River the livestock reared by almost all households. Usually with the snow melt, goat, sheep and cows giving no milk are taken to the alpine pastures for grazing. They stay there during the summer season and are brought back with the onset of snow on the top of the hills. When the animals are brought to the village they are grazed in the agricultural fields of maize crop residues. All the milking animals are kept in the houses and stall fed. In general women take care of all animals in the houses and graze cows around the village on pastoral lands. These are situated between agricultural and forest land and are covered with grasses intermixed with oak stands. Only men take small animals i.e., goats and sheep to the alpine pastures. Normally a herders belonging to the same village collects other farmers animals and take them to alpine pastures for grazing during summer. These herders keep all the milk produced at pastures in lieu of herding charges. They convert this milk into ghee and other dairy products for their own use and marketing. The number of domestic animals the villagers owned has decreased over the past few decades due to decrease in grasses near the villages.

Livestock contributes a great deal to the local economy. However, physical condition and general health of the animals is not satisfactory, especially in winter due to the shortage of fodder. Bullocks are the main source of farm power, but they are hardly capable of drawing plough due to poor health. Cows, sheep and goats are also lean and thin. Animal diseases cause considerable losses to the livestock. Productivity of cattle is generally low because of severe winter and lack of proper feed. Meat, milk, butter and eggs are the main animal /poultry products but most of these are consumed at the household level. At some places milk, meat, animal hides, wool and poultry are sold.

The livestock is also a social and financial capital of the family. Every family keeps some extra heads to be sold or slaughtered on occasions of marriage or death in the family. A few heads are kept to be given as dowry to daughters on their wedding. The livestock numbers far exceed the carrying capacity of natural pastures and available forage resources.



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List of veterinary units are shown in Table 4.10 below.

**Table 4-10: List of Veterinary Units**

| Veterinary Hospitals/Dispensaries | Ownership |
|---|---|
| Veterinary Hospital Aliabad (Not Functional currently at disposal of District Administration) | Government |
| Veterinary First Aid Post Khanabad Hunza | Rented |
| Veterinary Dispensary Nasirabad Hunza | Government |
| Veterinary Dispensary Murtazaabad Hunza | Government |
| Veterinary Dispensary Mominabad Hunza | Government |
| Veterinary Dispensary Gulmit Hunza | Community |
| Veterinary Dispensary Sost Hunza | Government |
| Veterinary Dispensary Misgar Hunza | Rented |
| Veterinary Dispensary Chupurson Hunza | Government |
| Veterinary Dispensary Shimshal Hunza | Community |

Source: Office of the Deputy Director Livestock & Dairy Development Hunza



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## Table 4-11: Livestock Census 2017

| Name of Village | No. of Farmers | Cow Local | Cow Jersy | Bull Local | Bull Jersy | Yak Male | Yak Female | Zho | Zomo | Horse | Donkey | Goat Local | Goat Imprd | Sheep Local | Sheep Imprd | Rural Poultry | Fancy Bird | Total No Large Animals | Total No Small Animals | Total No. Poultry |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Khizarabad | 14 | 24 | 2 | 11 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 27 | 2 | 79 | 6 | 72 | 0 | 38 | 114 | 72 |
| Hussainabad | 142 | 207 | 11 | 69 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 248 | 21 | 509 | 17 | 879 | 110 | 292 | 795 | 989 |
| Mayoon | 31 | 160 | 0 | 46 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 170 | 0 | 60 | 2 | 220 | 52 | 207 | 232 | 272 |
| Khanabad | 158 | 286 | 0 | 16 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 306 | 0 | 302 | 2 | 236 | 30 | 305 | 610 | 266 |
| Nasirabad | 465 | 829 | 3 | 304 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1598 | 0 | 3123 | 0 | 1942 | 0 | 1136 | 4721 | 1942 |
| Murtazabad | 289 | 424 | 43 | 96 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 434 | 82 | 112 | 24 | 522 | 41 | 573 | 652 | 563 |
| Hassanabad | 107 | 219 | 3 | 66 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 216 | 6 | 42 | 3 | 157 | 15 | 288 | 267 | 172 |
| Hyderabad | 376 | 477 | 48 | 123 | 29 | 27 | 45 | 6 | 2 | 0 | 0 | 551 | 44 | 479 | 25 | 590 | 26 | 757 | 1099 | 616 |
| Altit Hunza | 103 | 77 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 86 | 0 | 43 | 0 | 18 | 0 | 83 | 129 | 18 |
| Ganish | 224 | 243 | 1 | 49 | 0 | 8 | 11 | 1 | 0 | 0 | 0 | 291 | 0 | 156 | 2 | 281 | 100 | 313 | 449 | 281 |
| Gulmit | 728 | 1713 | 240 | 160 | 16 | 67 | 120 | 5 | 1 | 1 | 1 | 1685 | 40 | 2731 | 35 | 2006 | 15 | 2324 | 4491 | 2021 |
| Sost | 523 | 1158 | 136 | 6 | 5 | 150 | 235 | 0 | 0 | 0 | 2 | 2045 | 0 | 3002 | 0 | 3480 | 14 | 1692 | 5047 | 3494 |
| Chupurson | 396 | 1131 | 5 | 102 | 5 | 252 | 311 | 2 | 6 | 22 | 20 | 534 | 0 | 3370 | 0 | 1693 | 0 | 1856 | 3904 | 1693 |
| Misgar | 122 | 164 | 0 | 17 | 0 | 42 | 125 | 2 | 4 | 0 | 9 | 1163 | 0 | 1408 | 0 | 639 | 0 | 363 | 2571 | 639 |
| Shimshal | 174 | 412 | 0 | 0 | 0 | 440 | 447 | 0 | 0 | 0 | 40 | 1250 | 0 | 2100 | 0 | 408 | 1 | 1339 | 3350 | 409 |
| Ahmadabad | 90 | 179 | 36 | 40 | 6 | 11 | 1 | 0 | 0 | 0 | 0 | 104 | 40 | 39 | 24 | 191 | 0 | 273 | 207 | 191 |
| Karimabad | 103 | 126 | 3 | 19 | 0 | 86 | 75 | 0 | 0 | 0 | 0 | 202 | 2 | 172 | 7 | 302 | 0 | 309 | 383 | 302 |
| Aliabad | 208 | 337 | 8 | 9 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 298 | 7 | 232 | 20 | 295 | 0 | 360 | 557 | 295 |
| **Grand Total** | **4253** | **8166** | **539** | **1139** | **87** | **1083** | **1370** | **16** | **13** | **23** | **72** | **11208** | **244** | **17959** | **167** | **13931** | **404** | **12508** | **29578** | **14335** |

Source: Office of the Deputy Director Livestock & Dairy Development Hunza



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### 4.1.16 Hydrology

The Karakoram and Himalayan mountains form the main source of snow and ice melt runoff to the Indus River System. The precipitation enhancing and shadowing effects of the main mountain ranges provide dramatic contrasts that greatly complicate the hydrological picture. The main tributaries of Hunza River are; Chapursan, Kilik, Bola Das joining the Hunza river from the west and Khunjerab along with Ghujerab, Simshal and Hispar Rivers joining river from the east of the valley. The river flows of Hunza are usually maximum in the month of July when snow and glacier melt is at its peak while these are minimum in the month of March when snow and ice melting is insignificant.

There is only one hydrological gauging station on Hunza River at Danyore Bridge being operated by SWHP-WAPDA. This station is located at about 107 kilometers downstream of Attabad Landslide Dam Location. The catchment area of Hunza River upto Danyore gauging station is 13,157 $km^2$, whereas it is 14,083 $km^2$ upto its confluence with Gilgit River. Hunza River catchment area is 8,901 $km^2$ upto Attabad Landslide Dam Location. Therefore, river flows are transposed and estimated from documented discharge data from hydrological station at Danyore. Daily discharge data from 1966 to 2015 is available and processed for the calculations. Data for year 2016 was incomplete, missing the values of high flow months, and there was no record of hydrological data for the period 2017 to 2018 at SWHP therefore, it was not used in the calculations. Mean annual flows are calculated and drawn in the figure below for the period 1966-2015. Average value for mean annual flow has been calculated as 208.36 $m^3/s$.

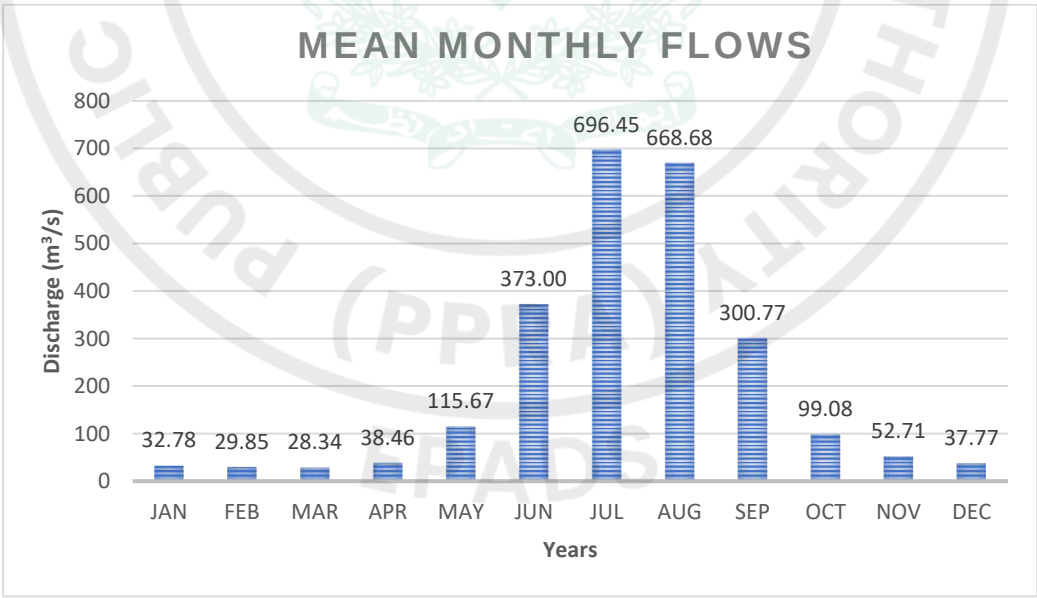


**Figure 4-1: Mean Monthly Flows**

Flows are generally maximum in July and August almost reaching 700 $m^3/s$. Whereas, flows are low from December to April each year when snow falls in the catchment. The record shows that design discharge of 60 $m^3/s$ is available for about half year (almost 6 months). Graph shows that flows are exceeding the design discharge from June to mid-December which shows the potential of hydropower generation.



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### 4.1.17 Flooding

The maximum peak discharges of mean daily for every year recorded. The instantaneous peaks will definitely be higher than the measured daily flows and can be enhanced while execution accordingly. Instantaneous peak flows for the period 1966 to 2015 has been calculated and plotted as well.

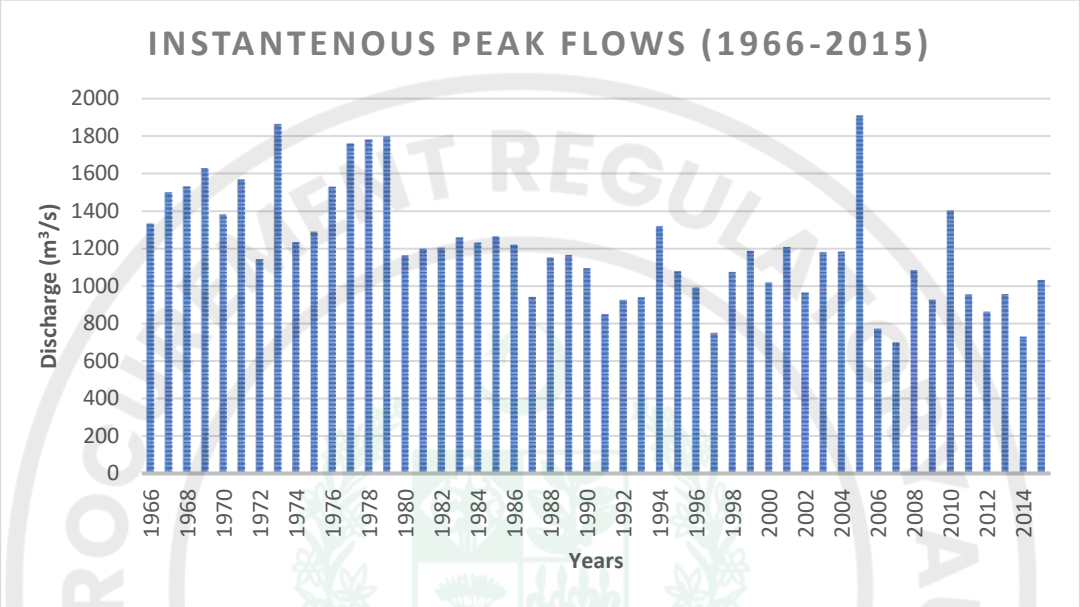


**Figure 4-2: Instantaneous Peak Flows at Attabad Lake HPP Site**

### 4.1.18 Surface Water

In the project area, the Hunza river carries water of various streams (nallahs)of snowmelt, and rainwater fall. The people use the water of these nallahs for drinking, household and agriculture purposes. Generally, there is no shortage of clean potable water in the project area as it is very difficult to fetch the water of river and nallahs due to the very steep slopes. People mostly use water from nallahs for drinking, washing and other domestic purposes. During the socio-cultural survey of the project area, many of the respondents from the villages falling in the project area reported stomach, skin, bones, diseases. Initially, rainwater as well as snowmelt water do not contain significant impurities. As these waters flow over land they pick up sediments, salts, toxic elements, pulverized organic matter and bacteria from the surface. Water samples were taken in November 2020 covering the complete affected area within the project area. The laboratory results of these samples summarized in Table 4.12 & 4.13 and detail at **Appendix-C** reveal that all the parameters are within the permissible limits when compared with drinking water quality standards of WHO, except the presence of Escherichia coli pathogenic bacteria which causes gastroenteritis in human beings.



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**Table 4-12: Chemical Parameters Results of the Samples (Surface Water)**

| National Standards for Drinking Water Quality of Pakistan (mg/l) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Nitrate** | **Nitrite** | **Cu** | **Al** | **Fe** | **Mn** | **Cr6** | **Zn** | **Ni** | **B** |
| ≤50 | ≤3 | 2.0 | ≤0.2 | ----- | ≤0.5 | ≤0.05 | 5.0 | ≤0.02 | 0.3 |

| **Sr. No** | **Location from Sample Collected** | **Test Results (mg/l)** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Nitrate** | **Nitrite** | **Cu** | **Al** | **Fe** | **Mn** | **Cr6** | **Zn** | **Ni** | **B** |
| 1 | Hunza River Side before Confluence of Shamshal Nullah | ND | ND | 0.4 | ND | ND | ND | 0.03 | ND | 0.01 | ND |
| 2 | Shamshal Nullah before entering Hunza River | ND | ND | 0.07 | ND | 0.04 | ND | 0.02 | ND | 0.02 | ND |
| 3 | Hunza River Side Near Power House | ND | ND | 0.2 | ND | 0.3 | ND | ND | ND | 0.01 | ND |
| 4 | Attabad Lake Boating Area | 1.3 | ND | ND | ND | ND | ND | 0.03 | ND | 0.02 | ND |
| 5 | Gulmit Tap Water | ND | ND | 0.02 | ND | ND | ND | ND | ND | 0.01 | ND |
| 6 | Gulmit Glacier Near Hunza River | ND | ND | ND | ND | ND | ND | 0.14 | ND | 0.2 | ND |
| **Conclusion**: | The concentrations of nitrate, copper, iron. Chromium 6 and nickel are within National Standards for Drinking Water Quality of Pakistan for first four areas. | | | | | | | | | | |



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**Table 4-13: Bacteriological and Physical Parameters Results of the Samples (Surface Water)**

| Bacteriological Parameter | National Standards for Drinking Water Quality of Pakistan (Physical Parameters) | | | | | | |
|---|---|---|---|---|---|---|---|
| **E.coli** | **pH** | **Turbidity** | **Total Dissolved Solids** | **Electrical Conductivity** | **Color** | **Odor** | **Taste** |
| 0/100 ml | 6.5-8.5 | <5 NTU | <1000 ppm | 2000 µs | Un Objectionable | Un Objectionable | Un Objectionable |

| Sr. No | Location from Sample Collected | Test Results | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Bacteriological | Physical Parameters | | | | | | | |
| | | E.coli | pH | Turbidity | Total Dissolved | Electrical Conductivity | Temp. | Color | Odor | Taste |
| 1 | Hunza River Side before Confluence of Shamshal | 0 col/100ml | 8.4 | <5 NTU | 67.8 ppm | 130.4 µs | 7ºC | Clear | Odorless | Tasteless |
| 2 | Shamshal Nullah by entering Hunza | 0 col/100ml | 8.4 | 15 NTU | 98.1 ppm | 186.8µs | 7ºC | Clear | Odorless | Tasteless |
| 3 | Hunza River Side Near Power House | 0 col/100ml | 8.0 | <5 NTU | 62.7 ppm | 125.4µs | 7ºC | Clear | Odorless | Tasteless |
| 4 | Attabad Lake Boating Area | 0 col/100ml | 8.5 | <5 NTU | 65.4 ppm | 129.7µs | 7ºC | Clear | Odorless | Tasteless |
| 5 | Gulmit Tap Water | 0 col/100ml | 7.4 | <5 NTU | 23.5 ppm | 47.2µs | 7ºC | Clear | Odorless | Tasteless |
| 6 | Gulmit Glacier Near Hunza River | 0 col/100ml | 8.0 | <5 NTU | 29.7 ppm | 59.4µs | 7ºC | Clear | Odorless | Tasteless |
| **Conclusion**: | | Results show that the turbidity in Shamshal Nullah by entering Hunza water sample exceed the National Standards for Drinking Water Quality of Pakistan. | | | | | | | | |



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### 4.1.19 Tributaries

Nine villages are located in the project area. All the villages are situated near to streams (nallah) fall in main tributaries of Hunza River. Main tributaries of Hunza River are:

- **Khunjerab River** begins in the snow clad mountains and glaciers in the north and south of Khunjerab pass. The river flows to the west then turns southward. It ends when it flows into the Hunza River.
- **Chapursan River** begins in the area of the Chilanji pass and Kampiri Diwar peak. It flows to the east and joins Khunjerab River near Khuda Abad.
- **Misgar River** begins from the mountains of Mintaka and the Kilik pass on the northern boundary of Hunza. It flows to the south east and ends when it falls into the Khunjerab River.
- **Gujerab River** starts from small glaciers and snow-topped mountains of the Gujerab range, and flows to the west and later joins Khunjerab River.
- **Shimshal River** begins in the Shimshal pass from Virjirab and other glaciers. This is in the north eastern region of the Gilgit Region. It flows to the west and after reaching Passu it joins the Khunjerab River.
- **Hispar River** forms from the melt water of the Hispar Glacier - a forty-nine-kilometer-long glacier in the Karakoram Mountains. The Hispar Glacier and river both flow northwest, passing through Hispar, Hopar and Nagar villages until the confluence with the Hunza River.

### 4.1.20 Groundwater

The project area consists of rocky mountainous terrain. The water originated from rainfall and snowmelt flows through streams and enters into river. Only a small quantity of water has the chance to percolate and form a groundwater reservoir.

### 4.1.21 Water Availability & Quality

Glacier and snowmelt are the main source of water for domestic use in the valley, while springs are the principal source of drinking water in Gojal tehsil. The melted water gradually enters the streams, which subsequently feed man-made channels - Kuhls - that bring water into the populated areas for agriculture, livestock and domestic purposes.

Piped water supply that covers only 40% of the total population of the Gilgit-Baltistan does not provide safe/ clean drinking water to urban and rural settlements in the region.

In upper Hunza region, drinking water is obtained from glacier melt and piped water only in summer season, because the glacier water freezes in winter for three months. The villagers meet their need of water from the Hunza River.



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### 4.1.22 Air Quality and Noise

The air quality of the project area and its vicinity is very fresh and clear under normal condition. There is no major source of air pollution as there are no major vehicular movement or industrial setup in its vicinity.

The vegetation cover in the area is thick and the level of ambient (suspended) dust increases during windy conditions. Being far from the roadside they are not faced with impact of air and noise pollution resulting from transport vehicles. Air and noise pollution has not yet emerged as an environmental issue owing to operation of a small number of vehicles increasing by a fair degree during the tourist season. Based on a number of observations on ambient air quality in rural areas the following range of concentration of gaseous pollutants is estimated on the roadside at Gulmit:

**Table 4-14: Range of Gaseous Pollutant Concentration & Noise Emission Level**

| Range of Variation | CO ppm | $SO_2$ ppb | $NO_x$ ppb | SPM $\mu g/m^3$ | Noise dB(A) |
|---|---|---|---|---|---|
| Minimum | 0.65 | 05 | 05 | 45 | 40 |
| Maximum | 0.9 | 10 | 12 | 90 | 70 |
| Average | 0.7 | 07 | 07 | 70 | 55 |

The noise level near the river is fairly high and range between 50 to 65 dB without traffic, mainly due to the flowing water colliding against rocks and boulders. There is normal traffic on the Karakoram Highway which runs through the Hunza valley. So traffic noise has negligible contribution to the noise level in the project area.

### 4.1.23 Greenhouse gases

Greenhouse gases are those gases ($CO_2$, $CH_4$, $O_2$, CFCs and NO) which contribute to global warming. The main sources of these gases are industries and vehicles using fossil fuel as fuel. At present there is no industry in the project area that emits greenhouse gas (GHG) and vehicles intensity is also very low. The main sources of carbon and nitrogen oxide emissions are the automobiles being operated in the project area.

### 4.1.24 Waste

The villages within the project area do not have any drainage, sewerage or treatment system for sewerage collection and disposal. More than50 per cent of the houses have improvised pour flush pit latrines. The remaining 50 per cent of the house hold use locally made toilets, dry pits or defecate in the fields. Wastewater (sludge) from kitchen, bathing and washing is discharged



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into small drains/water courses leading to the nalaor directly to small fields outside the houses. Modern health facilities are available at Hunza and patients are brought to Hunza for treatment.

There are no special disposal practices or collection in the area. People use their solid waste in the vegetable field as fertilizer. Animal waste especially cow dung is used for farm manure or used for burning after drying (though rarely).

## 4.2 BIOLOGICAL ENVIRONMENT

Habitat loss is considered as the leading cause of loss of world's biodiversity. Most species need undisturbed habitat to find food, water, shelter, and mates. But people are altering habitats all over the world. In such areas, the activities causing habitat loss include commercial logging (not based on technical and sustainable basis), land development, over-grazing, fuel wood collection, construction of roads, and building new settlements. All these actions change landscapes, natural water flows, and the species composition in the area. Moreover, changes in climate and land use patterns also reducing the amount of snowfall and rain upon which the habitat depends.

The high altitudes, rugged mountains and sweeping glaciers make much of the region uninhabitable. Only two per cent of the Northern Areas estimated to be suitable for agriculture through irrigation by diverting stream water. However, so far only one percent of the total area is being cropped. Approximately nine per cent of the Areas is covered by natural forests and open scrub, 22 per cent area constitutes alpine pasture, and remaining 68% is mostly bare rock, under permanent snow and glaciers.

### 4.2.1 Flora

A study was carried out on the Biodiversity of Khunjerab National Park (KNP) during May and June, 2006 to establish baseline information about existing plant wealth and wildlife including flora, reptiles, birds and mammals in order to make some vantage points for future monitoring of key wildlife species. Using different direct and indirect investigation techniques, 14 different valleys and Nullahs of KNP were surveyed and observations on various habitats were recorded.

Four types of vegetation zones were identified including Dry Alpine Scrub, Moist Alpine Pastures, Dry Alpine Plateau Pastures and Sub Alpine Scrub and Birch Forests. So far, 62 plant species belonging to 45 genera and 25 families were identified. Of them, 4 grasses and one species of Liliaceae were determined.

The wide variety of climatic conditions in the region, coupled with the extreme variations in altitude and aspect, has created a wide array of vegetation and ecological zones. Five distinct zones can be identified.

#### 4.2.1.1 Dry Alpine Zones and Permanent Snowfields

This ecological zone is characterized by vast glaciers, boulder fields and sheer cliffs. This zone predominates at high altitudes, around the major peaks of the Karakoram Mountains. It covers most of upper Hunza and the northern parts of Baltistan.



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#### 4.2.1.2 Alpine Meadows and Alpine Scrub

This zone covers the areas between the high valleys and the permanent snowfields, between 3,500 and 3,800 meters. It is characterized by lush, green and well-watered alpine meadows, located on valley bottoms or high plateau surrounding the main watercourses. Alpine meadows occur in almost all the higher regions of Gilgit, Baltistan, Ghizar and Diamir, particularly where mountains extend above the tree line. The meadows support a wide variety of wildflowers, grasses, sedges and other plants.

#### 4.2.1.3 Sub-Alpine Scrub

The sub-alpine scrub zone occurs throughout the higher mountains of the Himalaya, Hindu Kush and Karakoram, and is found in Gilgit, Skardu, Ghizar and Astore. However, it is often confined to small ravines on the upper slopes. The vegetation consists of small deciduous species such as Betula utilis, and evergreens such as Juniperus communis and Rhododendron hypenanthemum.

#### 4.2.1.4 Dry Temperate Coniferous Forest

These forests are usually found on the inner or northerly slopes of the Himalaya, between 1,500 and 3,400 meters. They occur in parts of Gilgit, Diamir and Baltistan Districts, and are characterized by single species stands of conifers. Typical tree species include Picea smithiana, Cedrus deodara and Pinus wallichiana, with an understory of Quercus ilex and Junglus regia and scattered shrubs of Artemisia maritima and other species.

#### 4.2.1.5 Dry Temperate Evergreen Oak Scrub

This is an intermediate zone, lying between 1,500 and 2,500 meters. The vegetation is dominated by dry oak forest (Quercus ilex). Occasionally individual stands of evergreen species are also found, including Pinus gerardiana, Pinus wallichiana, Cedrus deodara and Juniperus spp.

### 4.2.2 Medicinal Plants

A large number of medicinal plants grow in the natural forests of Gilgit-Baltistan, especially Astore Valley. The following is a list of important medicinal plants found in the region.

**Table 4-15: Important medicinal plants report in GB Forests**

| | Botanical Name | Local Name | | Botanical Name | Local Name |
|---|---|---|---|---|---|
| 1 | Aconitum chasmanthum | Mohri | 12 | Onasin echioides | Laljari |
| 2 | Aconitum hetrophyllum | Partis | 13 | Orchus-latifolia | Salib misri |
| 3 | Aconitum lavae | | 14 | Picrohiza-kurrva | karroo |
| 4 | Angelioa glauca | Chora | 15 | Podophyllum-emodi | Ban kakri |
| 5 | Arterrisia bravifolia | Rund | 16 | Rheun emodi | Rhewand chini |



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| | | | | | |
|---|---|---|---|---|---|
| 6 | Carum spp. | Kala zeera | 17 | Sausuria-lappa | Kuth |
| 7 | Ephedra spp. | Oman (asmani booti) | 18 | Saxifraga ciliata | Zakhmay hayat |
| 8 | Ferula feotida | Heeng | 19 | Shymus serpyllum | Bannanajwainu |
| 9 | Ferula narthex | Heeng | 20 | Swertia chiretha | Chiretta |
| 10 | Lavatria kashmirianian | Resha Khatimi | 21 | Valeriana wallichii | Mushak bala |
| 11 | Macrotomia-benthami | Gao zaban | 22 | Viola serpans | Banafsha |

### 4.2.3 Forestry

Forestry is important for fuel, timber, in addition to control of the soil erosion and reduction silt load in lakes and rivers. In the Gilgit-Baltistan only Diamer district is rich in forest while the other five districts including Hunza have nominal forest of Juniper. The forests consist of blue pine, spruce, willows and shrub consist of rosa species.

A new program of planting trees over private land by AKRSP and 10 billion trees tsunami in the valley has been started. The forest areas including uncultivated wasteland are State Forests owned by the government. Wood is used for timber, fire and fuel wood is used throughout the year. Firewood is used during winter season. Based on data used by AKRSP each house on average use 100monds of fire and fuel wood during a year. On the other hand, fire and fuel wood collected from common property is 63 mounds per annum. Forest trees are rich source of fodder. It was noted that 12 mounds of fodder are also collected by each household from the forest. The Region is rich in natural forest although it has been extensively exploited. In the valley more forest plots are planted to reduce the pressure on existing forest. For this purpose, an average 130 trees of Poplar by each household and 90 plants of willow per household are planted

In program of ten billion tree tsunami 4.4 Million trees were planted in 2019-20 year through Gilgit forest circle, Diamer Astore Forest Circle, Baltistan Forest Circle, Wildlife Divisions, AKRSP and through Agriculture Department in Gilgit Baltistan.



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- **Proposed Plantation in Hunza District for the year 2021**

| S.No | Activities | Sites | Area /KM | Total nos. of plants to be planted |
|---|---|---|---|---|
| 1 | Avenue Plantation | Nasirabad to Aliabad | 45 km | 30,000 |
| 2 | Slope plantation | Attabad lake | 700 Kanal | 25,000 (first Phase) |
| 3 | Block Plantation | Hussaini | 1680 Kanal | 50,000 (first Phase) |
| 4 | Block Plantation | Gulkin Shahabad | 948 Kanal | 25,000 (first Phase) |
| 5 | Block Plantation | Khuramabad | 1500 k | 50,000 (first Phase) |
| 6 | Free Distribution of plants | Across Hunza District | - | 150,000 |
| 7 | Urban Planation | District Head Quarter | - | 15,000 |
| **Total** | | | - | **345,000** |

With action plan of 10BBT, it will improve the production and procurement of forest and fruit plants, rehabilitation program of natural forest and awareness campaign for forestry will help in plantation of trees in the region. Proposed site for plantation is shown in figure.

**Figure 4-3: Plantation site Khuramand & Zarabad, Hunza**



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### 4.2.4 Fauna

This diverse range of vegetation and ecological zones also supports a rich faunal diversity, including an estimated 54 species of mammals and 230 species of birds. About 23 species of reptiles and 6 of amphibians have been reported from GB. Among reptiles 9 species are of lizards and 14 of snakes, while among amphibians 2 species of frogs and 4 of toads. Very little information is available on insect diversity in GB, however, about100 species of butterflies have been reported from GB.

Several globally threatened species – including the snow leopard and Markhor – continue to survive in Gilgit-Baltistan in significant numbers. The flora and fauna belong to Palearctic region. Fifty-four species of mammals have been reported in GB, which comprise 1 shrew, 10 bats, 18 carnivores, 6 artiodactyls, 3 lagomorphs, and 16 rodents. The region is also home to a few globally threatened species like Snow Leopard, Himalayan lynx, Marco polo sheep, Blue sheep, Ladakh urial, Markhor, Musk deer, and Woolly Flying Squirrel. The resident avifauna includes Monal pheasant, Snow Partridge, Himalayan Snow Cock, and several birds of prey species.

Woolly Flying Squirrel has been reported as endemic in GB, whereas Astore Markhor (flare-horned Markhor) can be considered near endemic, as its distribution is restricted to a few valleys mainly because of rugged terrain and geographic barrier like rivers. The distribution of many small mammal species is very patchy and restricted to the certain watersheds due to the physical barriers like high mountains and rivers.

Occurrence of some rare species has been reported in GB. These include species like Lammergeyer and Golden eagle. Few sightings of Lesser Kestrel have also been reported in lower Hunza near Hunza river. The main diverse group of birds in NA is the Passeriformes species. These are mostly Warblers, Tits, Flycatchers, and Buntings. Some of the restricted range species like Snow Partridge and Himalayan Monal pheasant are extremely rare and may be at the verge of extinction from many of their earlier strongholds. According to Birdlife International (2001) report there are 27 species of Pakistan, which are threatened internationally out of which 7 species are found in GB.

Hunza is very scattered settlement with meager population. Considering its wildlife resources to be protected and preserved. Shooting, trapping of wild animals is not allowed except with a special permit. The number of animals or birds killed or captured is also restricted and specified in the permit. Snow leopard and Ibex are already declared as endangered and other species of mammal are also scarce. But trophy hunting is allowed which is beneficial to the local community as the 70% of the funds go to local community which is used for the development of the local area.



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**Table 4-16: Fauna available in Gilgit Baltistan**

| English Name | Urdu Name | Scientific Name |
|---|---|---|
| Ibex | Kill or Kil | Capra ibex sibirica |
| Snow Leopard | Cheeta | Pantherauncia |
| Red fox | Lombrei | Vulpesvulpes |
| Lynx | Seaa gosh | Felis lynx |
| Wolf | Bharia or Bahdia | Canis lupus |
| Maramot | Barfani choh<br>Tershoon | MaramotaCandata |
| Alpine weasel | Gilhari | Mustelaaltacia |
| Musk rat | Chachondar | Mustelaaltacia |
| Himalayan snowcock | Ramchakur | Mustelaaltacia<br>Tetraogallushimalayencis |
| Chukor | Chukor | AlectorisChukor |
| Eagle | Shaheen | Aquila Chrysaetos |
| Hawk | Gid | - |
| Falcon | Ooqaabor Ooqabaa | - |
| Pie | Jample | UrocissaEryphrohyncha |
| Hopoe | Hodhodh | Upepaepaps |
| Pigeon | Kabutar | - |

### 4.2.5 Insects

The Project Areas is rich in biodiversity of insects including butterflies found in the project area, particularly during the humid months of July and August. In addition, caterpillars, bugs, beetles, black bees, weevils, mosquitoes, ants, green aphids, codling moths, leaf miners, mitts, fruit flies, woody aphids, stray grass hoppers, leaf hoppers, mealy and woolly bugs, peach leaf curling aphids, scale insects, walnut weevils, blister mites, and dusky veined aphides are all found in the Northern Areas including the project sites.

### 4.2.6 Endangered, Threatened or Vulnerable Species of Fauna

The IUCN Red List of endangered, threatened and vulnerable species in the project area are Markhor (*Capra flconeri*) Snow leopard (*Unica unical*) Ladakh urial (*Ovis vignei*) Woolly flying squirrel (*Eupegaurus cinereus*.)



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### 4.2.7 Community Controlled Hunting Areas

The concept of biodiversity conservation through community development was piloted in a few selected valleys by International Union for Conservation of Nature -IUCN under a Global Environment Facility (GEF)/ United Nations Development Programme (UNDP) project in Gilgit, Baltistan and Chitral during the period 1995-1998. The success of the project resulted in expanding the concept to a larger canvass and today there are 27 communities-controlled hunting areas. The participating communities are required to write a management plan for conservation and sustainable use and monitor the population of species targeted for trophy hunt. The major species being managed for trophy hunt are Markhor, Ibex, and Urial. The communities are issued permits by government for the number of animals that can be safely hunted. The community's sale the permits nationally and internationally through outfitters. Eighty percent of the income from successful hunt goes to local community while 20% goes to government to cover administrative costs.

In Diamer district, the local people manage wildlife through their own traditional system known as Zaitu Committee. These traditional committees exist in almost all villages/valleys of district Diamer for the sustainable management of respective natural resources. The Zaitus (conservation committee) are formed by village elders (mostly numbardars), with representation of the whole population from each Haiti (Muhallah). However, these traditional committees were reformed by Wildlife Conservation Society (WCS) as Wildlife Conservation and Social Development Organizations (WCSDOs) and have been registered under social act at respective districts offices.

### 4.2.8 Protected Area

In order to safeguard the biodiversity of key ecological systems, Government of Gilgit-Baltistan has declared four National Parks to protect and conserve bio-diversity of Gilgit Baltistan. These include Handarb National Park, Khunjerab National Park, Deosai National Park and Central Karakorum National Park. In the protected forest, the forest owned by Government as per Forest Act-1927, all activities are prohibited until and unless permitted by the government. Usually, removal of fallen, dying, and dead trees is not banned, however, grazing, sometimes, is regulated to ensure regeneration. In Gilgit Baltistan, designated protected forests cover an area of 445,712 ha and are mostly found in Ghizer, Astore, Skurdu and Gilgit Districts. Out of that 64,512 ha is conifer forests while 3, 81,200 ha are scrub forests (IUCN, 2003).

Aga Khan Rural Support Programme (AKRSP), International Union for Conservation of Nature (IUCN), Wildlife Conservation Society (WCS) and World Wide Fund (WWF) are the main international organizations who over the last two decades have played a crucial role in creating awareness among communities for sustainable management of biodiversity resources. The then Ministry of Environment also implemented a Program for Mountain Areas Conservation (PMAC) to promote biodiversity conservation in Gilgit Baltistan through community participation. This program was completed in 2011. As a result of these efforts the Gilgit Baltistan offers a model for community based management of forestry resources.



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Despite of all these conservation initiatives and efforts by government and international organization, fast depletion of forest ecosystems has been observed in the last two decades. The following strategies and actions will be taken to achieve the objectives of conservation, sustainable use and equitable sharing of benefits.

### 4.2.9 CONSERVATION AND SUSTAINABLE USE OF BIODIVERSITY

The major threats to biodiversity are deforestation, degradation and fragmentation of habitats, indiscriminate hunting, wildlife-livestock competition and killing predators to control livestock losses. Out of total area of 72,496 $Km^2$, less than one percent (5,016 ha) area – the protected forests, is under management of the government. In addition, 216, 584 or three percent of total area is designated community forests, where except for regulating logging the government has no other role. The remaining 98% landscape is under customary control of the local communities and is used for grazing of livestock and fuel wood collection.

In order to conserve representative samples of ecosystems, and protect the threatened species, a number of protected areas have been established across the region. There are four National Parks, two game sanctuaries, and six game reserves. In addition, to recover the populations of the rapidly declining game animals, the government has introduced a sport hunting programme where local communities are encouraged to protect populations of big game and keep 80% of the permit fee. The location of protected areas is shown in figure 4.6 and an over view of the conservation and sustainable use measures follows.

- Khunjerab National Park
- Central Karakorum National Park (CKNP)
- Deosai National Park
- Qurumbar (Karambar) National Park
- Shandur-Hundrub National Park

### 4.2.10 GAME RESERVES

The game reserves areas set aside for conservation of key game species, however, hunting and shooting is allowed except under a special permit. There are eight game reserves in GB and an overview of the major species in the area.

**Table 4-17: Game Reserves Areas**

| Game Reserve | Area ($km^2$) | Key Species |
|---|---|---|
| Danyore (Gilgit) | 443 | Markhor, ibex, Urial, snow leopard, lynx, wolf, fox, etc and bird species |
| Kilikmintika (Hunza Gojal) | 650 | Ibex, Marco polo sheep, snow leopard, brown bear, fox, marmot, etc and bird species |
| Nazbar Nallah (Ghizer Yasin) | 334 | Ibex, snow leopard, brown bear, wolf, fox, etc and bird species |



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| | | |
|---|---|---|
| Chassi Bowster (Ghizer Phander) | 370 | Ibex, snow leopard, wolf, brown bear, fox, etc and bird species |
| Pakora (Ghizer Ishkoman) | 75 | Ibex, snow leopard, wolf, fox, etc and bird species |
| Askore Nullah Skardu | 129 | Ibex, snow leopard, wolf, fox, etc and bird species |

### 4.2.11 Aquatic Ecology

Gilgit-Baltistan is blessed with highest potential of cold and clean water resources in shape of lakes, canal, reservoirs, rivers, and water logged areas that offer ideal habitat for trout and other cold water fish species. There is dire need to get maximum benefit from these resources through technological advancement in production, processing and marketing. Both the public and private sector are fully involved in order to judicially exploit this potential both in natural waters as well as its development in culture conditions.

Hunza Valley is blessed with great water resources comprised of streams and alpine lakes fed by the snowmelt and glacier waters. The fish fauna in Hunza Valley is relatively poor due to high turbidity, low water temperature and high water speed.

### 4.2.12 Fisheries

Fisheries department Hunza was established in the year 2012 with the core aim to develop and promote Fisheries and aquaculture activities in newly created district. District Hunza has very rich aquatic resources of aquaculture and fisheries in forms of bluish lakes, gashing rivers, torrential streams, seasonal and perennial springs etc.

District Hunza being gate way to the CPEC and hub for tourist has great potential in terms of natural recourses and well aware educated man power can contribute and play vital role in the development of the area. The scenic beauty and natural water resources of Hunza attracts a great influx of national and international tourist every year, which may directly or indirectly contribute to the economy of local people and the region.

Fisheries department Hunza has come up with novel approach and ideas to get maximum benefit from wise use and sustainable exploitation of natural resources in multiple ways with special focus on introduction and installation of cage culture system in Attabad lake under controlled environment to enhance production with stocking and multiplication of fine verities of fish in nature. At the same time, it has also been planned to promote sport fishery providing enabling environment and other related facilities for tourists and fish anglers.

For this the Attabad lake having crystal clear water offers as natural gene pool reserve, ideal for excessive multiplication and better growth of many indigenous and exotic fish species.



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**Table 4-18: Potential Fisheries Resources in District Hunza**

| S.No | Name of River | Name of Lakes | Name of Nallas |
|---|---|---|---|
| 1 | Hunza River | Attabad Lake | Misgar Nallah |
| 2 | | Borith Lake Gojal | Khunjarab Nallah |
| 3 | | Shimshal Lake I | Dee Nallah |
| 4 | | Shimshal Lake II | Choporsun Nallah |
| 5 | | Bathora lake Gojal | Gojarab Nallah |
| 6 | | Pasho Lake | Khyber Nallah |
| 7 | | | Shimshal Nallah |
| | | | Hassan Abad Nallah |
| Total | 01 | 06 | 08 |

#### 4.2.12.1 EXOTIC FISH SPECIES OF HUNZA

i. Salmo Trutta Fario (Brown Trout)

ii. Onchorynchus Mykiss (Rainbow Trout)

#### 4.2.12.2 INDEGENOUS FISH SPECIES

Among the 15 identified indigenous fish species in GB the following six fish species found in District Hunza:

i. Shizothorax plagiostomus

ii. Shizothorax Nasus

iii. Ptychobarbus Conirostris

iv. Triplophysa Terwasae

v. Triplophysa Yasinensis

vi. Diptychus Maculatus

## 4.3 SOCIAL AND ECONOMIC ENVIRONMENT

### 4.3.1 Population

The population in Gojal consists of 51% male and 49 % female; it has a population density of 17 persons/acre. The child-women ratio of the study area is 345 children per 1000 women. The dependency ratio is 142 % in Hunza Valley, which shows that there are about 3 dependents on every two earning members. The average size of household is 7.26 persons. The average size of family is 7 persons per household, while the density of room is 4 rooms per household.



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In the study area of Gulmit, Shishkat and and Passu total number of households according to the census 2017 is 8697 people, these are the areas surrounding the Attabad village. The detail of population is shown in table

**Table 4-19: Population of the Area (2017)**

| Name of Jamatkhana | No. of household registered | Actual Population |
|---|---|---|
| Gulmit central | 142 | 963 |
| Kamaris | 42 | 319 |
| Odver | 42 | 320 |
| Dalgiram | 44 | 307 |
| Chamangul | 131 | 858 |
| Ghulkin | 158 | 1178 |
| Hussaini | 89 | 670 |
| Passu | 89 | 771 |
| Janabad | 24 | 169 |
| Muradabad | 4 | 49 |
| Nazimabad central | 117 | 989 |
| Nazimabad-I- Bala | 76 | 638 |
| Nazimabad II Darmiyan | 142 | 1417 |
| Borith payeen | 6 | 49 |
| Borith bala | 2 | 1 |
| **Total** | **1108** | **8697** |

Source: Gulmit Local Council



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## Table 4-20: Jamatkhana Wise Population Information Summary 2016

| S.# | Name of Village | Name of Jamat Khana | No of Jamati H/holds | No. of Sister Community House Holds. | Sister Community Population | | | Total Population of Jamati Members | | | Total No. of House | Total Population | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Male | Female | Total | Male | Female | Total | Holds | Male | Female | Total |
| 1 | Gulmit | Gulmit Central | 128 | 0 | 0 | 0 | 0 | 486 | 505 | 991 | 128 | 486 | 505 | 991 |
| 2 | | Kamaris | 51 | 0 | 0 | 0 | 0 | 148 | 160 | 308 | 51 | 148 | 160 | 308 |
| 3 | | Odver | 48 | 0 | 0 | 0 | 0 | 163 | 153 | 316 | 48 | 163 | 153 | 316 |
| 4 | | Dalgiram | 39 | 0 | 0 | 0 | 0 | 165 | 151 | 316 | 39 | 165 | 151 | 316 |
| 5 | | Chamangul | 201 | 0 | 0 | 0 | 0 | 432 | 426 | 858 | 201 | 432 | 426 | 858 |
| OVERALL GULMIT | | | 467 | 0 | 0 | 0 | 0 | 1394 | 1395 | 2789 | 467 | 1394 | 1395 | 2789 |
| 6 | Shishkat | Nazimabad-II Centre | 154 | 0 | 0 | 0 | 0 | 761 | 698 | 1459 | 154 | 761 | 698 | 1459 |
| 7 | | Nazimabad-1 Bala | 80 | 0 | 0 | 0 | 0 | 345 | 312 | 657 | 80 | 345 | 312 | 657 |
| OVERALL SHISHKAT | | | 234 | 0 | 0 | 0 | 0 | 1106 | 1010 | 2116 | 234 | 1106 | 1010 | 2116 |
| 8 | Ghulkin | Ghulkin | 161 | 0 | 0 | 0 | 0 | 639 | 604 | 1243 | 161 | 639 | 604 | 1243 |
| 9 | Hussaini | Hussaini | 127 | 0 | 0 | 0 | 0 | 352 | 341 | 693 | 127 | 352 | 341 | 693 |
| 10 | Passu | Passu + Janabad | 119 | 0 | 0 | 0 | 0 | 523 | 444 | 967 | 119 | 523 | 444 | 967 |
| 11 | | Muradabad | 5 | 0 | 0 | 0 | 0 | 37 | 22 | 59 | 5 | 37 | 22 | 59 |
| OVERALL PASSU | | | 124 | 0 | 0 | 0 | 0 | 560 | 466 | 1026 | 124 | 560 | 466 | 1026 |
| 12 | Borith | Birith payeen | 7 | 0 | 0 | 0 | 0 | 16 | 8 | 24 | 7 | 16 | 8 | 24 |
| 13 | | Borith Bala | Include in Ghulkin | | | | | | | | | | | |
| TOTAL | | | 1120 | 0 | 0 | 0 | 0 | 4067 | 3824 | 7891 | 1120 | 4067 | | 7891 |



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### 4.3.2 Languages

Burushasky and Wakhi are the main languages of Hunza Valley. There are some other languages in the region as well which are described below:

- **Shina**. Shina is the main language in Gilgit. It is spoken in the Gilgit, Diamer, Ghizer and Astore. Shina speaking people are further found north in the Ishkoman valley and in Hunza, Nagar and further east in Baltistan.
- **Burushasky.** Burushaski is the main language of Hunza valley. It is spoken by the people settled on either sides of the middle cause of the Hunza River, on its northern bank (Hunza) as well as on its southern bank (Nagar). There are also Hunza speaking settlements in Yasin and in Gilgit. Burushasky is still an unwritten language.
- **Khowar.** It is the main language of Chitral, however Khowar speakers may be found in Yasin. Marriage ties make Khowar understood in Gilgit in some families.
- **Balti.** Balti is the sector largest language in the Baltistan Division. It is mainly spoken in the two districts of Baltistan division. Balti peaking people are settled in Skardu, Rondu, Shigar, Khapolu, Kharmang, Gultari and Ganche.
- **Domaaki.** Domaaki is the language of the Domas of Berichos who are also found in Gilgit and in some Shina speaking villages of the lower Hunza valley. They are mainly musicians and smiths.
- **Wakhi.** Wakhi is spoken in Ishkoman valley and in upper Hunza valley by more than 3,000 people. It belongs to the Pamirian branch of Iranian languages.
- **Gojri.** Gojri is the language of Gojar family settled in Naltar valley, Karga and also in the surrounding areas of Gilgit.

### 4.3.3 Ethnic Groups and Religions

Almost, 95% of the people living in Hunza valley and 100% in Upper Hunza belong to Ismaili faction with The His Highness Prince Karim Aga Khan as their spiritual leader. 5% in Hunza Valley are members of Shia Imami faction which is concentrated in the village Ganish and surrounding settlements.

### 4.3.4 Administrative Setup

Hunza remained an independent state after 1947 while still staying under the control of the Islamic Republic of Pakistan. The last Mir (Jamal Khan) and his family were retired and the Mirdom was abolished, and Hunza became a subdivision of the Northern Area in 1974. The government tried to establish administrative structure in the valley. The abolition of the traditional institutions left a gap that was partly filled by institutions established under projects of the Aga Khan Development Net Work (AKDN), which started operation in 1979.



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### 4.3.5 Aga Khan Development Network (AKDN)

After the annexation of Hunza and the abolition of the principal state a space concerning rule, law, administration and organization was created. It took a long time for the government institutions to fill this gap. AKDN is an international network and as part of Aga Khan Foundation (AKF) deals with issues such as education, rural development, culture, health services, housing programs and quite a few others. With its headquarters in Geneva and having been founded in 1967, The AKF is an international agency for development co-operation. Within the sub-branches of the AKDN, the Aga Khan Rural Support Program (AKRSP) is for rural development. The activities of the AKDN have shaped the development of the valley extraordinarily. Its various offices provide jobs for higher qualified Hunza cuts when they return from their studies in down country. Employment is also provided in the public sector in the rural areas. The AKDN extends its activities to establishing healthcare facilities and educational institutions.

The AKRSP was established in Gilgit and covers 84% of the household in Gilgit-Baltistan. The AKRSP started supporting institutional development on the local level in 1982 by establishing community-based organizations (CBOs) like Village Organizations (VO) and Women Organizations (WO). These associations were established all over Hunza within a few years. It initiated developmental projects in this area aiming at improvement of the condition of the rural population and providing basic facilities to the masses, with special emphasis on infrastructure.

### 4.3.6 Housing Characteristics

People in Gojal valley are very traditional about the situation of their households. Settlements are located in the center of the village and agriculture area surrounded it. The center still remains the center but the settlement is now of dispersed type, with the houses being sited on the individual fields. The area also remained safe and secure, and therefore the people did not find it necessary to cluster their houses together in selected sites. Thus the houses are scattered throughout the village from one end to the other end.

The Wakhi house type is a combination of all human activities in one open connected space. The whole structure is erected on five central pillars to support the roof. The fireplace is in the middle of the floor. The different functions of houses are located around the central fireplace (buxari). The house has a lantern place at the ceiling. Almost all the houses in the valley have the facilities of electricity.

### 4.3.7 Health Facilities and Common Diseases

The villages in the Hunza Valley have somewhat better healthcare facilities than rest of the GB except Gilgit and Skardu. Aga Khan Health Service (AKHS) and Government health workers are providing health facilities in the area. They provide first aid facilities and also give family planning guidance to the people. Gulmit Government hospital was established in 1980.



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### 4.3.8 Education and Literacy

Almost all the settlements in Hunza Valley have a high literacy rate. There was no school before 1946 in the villages of Gojal. Diamond Jubilee School for Boys was established in the Gulmit on the occasion of the Diamond Jubilee Ceremony of Sir Sultan Mohmmad Shah, Aga Khan III in 1946. At present there is one Government High School for Boys and one D. J. High School for Girls, besides one public high school: Al-Amin Model School for boys and girls. There are two primary schools in Hussaini village. Literacy rate in Hunza is almost 95% which is higher than other districts of GB. Girls in Hunza are enthusiastic about their future so they prefer to have higher education. For higher education students go to KIU Hunza Campus in central Hunza; a number of boys and girls are studying in Gilgit, Islamabad, Peshawar, Lahore, and Karachi for higher studies.

### 4.3.9 Infrastructure and Recreation

Infrastructure facilities including health, education and transportation are available in Hunza Valley to those near the KKH. Construction of Karakoram Highway (KKH), the Silk route or Pak China Friendship Highway, was started in 1965 and was completed in 1986. The KKH starts from Thakot in KPK and continues up to Khunjerab Pass; it has over one hundred bridges. The length of KKH is 1300 km and width is two lanes. KKH has played an important role in the development of Hunza Valley. Buses and vans are used for traveling in Gojal from and to Gilgit and down areas of the country. Public transport is provided by both Private vans and Government buses (NATCO).

The impact of the Karakoram Highway is very conspicuous on the socio-economic condition of the villages. Karakoram Highway provides an important link between Pakistan and China. This road serves the tourist traffic and acts as supply route for the mountaineers to the down country and other neighboring countries.

Recreation and tourism has grown in the area rapidly, which in future can become an important source of income. Impact on literacy rate is also becoming obvious with the fact that on the one hand more educational institutions are being opened.

### 4.3.10 Professions and Source of Income

The people of the area are linked with different professions like tourism sector, business, livestock, dry fruits, trade and government jobs.

### 4.3.11 Social Organizations and NGO Involvement

NGOs have also been very active in the water sector. Aga Khan Rural Support Programme (AKRSP) has accorded high priority to the Northern Areas' irrigation systems and water supplies from its inception; AKRSP also pioneered the creation of Water Users' Organizations (WUOs), which now play a pivotal role in all village-level, water-related activities. With the technical assistance of Aga Khan Cultural Service Pakistan (AKCSP), the Karimabad Town Management Society has been involved in the development of a new sewerage system for the town of Karimabad.



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### 4.3.12 Tourism and Cultural Heritage

Hunza is the tourism and business hub of Gilgit-Baltistan thus a large number of residents from this area directly or indirectly involves either in business or work in tourism sector.

### 4.3.13 Status of Women

Women are empowered in Hunza Valley and receive primary as well as secondary level education, while those having education limited to intermediate go in for teaching thus making primary female teachers available locally. Moreover, male as well female students from each village in the Gojal tehsil are studying outside Gojal and also abroad and more preparing to leave in the near future, women and girls have to take up what the men and boys were supposed to do.



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# 5 ESIA AND MITIGATION MEASURES

## 5.1 GENERAL

Determining the significance of impacts identified is one of the main purposes of an ESIA and it enables the identification of necessary mitigation and a determination of environmental and social costs associated with the Project. Environmental and social impacts of any project are identified taking into account all phases of the project cycle, including planning, construction, operation and decommissioning. The environmental issues and impacts of a project depend upon the nature of the project activities, and the types and extent of interventions involved. It is not easy to predict the future and assign a relative value or overall significance to an impact, since every impact has a different and multi-dimensional nature, and also because it involves personal and subjective judgment for many attributes. An environmental or social impact can be either beneficial or adverse and is assessed by comparing the quality of the existing environment with the predicted quality of the environment once the project is in place. This ESIA identifies the impacts likely to arise as a result of construction and operational activities and assesses the likely magnitude of the impact in order to provide some indication as to which impacts are likely to be most significant. The impact assessment has been based on that environmental checklist developed by the Asian Development Bank (ADB).

## 5.2 IMPACT ASSESSMENT PROCEDURE

In order to describe the significance of an impact it is important to distinguish between two concepts: sensitivity and magnitude. As far as possible the sensitivity and magnitude of the impact are described with reference to legal requirements, accepted scientific standards or accepted impact assessment practice, and/or social acceptability. Where no known published ‘standard’ criteria exist for determining the magnitude of effects, established professional criteria and best practice techniques are used and clearly described.

### 5.2.1 Sensitivity

Sensitivity is generally site specific and criteria are developed from baseline conditions. The sensitivity of a receptor is determined based on review of the population (proximity/ numbers/vulnerability), presence of biological features of the site or the surrounding area, soil, agricultural suitability, geology and geomorphology, existing air quality, presence of any architectural and historic heritage, landscape etc. Sensitivity, relates to the value, importance and tolerance of an environmental resource or receptor and should take into account where possible stakeholders views and public acceptability. Sensitivity can be categorized as high, medium, low, and negligible to the assessment of receptor sensitivity.

### 5.2.2 Magnitude

The assessment of magnitude is undertaken in two steps. Firstly, the key issues associated with the project are categorized as being either adverse or beneficial. Secondly, beneficial and



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adverse impacts are then further subdivided into major, moderate, minor or negligible based on consideration of the parameters listed below:

- duration of the impact
- spatial extent of the impact
- reversibility
- likelihood; and
- legal standards and established professional criteria.

In order to make the report as meaningful and useful as possible, an attempt has been made to describe each impact in the following terms: positive impacts refer to beneficial effects and negative impacts refer to harmful effects on e.g. natural resources, human beings and economy.

## 5.3 IMPACTS DURING CONSTRUCTION

During the construction phase of the project most of the impacts identified are of a negative nature but some of them will be temporary and will vanish with the completion of project.

### 5.3.1 Impacts on Topography

Topographically, the study area (consisting of a major part of the Hunza Valley), is characterized by steep slopes and narrow valleys. Attabad situated on the outside bend of the Hunza River bed is one of the smaller villages of the Hunza Valley and was located in a rough pastoral environment surrounded by natural slopes with sparse vegetation.

The interventions of the Attabad Lake HPP are not likely to impact the topography of the area on a large scale except for those areas where the physical activities of excavation, digging and movement of heavy machinery will take place. Similarly, areas where excavated material from tunnels will be disposed, dumped or stored will be negatively affected. This impact can be considered as a negative impact with moderate magnitude.

**Mitigation**

To reduce the negative impacts of excavated material: firstly, the emphasis should be to reduce the volume of material requiring disposal and, secondly, to dispose it in environmentally friendly way. The following measures are proposed in this respect:

- As far as disposal on the dam site area is concerned, some of the spoil can be used for construction project related structures.

- To make the dam site easily accessible for movement of heavy machinery and for large number of vehicles (per hour/per day), it will be necessary to improve, upgrade and widen the roads. Some of the spoil can be used for widening of the roads.



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- Part of the excavated material on the powerhouse site can be used for making aggregate required for project construction and for the development of infrastructure such as roads and filling of natural depressions.

### 5.3.2 Impact on Seismicity

The area is well known to consist of active landslide zones as more than 33 damaging events have occurred in the region during the period from the year 1830 till January 2010 (Kreutzmann 1994). In addition to this, according to the Geological Survey of Pakistan (GSP) a fault line also passes through the area. During the devastating 2002 earthquake in Astore that also hit Attabad, the process of crack evolution in the mountains of Attabad region was observed, which worsened during the subsequent strong earthquake (7.5 on Richter scale) in 2005. With the passage of time, cracks began to widen slowly and gradually on January 4, 2010, slope failure occurred in the Attabad region resulting in the establishment of a natural dam that completely blocked the Hunza River. According to the initial estimates, a slide mass of approximately 30 million $m_3$ fell from the northern valley wall.

**Mitigation**

All structures to be built must be designed giving maximum allowance to seismic factors. A very careful analysis of the situation will be required during the design stage of the project by specialist consultants.

### 5.3.3 Impact on Geology

Almost all project interventions involve excavation of natural rocks, cutting of formations, moving and dumping of spoil. During tunnel excavation and some other operations, blasting of the formation will be required. All these activities will disturb the existing geological formations and consequently physical features of the local geological formations of the project area will be damaged at some places, which is a negative impact of moderate magnitude.

**Mitigation**

All these activities are an integral part of the project interventions and cannot be avoided. Blasting should be minimized where possible (near the surface) and, if unavoidable, low power explosive should be used and a greater number of blasts with low power material may be preferred instead of high intensity single blasting.

### 5.3.4 Impacts on Landslides

As the natural dam had been a result of a major landslide, therefore, special emphasis should be given to this aspect. Landslides are common in the project area due to the high steepness, unstable geological formations on both sides of the river and common seismic activities. Due to the project activities, especially blasting of rocks in some areas, the formation will become loose and the risk of landslides will increase in the immediate vicinity of the construction sites



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specially at the right bank of Hunza River, which may be considered as a moderate negative impact of the project.

**Mitigation**

To avoid the major risks, all structures are proposed on the left bank of Hunza River. Further, to minimize blasting of formations and, if unavoidable, then use low intensity explosive if possible.

### 5.3.5 Impacts on Land Use

There will be no major impacts on the land use of the area as the lake has already been formed and changes has already been taken place long before this project. However, new infrastructure will be built in the area which would have positive impacts on the land use.

### 5.3.6 Impacts of Excavated Material

It is planned to excavate a 5.3 m diameter headrace tunnel 2.1 km long from the weir site to the powerhouse, one diversion channel and one tailrace tunnel. Excavated spoil material will require dumping at both ends of the tunnels near the dam and near the powerhouse. Unplanned disposal may create environmental degradation of the area and environmental issues of significant adverse impacts can emerge during construction of the project. The nuisance created by excavated material will be a moderate negative impact of the project.

**Mitigation**

Same mitigation measures as of Section 5.3.1.

### 5.3.7 Impacts on Infrastructure

As there would be no resettlement involved in the project, therefore, impacts on infrastructure would be rather positive.

### 5.3.8 Impact on Climate

Project construction involves large scale activities including the movement of different types of light and heavy traffic, working of heavy machinery, blasting of rocks, operation of batching and mixing plants and the presence of large numbers of people in the area. Due to all these activities, it is expected that the microclimate of the project area (surrounding the dam site and powerhouse site) will suffer significantly. However, no impact on climate of the whole project area is expected, either positive or negative, during the construction phase.

**Mitigation**

The deterioration in the local climate during the construction phase will be of a temporary nature and will disappear with the completion of the project. However, some measures to minimize the impacts on air quality mentioned are as under:



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- Use of new and good condition old vehicles which emit less quantity of smoke.
- Regular tuning and maintenance of vehicles and other machinery.
- Avoid blasting to the maximum level but where necessary make the moderate intensity blasting instead of heavy intensity and blasting must be during daytime.

### 5.3.9 Impacts on Hydrology

During the construction stage, there will be no changes in the hydrology of the river. The flow from the reservoir will be diverted to downstream of the weir through diversion channel. The adverse impact may be considered as of negligible magnitude.

**Mitigation**

No mitigation is required as impact is very minor in nature.

### 5.3.10 Impacts on Surface Water

During the construction stage, no impact on quantity and quality of the surface water is envisaged as entire water in the river will be diverted from the reservoir to the river from the diversion channel.

**Mitigation**

No mitigation is required.

### 5.3.11 Impacts on Sedimentation

During the construction stage, the overall sedimentation rate will remain almost the same up to the dam site, but it may change because of movement of heavy traffic, dumping of the excavated material and other project related activities. The impact is considered as negative but of short duration and of minor magnitude.

**Mitigation**

This impact is unavoidable due to the nature associated with project activities, which will disappear with the completion of the project.

### 5.3.12 Impacts on Flooding

Flooding of the river at the dam site is not a common feature although some floods of high intensity are recorded in the past e.g. the glacial lake outburst floods of 1929. As river water from the upper cofferdam will be passed through diversion channels, there is chance that these tunnels could not accommodate the flows in any abnormal year. In such cases, floodwater can overtop or breach the cofferdam and damage the partially constructed civil works and lower cofferdam. The impact can be considered as significant positive impact.

Mitigation



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The diversion tunnels must be designed to pass maximum flow of the river and height of the upper cofferdam should be fixed keeping in view the historic flood height at dam site.

### 5.3.13 Impacts on Groundwater

During construction stage, no impact on groundwater is envisaged as the flow of water will continue as such without any storage.

### 5.3.14 Impacts on Air Quality

The project activities during construction at both weir and powerhouse sites will involve large movements of heavy diesel operated machinery and vehicles which produce more noise and generally emit more smoke. Similarly, various levels of noise and air pollution are expected to be generated from construction machinery and equipment, working of heavy earth moving machinery, drilling, blasting operations, concrete mixing, pouring equipment and stone crushers etc. The impact on air quality is considered as short duration negative impact of moderate magnitude.

**Mitigation**

All sources of air quality deterioration will be for short duration, temporary in nature and associated with project construction activities, which will end with the completion of the project. The contractors and sub-contractors must be held responsible through special clauses in the tender documents to strictly follow precautionary measures.

### 5.3.15 Impacts on Agriculture and Vegetation

Agriculture in the project area is practiced on a limited scale on scattered flat patches and on contour strips developed by the farmers with their own efforts and resources. The main source of irrigation in the area is the snow melt water diverted from streams towards crops, orchards and fields. No irrigation is practiced from river water in any part of the project and no impact on agriculture is expected during the construction phase of the project.

### 5.3.16 Impacts on Terrestrial Flora

The project area has very thin vegetation cover due to the special features of the terrain i.e. poor rainfall and steep mountains with very little soil cover. During construction stage, the damages to flora can be done by vehicles and machinery, establishment of camps and permanent structures etc.

**Mitigation**

Dumping of construction materials should be avoided where large number of terrestrial trees, shrubs, herbs, grasses and fruit trees are found.



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### 5.3.17 Impact on Terrestrial Fauna

Construction activities will generate moderate to major impacts to Fauna within the project area in particular at the powerhouse, dam site, tunnel route and quarrying areas. Blasting and tunneling in particular will cause loud shocks and vibrations that are likely to affect habitats and wildlife in surrounding of the project area. The ability of wildlife species to move out of construction areas will depend on the availability of suitable alternative habitats, access to those habitats, and rapid mobility required to avoid construction clearance activities. Sometimes some mammals come down from the uplands in search of food. Construction activities will disturb the migratory route of mammal species, however, this will be a minor impact.

Overall, the construction activities will generate impacts of negative nature on all types of fauna but of moderate magnitude.

**Mitigation**

Almost all impacts will be of a temporary nature, which will end with completion of the project. Dumping of construction materials should be avoided in areas where mammals, amphibians, reptiles and birds settle.

### 5.3.18 Impacts on Aquatic Life

During the construction phase, very nominal impact on aquatic life is expected as there will be no change in flow patterns in the river. The impact can be taken as of negligible magnitude.

### 5.3.19 Involuntary Resettlement

There is no displacement involved for the project, thus, no resettlement will be taken place.

### 5.3.20 Impacts on Employment Opportunities

At present employment opportunities in the project area are limited to few fields which would increase with the construction activities. Majority of local employees will be engaged in the unskilled and semi-skilled sectors. Employment generation impacts during the construction period are to be considered as major positive impact of the project.

**Enhancement**

The contractors of the project components shall be bound legally through contract agreements to engage 100% unskilled labor from project area / Gilgit-Baltistan. Preference should also be given to local skilled and semi-skilled manpower if available.

### 5.3.21 Impacts on Regional Safety and Health

People of Hunza are used to interact with people from different areas, cultures and communities. However, when there is sudden influx and congestion of people at any place from other areas for a longer period of time, it may contribute to adverse effects on the community health, safety



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and security of locals. There is always potential for such social impacts as incidences of accidents, social conflicts, theft and spread of communicable diseases.

**Mitigation**

The contractors must be bound to establish workers camps sufficiently away from the settlements of local people. During construction, the project working sites need to be bordered by a fence to safeguard life and property. As appropriate, any warning signs related to safety and security should be displayed in local languages. An appropriate security system must be in place to control all access routes to the site.

### 5.3.22 Impacts on Occupational Health and Safety

There is a tendency for the construction sector to be unregulated with respect to occupational health and safety. Additionally, unskilled and even some skilled construction workers may be illiterate and not necessarily informed or familiar with the protective measures to be adopted during work.

**Mitigation**

The contractors will need to carry out risk assessments and then develop site and project specific Health and Safety Management Plans to prevent accidents, injuries and work-related diseases.

### 5.3.23 Impacts on Resources

Construction workers will need their daily supplies in the project area. This could potentially negatively affect the existing resource base and cost for firewood, food, goods, water and fish as well as create considerable amounts of waste. Both community members and construction workers will be affected by resource constraints and changing prices and are considered sensitive socio-economic receptors, because of their limited purchasing power and state of poverty which could be affected by these impacts. These impacts are considered to be negative and of minor magnitude.

**Mitigation**

Mitigation measures will be needed to ensure that the project site is managed in a manner that is socially responsible and reflect sound environmental management practices. With respect to resource use, the Contractors will be expected to develop a plan and budget for providing workers with fuel for cooking and heating, water for cooking and cleaning, food supplies, and hygienic sanitation facilities for collecting and disposing rubbish, including construction waste.

### 5.3.24 Impact on Roads Traffic

The project area is approachable only through KKH which is also used for trade purposes with China, however, some weir and tier will be occurred with the movement of heavy traffic. This impact is one of the minor negative impacts of the project.



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**Mitigation**

Care must be exercised for the safe transport of raw materials and the transport and disposal of waste. Project vehicles and equipment will be maintained properly and project related traffic will be required, as a minimum, to travel at not more than the speed limit.

### 5.3.25 Impacts on Communication

The existing local roads network of the area is very poor. During construction, a number of additional local access roads and bridges will be required to facilitate construction works. The proposed location for the headrace tunnel is currently not properly accessible at the weir site on left side of the river and will require repair. Impacts of the enhanced road network and improved communication facilities in the project area are considered to be a major positive impact of the project as local inhabitants will also use the same infrastructure.

**Mitigation**

No mitigation is required as impacts are positive in nature.

### 5.3.26 Impacts on Cultural Heritage and Archaeology

No site of archaeological and historical importance has been identified in the project site. Some carving on stones were found near the powerhouse site regarding the incident of 2010 landslide but these carvings are outside the project construction area.

**Mitigation**

Appropriate community relations have to be maintained for social respect between the local people and labor coming from other parts of the country.

### 5.3.27 Impacts on Tourism

The Gilgit Baltistan areas of Pakistan cover 72,496 km² and possess one of the most rugged landscapes on earth and about 101 peaks above El 7,000 m. Hunza has even a special place in GB itself and every year hundreds of local and foreign tourists move into the area particularly during the summer. During the construction phase of the project no impact of any positive or negative nature is expected.

### 5.3.28 Impacts on Women and Indigenous People

Construction of the project may affect access of local people to their traditional migratory routes, and may reduce safe passage not only for the people but also for their animal herds.

**Mitigation**

The impacts described above will occur during the construction period and are reversible once the project is complete. Efforts shall be made by the contractor to inform and consult the leaders



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and elders of the community about the project, especially regarding mobility and access through the construction areas.

## 5.4 IMPACTS DURING OPERATIONAL STAGE

During the operation phase, most of the impacts of the project on the environment of the area will be of a positive nature and negative impacts will be much less as compared to the construction phase.

### 5.4.1 Impact on Seismicity

The project area is considered as part of a seismically active zone. The construction of large structures may enhance seismic activity in the area which can adversely affect the weir structure, headrace tunnel, diversion channel and other structures as well as public and private property besides the loss of human life.

**Mitigation**

As the project is situated in an active seismic zone, continuous monitoring of the behavior of faults will be required during the operation stage and contingency plans to deal with such a situation must be part of the project management. Instruments to monitor seismic activity must be installed at the time of construction.

### 5.4.2 Impacts on Geology

During operation of the project the seepage from the reservoir will significantly impact the geology of the area. The seepage water will saturate the formation below and along the reservoir and soluble minerals from the rocks will dissolve in the water. Some solution channels may develop in the formation making the formation more pervious.

**Mitigation**

It is difficult to check or reduce the seepage from the reservoir. A continuous monitoring system will be required during operation of the project to monitor the changes in groundwater level and chemistry of ground water.

### 5.4.3 Impacts on Landslides

It is expected that landslides could increase due to construction activities. Further the seepage of water will make the formation loose and unstable and the chances of sliding due to rainfall, abnormally high and low temperatures and due to seismic activities will increase. The sloughing and slippage of saturated formation during regular flushing of the reservoir may also enhance the sliding potential of the area. This impact may be considered as a major negative impact.

**Mitigation**



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As no mitigation is possible to check either the seepage or any resulting landslide, however, as after a few years of project operation most of the rocks along the weir site will become stable.

### 5.4.4 Impacts on Land Use

After construction and during the operation phase, some positive changes in land use are expected as areas under construction camps and other auxiliary services will revert to their pre-project use.

### 5.4.5 Impacts of Dismantling Material

After completion of the project construction but before operation of the project, temporary structures, batching and mixing plants and labor camps etc. will require dismantling and a large quantity of spoil material will become available for proper disposal, which will be a moderate level negative impact of the project. The debris produced will require proper dumping or disposal to avoid any environmental degradation. This spoil will pose a moderate negative threat to the environment.

**Mitigation**

There are places in this length near powerhouse site where spoil can be dumped without producing any adverse impact.

### 5.4.6 Impacts on Infrastructure

The construction at powerhouse site will disturb the supply line of goods and services for people living on the right side of the river at Sarat Village, however, enough space is available at the powerhouse site for the movement of locals. The impact is considered as a moderate negative impact of the project.

**Mitigation**

Proper boundary shall be marked by the contractor at the construction sites to facilitate the locals.

### 5.4.7 Impacts on Climate

The lake has already been there since 2010, therefore, no major changes would occur to the climate after the project has been completed.

### 5.4.8 Impacts on Hydrology

During the operation stage, there will be no changes in the hydrology of the river. Flushing will be carried out regularly and no special annual flushing will be needed, therefore, no changes would take place on hydrology of Hunza River, moreover, 3 $m^3/s$ environmental flows will be released, at least, to downstream of the weir for the aquatic life during operation.

**Mitigation**



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To conserve the aquatic life (flora and fauna) of the river downstream of the weir (2 km patch), minimum flow of 3 m³/s has been calculated as the environmental flow. It will be obligatory for project operating agency to release 3 m³/s in the river throughout the year as environmental flow.

### 5.4.9 Impacts on Surface Water

The capacity of the reservoir at El 2,409 m.a.s.l is calculated as 125 Mm³, which is very small compared to inflows. As the Attabad Lake HPP is a run-of-river power project, with the implementation of the project there is no chance of reduction of discharge in the river except in the section between weir and end of tailrace (2 km). Presently, in this section of the river, water is not being used for any purposes either for human consumption or for agriculture. Therefore, it is anticipated that there will be no impact on human population due to the diversion of discharge into the tunnel.

**Mitigation**

Environmental flows must be ensured to maintain the surface water hydrology of the Hunza River.

### 5.4.10 Impacts on Sedimentation

The Hunza river water always contains huge sediments of around 20-21 Million Tons annually on average. Diversion Channel will be used for flushing of sediments during high flow months. It is expected that release of sediments in moderate quantity could change the morphology of the river below the dam. However, as sediments will be released during high flow months with relatively high velocity of water and the river in this section has a high gradient, it is expected that sediment will move far away from the downstream of the weir site.

**Mitigation**

The silt clearance (flushing) mechanism has been provided in the project design through channel/sluices. It is proposed to flush the reservoir regularly during high flow months.

### 5.4.11 Impacts on Flooding

Flooding of the Hunza River at the weir site is not a common feature although some floods of high intensity have been recorded in the past at upstream site e.g. the glacial lake outburst floods (GLOF) at Shimshal River. As river water will pass through the headrace tunnel and overflow spillways, there is a chance that these tunnel and spillways could not accommodate the flows in abnormal years, which may pose a threat to the main structures and this impact can be treated as major negative threat.

**Mitigation**

The design of the weir has considered the design flood of 1 in 10,000-year flood of 3,250 m³/s.



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### 5.4.12 Impacts on Groundwater

The lake has already been formed, therefore, there will be no change to the groundwater.

**Mitigation**

No mitigation measures are required.

### 5.4.13 Impacts on Air Quality

Ambient air quality of microenvironment i.e. at Sarat and Salmanabad Villages would be raised, though, slightly during the construction and reconstruction activities. Fugitive dust emission from discharge of mining waste would result from tunnel excavation. This waste will have to be suitably disposed-of, or else it would add to the sediment load that will be carried by the river.

### 5.4.14 Impacts on Agriculture and Terrestrial Vegetation

Agriculture in the project area is practiced on a limited scale on scattered flat patches and on contour strips developed by the farmers with their own efforts and resources. The main source of irrigation in the area is the snow melt water diverted from streams towards crops and orchards and no irrigation is practiced from river water in any part of the project, and no major impact on agriculture is expected in the project area with the implementation of the project.

### 5.4.15 Impacts on Flora and Fauna

There would be no significant impacts on Flora and Fauna of the microenvironment of the area during operation stage.

### 5.4.16 Aquatic Life and Fish Stocks

#### 5.4.16.1 Habitat Destruction

During construction and operational phases of 54 MW hydropower project cutting, blasting, excavation, drilling, extraction, removing and dumping activities of materials at large scale contribute heavy sedimentation and soil erosion which may cause habitat damage, loss of vegetation, contamination and toxic accumulation of waste not only at Attabad lake but its impact can be seen downstream of the river as well. This situation can contribute up to great extent to destruct the aquatic life, ecology, breeding and spawning grounds of fishes, benthic fauna, food chain and abundance of micro and macro living organisms. This may lead rapid shortage of food like benthic population, phytoplankton, zooplankton, nekton etc which play an important role to sustain food chain with different trophic level in any eco-system.

Fisheries Department of Hunza has introduced several thousand fingerlings of exotic fish species namely Salmo Trutta Fario (Brown Trout) at Attabad Lake and downstream river during the period from 2012 to date for propagation and the said specie has made breeding grounds at Attabad Lake and downstream as well. Besides this a number of indigenous fish species also exist in the same water bodies having commercial as well as ecological importance.



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### 5.4.16.2 Water Pollution

Heavy machinery and equipment will be used during construction and operational phases of the project with huge quantity of explosives for blasting of rocks. Resultantly heaps of leftovers of explosives, grease, chemicals, lubricants, and other harmful materials will be produced on daily basis. These pollutants through run off rain water enter into the lake and river course increase toxicity of water causing rapid destruction of fish population and riverine ecology.

### 5.4.16.3 Fish Migration

Fish usually migrate from one place to another for search of food, shelter and spawning/breeding. Due to construction of the project fish migration might be affect up to some extent.

**Mitigation**

- Rapid mechanism of dispose-off of such kinds of hazardous materials will be required on urgency basis by dumping the extracted hazardous materials selecting safe landfill areas away from the main river course and its watershed, so that contaminated water in form of runoff could not enter directly into the main course.
- Land sliding and soil erosion are also the main factor to contribute silt load on river bed manifold causing damage to resting and nesting grounds of fishes. Construction of protective walls and gabions at certain points to make sure the stoppage of sliding debris. Plantation and vegetation cover can also be helpful for slope stabilization. Plants, herbs and sharbs reduce the level of pollution and toxicity at a great extent as bio-filter and carbon suckers.
- Fish ladder shall be insured for freely movement of fishes.
- Fish screening system should be developed so that fish may not be trap at intake, penstock pipe or channel.
- Sewage water treatment discharged from all labour camps and toilet facilities must be treated before disposal into the river.
- Tanks of fuel, oil and other liquids to be placed quite distant from any water body.
- Washing of vehicles or other machinery in the river or nallahs to be strictly prohibited.
- Oil changes for engines and other machinery to be only allowed in workshops.
- All vehicle and machinery to be maintained properly in order to avoid any leakages.

### 5.4.17 Impacts on Power

The most significant impact of the project will be the power generation as the region is presently facing acute shortage of power. The power generating capacity of the project is estimated as 54 MW, which is enough to remove the power shortage from the area. The power generated will help to establish new industries, to boost commercial activities and to enhance job opportunities



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in the valley. Electricity generation impacts are considered to be most significant positive impact of the project.

### 5.4.18 Impacts on Employment Opportunities

During operation stage, a large number of both skilled and semi- skilled manpower will be required, who will be recruited from the local area. Employment generation during the operation phase is considered to be of a major positive nature.

### 5.4.19 Impacts on Social Services

Access roads and basic infrastructure will be built as part of the project and will facilitate the access for people to goods and services. After completion of the project, these facilities and infrastructure will be available to the general public of nearby villages. The impact of better communication and other social services is considered to be a moderate positive impact of the project.

### 5.4.20 Impacts on Tourism, Landscaping and Visual Amenity

The Northern Areas of Pakistan cover 72,496 km² and possess one of the most rugged landscapes on earth and about 101 peaks above El 7,000 m. Every year hundreds of tourists (local and foreign) visit the area particularly during the summer.

Hunza is known for their outstanding natural beauty, high peaks and landscape and it is a popular destination among tourists from both Pakistan and abroad. The area offers tourists opportunities for outdoor activities such as hiking, fishing and trophy hunting. Impact relating to recreation activities is considered to be moderately positive.

### 5.4.21 Impact on Women

Contrary to the construction phase, there will be much less movement of vehicles as well as people in the area during the operation phase. Thus during this phase no negative impacts on women are expected.



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# 6 ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN

## 6.1 OBJECTIVES OF ENVIRONMENTAL MANAGEMENT AND MONITORING

This section of the ESIA report provides an overall approach for managing and monitoring the environmental and social issues raised by the construction and operation of the Attabad Lake Hydropower Project. The objective is to provide an overall framework for implementing the mitigation measures that adequately address the identified adverse impacts and also the enhancements for predicted positive impacts. In addition, the items that require monitoring of the environment are also identified. All of these measures are to be put into a coherent Environmental Management and Monitoring Plan (EMMP), complete with the institutional arrangements and resources required to successfully implement the required actions.

The main objectives of an EMMP are as under:

- Provide the details of the project impacts, along with the proposed mitigation and enhancement measures.
- Define the roles and responsibilities of the project stakeholders, including the project proponent, contractor, supervisory consultants and other key players.
- Identify the training requirements needed for the key role players in order for them to effectively implement the EMMP.
- Provide a mechanism in the form of an environmental monitoring program, that outlines which key parameters (both for the natural and social environment) will need to be monitored and the frequency that each of these has to be carried out.
- The objective is to ensure that mitigation measures are being effective in keeping environmental conditions within prescribed limits and if they are not, then making sure that there is an effective response mechanism that allows corrective action to be implemented.

## 6.2 MITIGATION MANAGEMENT MATRIX

The Mitigation Management Matrix (MMM), a preliminary outline is considered to be one of the main elements of the EMMP. The MMM shall be prepared during detailed design keeping in view the required functions and responsibilities and is to be used as the management tool for the implementation of mitigation measures. The mitigation management matrix should include:

- The required mitigation measures recommended in the ESIA report.
- Identification of the person or institution/organization directly responsible for adhering to or executing the required mitigation measures.
- The person or institution/organization responsible for ensuring and monitoring adherence to the mitigation measures.



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- The parameters that will be monitored to ensure compliance with environmental standards and also with the requirements and objectives of the mitigation measures.
- The timing at which the mitigation or monitoring has to be carried out.

## 6.3 MANAGEMENT OF DIRECT CONSTRUCTION IMPACTS

Construction programs and management of construction impacts shall be included by drafting appropriate environmental management clauses into the construction contracts. Once a master checklist of direct construction impact issues has been finalized then a monitoring checklist can be created for use by the supervising engineers during the construction period. It is crucial to clearly define the responsibilities of each of the parties in the construction works (contractors, supervisors and the project proponent).

## 6.4 SITE RESTORATION PLAN

The main areas that will require site restoration include the main construction site area, workers' accommodation sites, land used for vehicle and material workshops and stores along with material excavation and storage areas and temporary access roads and tracks. These areas will need to be restored to their original condition as far is possible and where there has been significant change then landscaped to fit with the surrounding area. The restoration work includes the removal of all temporary construction works and materials, followed by the landscaping and planting of the areas, including provision of adequate surface drainage to ensure that there will be no erosion and particularly sedimentation into the reservoir. The following procedures will be adopted for the restoration of the site:

- All temporary constructions built for the site development will be removed.
- Areas used for construction camps will be restored to their previous condition as far as is possible and where this is not then appropriately landscaped and planted to an agreed plan.
- All toxic and hazardous chemicals and materials will be totally removed from the site followed by treatment and environmentally appropriate disposal.
- During the construction program efforts will be made to minimize the risk of oil and chemical spills and an effective clean-up program should be in place to remove these as soon as they happen.
- All debris from construction activities should be removed from the site and appropriately separated, reused, recycled and composted with the residual material appropriately incinerated.
- All redundant fencing and gates will be removed and excavated pits will be appropriately backfilled.

## 6.5 RESERVOIR MANAGEMENT PLAN

Reservoir area will need to be managed during both the construction and operation of the project. The risk of debris entering the intakes also has to be considered. Once a clear idea of the construction program has been agreed then an appropriate reservoir management plan can



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be drawn up. This should also include the fisheries development plan for the reservoir, along with a recreation and tourism management program for the area.

The reservoir management plan will also have to consider the need for upstream catchment management measures in the watercourses that directly discharge into the reservoir, based upon the results of water quality monitoring that will be carried out. The quality of the reservoir water will also need to be monitored to ensure that there is not a buildup of nutrients that could cause problems with algal growth. If this should start to occur, then adequate measures will need to be taken to prevent nutrient loaded water from flowing into the reservoir.

## 6.6 IMPACT MONITORING PROGRAM

### 6.6.1 Objectives of the Impact Monitoring Plan

The objective of the environmental monitoring activities to be carried out during the construction and operation stages of the project will be as follows:

- To monitor the actual project environmental impact on the physical, biological and socioeconomic indicators that will be selected to be appropriate for such work in order to compare appropriate indicators with the situation before the start of the project.
- To provide information that will allow recommend mitigation measures to be drawn up for any unforeseen impact or where the adverse impact level exceeds that anticipated.
- Ensure compliance with legal regulatory requirements and also community obligations, including health and safety at both the construction and operational stages of the project.
- Ensure the safe and environmentally sound disposal of excess construction materials, solid waste and effluents, along with the adequate management of noise and dust emissions.

The main objectives of environmental monitoring during the operation phase will be to:

- Appraise the adequacy of the ESIA with respect to the predicted long-term impacts of the project on the physical, biological and socio-economic environment of the area.
- Evaluate the effectiveness of the mitigation measures proposed in the EMMP and recommend any improvements in the EMMP if they are found to be required.
- Compile periodic incident and accident data to support analyses that will help to minimize future risks.
- Monitor the survival rate of the proposed vegetation planting program and make appropriate proposals to ensure that balanced mixed age and species stands develop in the area that provide sustainable supplies of fruit, fuel-wood and fodder for the local population.

### 6.6.2 Monitoring Strategy

All the compliance monitoring will be executed by the Contractor during the construction stage of the project to ensure that they operate according to the regulatory framework. Supervision of the



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compliance environmental monitoring work during the construction stage will be carried out by the Supervisory/Management Consultants (SC).

### 6.6.3 Monitoring Parameters and Frequency

#### i) Natural Environment

For the physical environment the following parameters will need to be regularly monitored both before and during construction:

- Ambient air quality (mainly NOx, Sox and CO)
- Batching and crushing plant emissions (smoke, dust, etc.) during operation
- Ambient noise levels
- Water quality (drinking, surface and groundwater), for both chemical composition and also sediment

#### ii) Socio-economic Environment

The impacts on the socio-economic environment will be monitored by the SC using changes in household economic livelihoods as a major indicator in the longer term. Other key aspects that will need to be monitored include environmental and community health, safety issues, employment availability and generation, along with physical mobility and access, especially for women.

At the construction stage of the project the Supervisory Consultant will maintain a Social Complaints Register. This is an open public document that allows anybody to register a complaint which must then be thoroughly investigated and a judgment made as to its justification and the action need to address the issue.

## 6.7 CONSTITUTION OF PROJECT ENVIRONMENT MANAGEMENT COMMITTEE

| Sr. No. | Agency | Representative | Status |
|---|---|---|---|
| 1 | WAPDA | Project Director | Chairman |
| 2 | Government of GB | DC/ AC (Concerned) | Member |
| 3 | Consultant | Resident Engineer | Member |
| 4 | Main Contractor | Designated Engineer | Member |
| 5 | Environment Department | Director, EPA GB Representative | Member |
| 6 | Local Government | Chairman District Council | Member |
| 7 | NGO | Representatives of two functional NGOs of the region | Member |



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## 6.8 LAND REQUIREMENTS FOR THE PROJECT

Resettlement, land requirements and acquisition for any mega project is a sensitive task, however, for this project these issues are not as critical as in other projects. Attabad Lake was formed in 2010 as a result of a natural disaster and it still recovers about 4.5 $km^2$ of land which includes lands of Ainabad, Shishkat, Gulmit and Gulkin. Shishkat, Gulmit and Gulkin are were partly damaged but Ainabad was completely submerged.

Land will be acquired for mostly powerhouse site which includes land powerhouse, switchyard, project colony and project offices. Land at weir site is mostly riverine land and will be acquired from the government. Land required for the Attabad Lake HPP is mentioned in the Table 6-1. Land Requirement for the Project is depicted at **Drawing-II**

**Table 6-1: Land Requirements for Attabad Lake HPP**

| Sr. No. | Description | Town / Village | Land in Acres | Land in Kanals | Land Cost per Kanal (DC Rates) | Remarks |
|---|---|---|---|---|---|---|
| 1 | Powerhouse Side | Sarat | 4 | 32 | 750,000 | Community Land of Ganish Village |
| 2 | Weir and Associated Structures | Attabad | 15 | 120 | 500,000 | Mostly it is riverine land. Left Side of Hunza River is Community Land of Ganish Village and Right Side is Community Land of Attabad Village. |
| 3 | Access Roads to Sites | - | - | - | - | Old KKH will be repaired where available and new will be constructed where not available |
| 4 | Permanent Project Colony | Sarat | 2.5 | 20 | 1,500,000 | Community Land of Ganish Village |
| 5 | Transmission Line | Throughout the T.L route | As per site | As per site | Varies | Land for T.L will be acquired along the route |
| | **Total** | | **21.5** | **172** | | |

## 6.9 ENVIRONMENTAL MITIGATION AND LAND ACQUISITION COST

Land Acquisition and Environmental Mitigation cost have been kept for the cost of permanent land acquisition for project components, temporary land acquisition, building compensation, spoil disposal area rehabilitation, rehabilitation of villages, livelihood allowance for affectees,



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monitoring & evaluation and land conservation etc. The total cost of land acquisition and environmental mitigation is estimated as Rs. 208.450 Million as shown in Table 6-2

**Table 6-2: Cost Estimate for Land Acquisition and Environmental Mitigation**

Price Index – March, 2021
US$ Exchange Rate = Rs. 157

| Sr. No. | Description | Unit | Qty | Rate | Cost | |
|---|---|---|---|---|---|---|
| | | | | (PKR) | (PKR) | (US$) |
| 1 | Permanent Land Acquisition* | | | | | |
| - | Powerhouse Site | kanal | 32 | 750,000 | 24,000,000 | 152,866 |
| - | Weir & Associated Structures | kanal | 120 | 750,000 | 90,000,000 | 573,248 |
| - | Project Colony | kanal | 20 | 750,000 | 15,000,000 | 57,325 |
| - | Miscellaneous | LS | 1 | 16,000,000 | 16,000,000 | 101,911 |
| 2 | Temporary Land Acquisition | LS | 1 | 1,000,000 | 1,000,000 | 6,369 |
| 3 | Building Compensation | LS | 1 | 15,000,000 | 15,000,000 | 95,541 |
| 4 | Spoil Disposal Area Rehabilitation | LS | 1 | 4,000,000 | 4,000,000 | 25,478 |
| 5 | Rehabilitation of Villages | LS | 1 | 2,000,000 | 2,000,000 | 12,739 |
| 6 | Livelihood Allowance for Affectees | LS | 1 | 2,000,000 | 2,000,000 | 12,739 |
| 7 | Monitoring and Evaluation | LS | 1 | 16,500,000 | 16,500,000 | 105,096 |
| 8 | Capacity Building/training | LS | 1 | 2,000,000 | 2,000,000 | 12,739 |
| 9 | Land Conservation | LS | 1 | 2,000,000 | 2,000,000 | 12,739 |
| | | | | **Sub-Total** | **189,500,000** | **1,207,006** |
| 10 | Contingencies 10% | | | | 18,950,000 | 120,701 |
| | | | | **Total** | **208,450,000** | **1,327,707** |



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# PHOTOGRAPHS



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**Photograph 1: Attabad Lake**

**Photograph 2: Attabad Land Slide Information**

**Photograph 3: Shamshal Nullah**

**Photograph 4: Fine Sediment Deposits near Passu**



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**Photograph 5: Powerhouse Site**

**Photograph 6: Hunza River D/S of PH Site**



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**Photograph 7: Hunza and Nagar Rivers Confluence Point near Ganish**

**Photograph 8: Civil Dispensary Gulmit**



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**Photograph 9: Meeting with Director EPA Gilgit**

**Photograph 10: Meeting with Director KIU Hunza Campus**



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**Photograph 11: Meeting with Assistant Commissionaire Gojal Hunza**

**Photograph 12: Meeting with Representative of Water & Power Dept. of GB**



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**Photograph 13: Meeting with President Local Ismaili Council Gulmit**

**Photograph 14: Meeting with Director Forrest and Wildlife Department Hunza**



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**Photograph 15: Meeting District Health Officer Hunza**

**Photograph 16: Meeting with Director Agricultural Department**



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**Photograph 17: Meeting with District Education Office Hunza**

**Photograph 18: Meeting with Principal Al-Amin Model School Gulmit**



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**Photograph 19: Visit of Bulbulik Music School Gojal**

**Photograph 20: Socio-Economic Survey of Local Cummunity Gulmit**



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**Photograph 21: Bulbulik Music School Gojal**

**Photograph 22: Socio-Economic Survey of Locals near Attabad Lake Site**



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**Photograph 23: Socio-Economic Survey of Local Community Shishkat**

**Photograph 24: Socio-Economic Survey of Locals Gulkhin**



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**Photograph 25: Socio-Economic Survey of Locals Sarat**

**Photograph 26: Socio-Economic Survey of Locals Salman Abad**



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**Photograph 27: Socio-Economic Survey of Locals Gulmit**

**Photograph 28: Socio-Economic Survey of Locals Gulmit**



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**Photograph 29: Socio-Economic Survey of Locals near Attabad Lake Site Shishkat**

**Photograph 30: Environmental & Socio-Economic Survey Team**



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**Photograph 31: Collection of Water Sample from Attabad Lake**

**Photograph 32: Collection of Water Sample from Gulmit Glacier Melt**



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**Photograph 33: Agriculture Seed Farm/Nursery Shishkat Gojal**

**Photograph 34: Government Middle School Shishkat Gojal Hunza**



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**Photograph 35: Testing of Lake Water with Portable TDS Meter**

**Photograph 36: Testing of Lake Water with Portable PH Meter**



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# APPENDICES



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## List of Respondents of Socio-Economic Survey

| S. No | Name | Village/ tehsil/UC | Profession | Land owned (Kanal) | Comments and concerns about Attabad Lake | In case of Resettlement |
|---|---|---|---|---|---|---|
| 1. | Sabir Shah | Gulmit/ Gojal-1 | Abroad Job | 3 | It will produce electricity but it will increase upstream level. | No where |
| 2. | Zaheer | Gulmit/Gojal-1 | Farmer | 2 | Electricity generation | Islamabad |
| 3. | Didar Karim | Gulmit/Gojal | Forester | 40 | Electricity generation | Nearest village |
| 4. | Didar Ali | Gulmit/Gojal | Manager | ---- | Hydropower Project | Islamabad |
| 5. | Ghulam Muhammad | Gulmit/Gojal | NGO Job | 5 | Power generation | Hunza |
| 6. | Aaqib Jaffar | Gulmit/Gojal | Business Man | 15 | Life of lake is short/ Electricity generation | No where |
| 7. | M.Khan | Gulmit/ Gojal | Tehsil officer | 25 | Electricity generation | City |
| 8. | Bashir Khan | Gulmit/Gojal-1 | Business student | 1 | Electricity generation | No where |
| 9. | Karim Ullah | Gulmit/Gojal-1 | Farmer | 3 | Electricity generation | No where |
| 10. | Arman Ali Shah | Gulmit/Gojal-1 | Farmer | 5 | Electricity generation | No where |
| 11. | Aman Gul | Gulmit/Gojal-1 | Farmer | 2 | | No where |
| 12. | Akbar Khan | Gulmit/Gojal-1 | Farmer | 2 | Electricity generation | No where |
| 13. | Sherdil Khan | Gulmit/Gojal | Shop Keeper | 4 | Power House | No where |
| 14. | Razia | Gulmit/Gojal | Farmer | ---- | ---------- | Karachi |



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| S. No | Name | Village/ tehsil/UC | Profession | Land owned (Kanal) | Comments and concerns about Attabad Lake | In case of Resettlement |
|---|---|---|---|---|---|---|
| 15. | Nazir Ahmad bulbul | Gulmit/Gojal | Head Master | 10 | It will produce electricity but it will increase upstream level. | No where |
| 16. | Malika | Gulmit/Gojal | Business | ----- | Electricity generation | Gulmit |
| 17. | Ayyaz Uddin | Gulmit/Gojal | Master trainer | 3 | Electricity generation | Islamabad |
| 18. | Karim Jan | Gulmit/Gojal | Dtiver | 1 | Electricity generation | Karachi |
| 19. | Noor Jahan | Gulmit/Gojal | Govt Officer (retd) | 2 | Electricity generation | Islamabad |
| 20. | Hajat begum | Gulmit central | Farmer | ------ | --------- | No where |
| 21. | Abdul-a-Jan | Shishkat/Gojal | Shop keeper | 20 | Electricity generation | ---------- |
| 22. | Shor Khan | Shishkat/Gojal | Health worker | 15 | It will increase water level | Hunza |
| 23. | Habib-ur-Rehman | Shishkat/Gojal | Electrician | 4 | Electricity generation | ---------- |
| 24. | Ghulam Sarwar | Shishkat/Gojal | Teacher (retd.) | 2 | Electric power project | No where |
| 25. | Walayat Khan | Shishkat/Gojal | Farmer | 20 | Electric power project | Hunza |
| 26. | Ameer Ali | Shishkat/Gojal | Army (retd.) | 18 | Power Project | Hunza |
| 27. | Rahat Shah | Shishkat/Gojal | Shop Keeper | 7 | No idea about project | Hunza |
| 28. | Liaquat Ali Khan | Shishkat/Gojal | Driver | 10 | Power Grid | No where |



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| S. No | Name | Village/ tehsil/UC | Profession | Land owned (Kanal) | Comments and concerns about Attabad Lake | In case of Resettlement |
|---|---|---|---|---|---|---|
| 29. | Hussan Bano | Shishkat/Gojal | House Wife | 20 | Electricity generation | City |
| 30. | Ghulam Qadir | Shiskat/Gojal | Teacher (retd.) | 20 | Electricity generation | No where |
| 31. | Asghar Khan | Shiskat/Gojal | Teacher | 3 | Electricity generation | ---------- |
| 32. | Hafeez Ullah | Shiskat/Gojal | Tanslator (Chinese) | 10 | Dam and Electricity | City |
| 33. | Karim Baig | Passu/Gojal-1 | Army Retd. | 5 | ---------- | No where |
| 34. | Muhammad Jan | Passu/Gojal-1 | Farmer | 70 | ---------- | City |
| 35. | Jalal-Uddin | Passu/Gojal-1 | Farmer | 80 | ---------- | No where |
| 36. | Baber Majeed | Passu/Gojal | Manager US-Aid | 200 | Electricity generation | Karachi |
| 37. | Tariq Aziz | Passu/Gojal | Business Man | 25 | ---------- | No where |
| 38. | Tahira Parveen | Passu/Gojal | Business Man | 40 | ---------- | Not decided |
| 39. | Malika | Passu/Gojal | Banker (Retd.) | 30 | ---------- | No where |
| 40. | Ghulam Rahim | Passu/Gojal | Shop Keeper | 100 | Elecricity generation | ---------- |
| 41. | Nazara Baig Tajil | Passu/Gojal | Shop Keeper | 10 | Termination of Load shedding | Not decided |
| 42. | Liaquat Ali Khan | ---------- | Business Man | 40 | Electricity generation | Zarabad |
| 43. | Didar Ali | Passu/Gojal | Shop Keeper | 60 | Electricity generation | Sultanabad |
| 44. | Rehana Parveen | Hussaini/Gojal | Business woman | 1 | Electricity generation | Gilgit |



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| S. No | Name | Village/ tehsil/UC | Profession | Land owned (Kanal) | Comments and concerns about Attabad Lake | In case of Resettlement |
|---|---|---|---|---|---|---|
| 45. | Javed Iqbal | Hussaini/Gojal | Business | 15 | ---------- | Gulkin |
| 46. | Bibi Hijrat | Hussaini/Gojal | Farmer | 1 | Electricity generation | Gilgit |
| 47. | Akbar Hussain | Hussaini/Gojal | Business Man | 40 | Power Plant | Karachi |
| 48. | Nasir Khan | Ghullkin/Gojal | Army (retd.) | 100 | ---------- | Abroad |
| 49. | Qadir Parwana | Ghullkin/Gojal | Hotel Manager | 14 | Dam & Power Supply | No where |
| 50. | Sift Ullah | Ghullkin/Gojal | Army ( retd). | 24 | Power House | Gilgit |
| 51. | Mehar Numa | Sarat/Ali Abad | ---------- | 60 | Electricity generation | Ali Abad |
| 52. | Isa Khan Numberdar | Sarat/Ali abad | Numberdar/farmer | 10 | Power Grid | Nearest Town |
| 53. | Alam zewar | Sarat/Ali Abad | House wife | 5 | ---------- | Ali abad |
| 54. | Irfan Karim | Sarat/Ali Abad | Chinese Translator | 50 | Electricity generation | Nearest Town |
| 55. | Ghulam Jafar | Attabad/Aliabad | Farmer | 4 | Electricity generation | Altit |
| 56. | Sadam Hussain | Attabad/Aliabad | Farmer | 25 | Power Grid | Nearest Town |



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**Appendix-B-I**

**Questionnaire for Socio-Environmental Survey (EIA)**

(Interview Schedule for Village/Town Profile)

Interviewer_____ Date_____

**INTERVIEW LOCATION**

Village/Town_____ Union Council_____

Tehsil_____ District_____

---

**1. POPULATION**

i. Total Population_____
ii. No. of Males_____
iii. No. of Females_____
iv. No. of Children_____

**2. ETHIC GROUPS**

Major Castes:

i) _____ ii)_____ iii)_____

iv) _____ v)_____ vi)_____

**3. HOUSING**

i. Total Houses _____
ii. Pacca Houses _____
iii. Mix Houses _____
iv. Katcha Houses _____
v. Total Farm Households _____
vi. Total Landless Household _____



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## 4. LANDHOLDINGS

(a) Total Agriculture Land of the Village/Town

i. Land under Cultivation (%age) _____

ii. Land Non-cultivable (%age) _____

(b) Distribution of Farmers by Farm Size

i. No. of Farmers owning Large Farm Size 100 acre

ii. No. of Farmers owning Medium Farm Size 50 acre

iii. No. of Farmers owning Small Farm Size below – 10 acre

(c) Water Supply System source

i) River ii) Irrigation iii) Tube well

iv) Rain Water

## 5. EDUCATIONAL FACILITIES

| School | Type | Available | Available Outside the Village/Town | | |
|---|---|---|---|---|---|
| | | No. of Students | Place | Distance (km) | Approximate No. of student going to |
| **Primary School** | | | | | |
| Boys | Govt. | | | | |
| | Private | | | | |
| Girls | Govt. | | | | |
| | Private | | | | |
| **Middle School** | | | | | |
| Boys | Govt. | | | | |
| | Private | | | | |
| Girls | Govt. | | | | |
| | Private | | | | |
| **High School** | | | | | |
| Boys | Govt. | | | | |
| | Private | | | | |
| Girls | Govt. | | | | |
| | Private | | | | |



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## 6. CONDITION OF SCHOOLS

| Description | Types of Condition | | |
|---|---|---|---|
| | Good | Satisfactory | Bad |
| | | | |
| **Boys School** | | | |
| Building | | | |
| Staff Competency | | | |
| Student Discipline | | | |
| Student Performance | | | |
| Student Strength | | | |
| **Girls School** | | | |
| Building | | | |
| Staff Competency | | | |
| Staff Regularity | | | |
| Student Strength | | | |
| Student Discipline | | | |
| Student Performance | | | |

## 7. HEALTH FACILITIES

| Description | Available in Village/Town | Outside the Village/Town | |
|---|---|---|---|
| | | Place | Distance (km) |
| **Human Health** | | | |
| Rural Health Dispensary | | | |
| Mother's Child Centre | | | |
| Private Doctor | | | |
| Lady Health Visitor (LHV) | | | |
| TBAs | | | |
| Hakim | | | |
| Others | | | |
| **Livestock Health** | | | |
| Veterinary Hospital/Dispensary | | | |
| Other | | | |
| **Other Basic Facilities** | | | |
| Post Office | | | |
| Bank | | | |
| Telephone PCO | | | |
| Pacca Link Road | | | |
| Clean Drinking Water | | | |
| Water Supply Scheme | | | |

## 8. COMMON DISEASES

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| i. | Malaria | ii. | Cholera | iii. | Arthritis | iv. | Goiter |
| v. | Stomach | vi. | TB | vii. | Diabetes | vii. | Any other |



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**9. NEAREST TOWN**

Name _____

Distance (km) _____

**10. MAIN CROPS AND THEIR YIELDS**

| Crops | Yield (Kg/Area) | | | Major Reason (s) for Low Yield |
|---|---|---|---|---|
| | Maximum | Minimum | Average | |
| Wheat | | | | |
| Vegetable | | | | |
| Fodder | | | | |
| Maize | | | | |
| Orchard | | | | |
| Other | | | | |
| Fruits | | | | |

**11.** People engaged in other occupations

| | |
|---|---|
| Fishery | |
| Govt. Job | |
| Private. Job | |
| Other Job | |
| Labour | |
| Unemployment | |
| | |



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**Appendix-B-2**

**Questionnaire for Sociological Survey**

(Interview Schedule for Village/Town Profile)

Interviewer _____ Dated _____

Male/Female _____

**INTERVIEW LOCATION**

Village/Town_____ Union Council_____

Tehsil _____ District_____

_____

**1. Project Awareness**

i) Have you heard about Attabad Lake Hydropower Project

Yes _____ No_____(Tick the Applicable).

ii) How did you learn about it?

Radio/TV_____ Relatives _____

Newspapers_____ (other specify)_____

iii) What do you know about the Project?

_____

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## 2. Household Details of Respondents

Enter details of household

| Sr. No. | Name | Position in family | Age/ Year | Occupation | Highest Level of Edu achieved | Vaccination Y N | Resident house | If No, Where Living | This land | Other Land | Reason work |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
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### 3. Land Holdings of Respondents

List: The areas of land that you occupy

| Place | Location (Name of village/Town) | Size Acre | Owned Y or N | Distance from main area | If not owned temporary basis | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Share crop | Rent | Other specify | Rent Paid |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

### 4. House of Respondents

| House details | Area ($ft^2$) | Constructed area ($ft^2$) | Room Nos. | Constructed Form | |
|---|---|---|---|---|---|
| | | | | Kacha | Pacca |
| | | | | | |
| | | | | | |
| | | | | | |
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## 5. Food & Agriculture of Respondents

### 5.1 Main Area

i) Crop (given area in Area)

| Crop Name Rabi/Kharif | Machinery use of animals use for harvesting the crop | Irrigated (kg) | | | | Barrani (kg) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Area | Harvested | Sold | Bought | Area | Harvested | Area | Bought |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

ii) Fruit Trees or Tree Crops in Village/Town

Indicate harvested, sold & bought yield in kg.

| Fruit Trees | Nos. | Harvested | Sold | Bought |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

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iii) Live Stock of Respondents

| Live Stocks | Current | Sold | Bought |
|---|---|---|---|
| Bull | | | |
| Cow | | | |
| Calves | | | |
| Horses | | | |
| Mules/Donkeys | | | |
| Goats | | | |
| Sheep | | | |
| Poultry | | | |
| Ducks | | | |

5.2 **Area Number for crops in acre.**

| Crops Name | Irrigated (kg) | | | | Barrani (kg) | | | |
|---|---|---|---|---|---|---|---|---|
| Rabi/Kharif | Area | Harvested | Sold | Bought | Area | Harvested | Area | Bought |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
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| | | | | | | | | |



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### 6. Living Standard Survey of Respondents

Which of the following items do you have?

| Item No. | | |
|---|---|---|
| 1. | Refrigerator | |
| 2. | Deep Freezer | |
| 3. | Television | |
| 4. | Washing Machines | |
| 5. | Geyser | |
| 6. | Electric Fan | |
| 7. | Electric Iron | |
| 8. | Sewing Machine | |
| 9. | Radio/Tape Recorder | |
| 10. | Bicycle | |
| 11. | Motor Cycle/Scooter | |
| 12. | Rickshaw | |
| 13. | Dish Antenna | |
| 14. | Telephone | |
| 15. | Air Cooler | |
| 16. | Power Generator | |
| 17. | Tractor | |
| 18. | Truck | |
| 19. | Tractor Trolley | |
| 20. | Electric Water Pump | |

### 6.1 Living Expenditure Estimates of Respondents

i) Agriculture (yearly estimates)

| Item | Cost Rs. |
|---|---|
| Seed | |
| Bagged Inorganic Fertilizer | |
| Crop Agrochemicals herbicides insecticides | |
| Live stock, agrochemicals | |
| Hired Labour from location | |

ii) Food Expenses of Respondents

| Item | Cost Rs. |
|---|---|
| Meet/Beef/Chicken | |
| Milk | |
| Eggs | |
| Ghee/Butter | |
| Flour | |
| Rice | |
| Fish (Fresh from river) | |
| Fertile/Pulses/Grams | |
| Other Specify | |



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iii) Household (non food) expenses (average for month) of Respondents

| Item | Cost Rs. |
|---|---|
| Washing Soap (Powder) | |
| Bathing Soap/Slopes | |
| Kerosene Oil | |
| Forest Wood for cooking | |
| Electricity | |
| Telephone | |
| Other specify | |

iv) Clothing Shoe expenses (for family) during the month of Respondents

| Item | Cost Rs. |
|---|---|
| Winter (Last) | |
| Summer (Last) | |

v) Education expenses average for year Rs._____

vi) No. of boys attending school No. of girls _____

vii) Health Expenses (average for year) Rs._____

viii) Transportation Cost average/month Rs._____

ix) Govt. Taxes (average for year) Rs._____

**7. Borrowings Facilities**

Last year did you borrow money

i) Yes _____ or No _____

If yes

a. How much did you borrow?

b. For what purpose was the money borrowed?

c. Source of Borrow?

d. How much has been paid back?

1. None 2. On quarter 3. One half paid

4. Three quarters 5. All



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## 8. Health

What are some of the common diseases occurring in your family during the last year.

| | | Place where treatment sought (click for each disease) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Gender | Disease | None | Dr./Hospital | MCH Centre | Dispensary | Hakeem | Pir/Moulvi/Sufi | Pharmacist | Medical Store | Homeopath | Other specify |
| Men | | | | | | | | | | | |
| Women | | | | | | | | | | | |
| Children | | | | | | | | | | | |

## 9. Child Birth

9.1 How many of your children were born at hospital

9.2 How many children were born at home

9.3 Who delivered the last baby born? was it any of the following (Tick 1)

i) Traditional _____

ii) TBA _____

iii) Doctor _____

iv) Other Specify _____

## 10. Forest

i) Do you own trees/Forests? Yes / No

If Yes, No. of forest trees _____

ii) Did you plant any tree last year? Yes / No

If Yes, how many did you plant and name of trees _____

iii) How many trees did you cut down last year? _____

iv) Why did you cut these down? _____

v) How much money did you get from tree sales? _____Rs. (last year)

vi) How much fuel wood do you need per day for domestic purposes ____kg/day



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vii) Where do you harvest this fuel wood?

Location, distance to carry _____

viii) Do you gather other forest products? If yes what are these.

ix) Did you sell any forest products last year? If so how much money did you earn _____Rs.

**11. River & Water Supply Usage**

i) For which of the following purpose do you use River and Water Supply? Choose multiple options for more than one answer.

1) Fish (if yes) 2) Washing/Bathing 3) Drinking

4) Other uses specify

ii) If you do not use the river water, what are your water supply sources?

1) Spring 2) Well 3) Pumped groundwater

4) Public stand Pipe 5) Hand Pump 6) Other specify

iii) How much far do you have to travel to fetch water for daily use? _____km

iv) Who fetches water mostly? Husband/Wife Daughter/Son Male/Female

**12. River Flow Reduction in Hunza River**

12.1 If the project reduced the river flow, Is this concern you? Yes/No

If Yes why _____

**13. Fishing**

i) Name the water source where your catch fish? _____

ii) How much times you catch fish in a week? (summer/winter) _____

iii) What is your purpose for catching fishing? _____

iv) How much do you normally catch per week (summer/winter) _____kg.

v) What fishing gear do you use?

Net _____ Hand line_____ Trap_____ Other specify

vi) Do you sell fish? Yes / No

If Yes, location where you sell your catch _____?

vii) How much of your caught fish do you able sell each week? _____kg.

viii) What is value of this sale of caught fish per day? _____Rs.



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**14. Alternative Income sources & development requirement.**

14.1 Are you satisfied with your living conditions Yes / No

If yes why_____

14.2 In your opinion what kinds of development projects/improvements are needed for this area. please explain your reasons.

**15. General Resettlement Concerns**

15.1 If the project proceeds, some people may be relocated. If this happens what beneficial/adverse effects do you consider, the Project would have on the following:

| Question | Beneficial | Adverse |
|---|---|---|
| On your farming | | |
| On your livestock of grazing | | |
| On your family | | |
| On your village community | | |
| Other specify | | |

15.2 In case you will have to move, do you have any place where you could move?

15.3 Location and distance from your present residence.



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**Appendix- B-3**

**Questionnaire for Women Survey**

(Interview Schedule for Village/Town Profile)

Interviewer _____ Dated _____

Name Female _____ Age _____years

**INTERVIEW LOCATION**

Village/Town_____ Union Council_____

Tehsil _____ District_____

1. What is your marital status? Single / Married
2. How many children do you have? _____boys _____girls
3. At what age you were married? _____years
4. Family size
5. What is your Education?
6. What is your occupation?
   a. Job (if yes, specify_____)
   b. Housewife
   c. Student (if yes, then level _____ and education institute _____)
7. Role of women in decision making?
8. Diseases
9. Early age marriages
10. Medical facilities for women
11. In your opinion, which steps should be taken for uplifting of women social status?



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12. Do you know or have an idea of project?

13. In case, compensation will give to you, where do you want to live

(near village/or another big city)

14. If vocational training institute is opened for women's social uplifting then which of the following setup would you prefer?

a. Fruits or vegetables preserve factory
b. Livestock
c. Fish Packaging Setup

15. Do your children go to school? Yes/No

If No then why? _____

If yes then which level _____ School name_____

16. Does your Daughter go to School? Yes/No

If No then why? _____

If yes then which level _____ School name_____

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**Government of Gilgit-Baltistan**
Gilgit-Baltistan Environmental Protection Agency
Shahrah-e-Quaid-e-Azam, Khomer, Gilgit
Phn 05811-920679, Fax 05811-922016

No. GB-EPA-WQMS-5(6)/2018/604

Gilgit, dated November 19th, 2020

To,

The Additional Chief Engineer (Planning),
WAPDA Lahore.

Addl. C.E. HP
No: 580
Date: 23-11-2020

Subject: **ATTABAD LAKE HYDROPOWER PROJECT- WATER SAMPLES LABORATORY TESTING**

I am directed to refer your office letter No.GM(H)P/D-(I/680/2407dated 9th November, 2020 on the subject and enclose herewith the invoice and results of water samples tested in Gilgit-Baltistan Environmental Protection Agency Laboratory as received.

Enclose: As above

Syed Jarrar Hussain

(SYED JARRAR HUSSAIN)
Assistant Director (Lab/NEQS)

DD(Civil)

Needful done.

www.gbepa.gog.pk

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**Government of Gilgit-Baltistan**
Gilgit-Baltistan Environmental Protection Agency
Shahrah-e-Quaid-e-Azam, Khomer, Gilgit
Ph# 05811-920679, Fax 05811-922016

No. GB-EPA-WQMS-5(6)/2018

Gilgit, dated November 19th, 2020

To,

The Additional Chief Engineer (Planning),
WAPDA Lahore.

**INVOICE OF WATER SAMPLES TESTED**

| Sr# | Test Parameters | Total Samples Tested | Rate per Sample | Total |
|---|---|---|---|---|
| 01 | **Bacteriological Test** | | | |
| | E.coli | 06 | 8000 | 48000 |
| 02 | **Physical Tests** | | | |
| | pH | | | |
| | Temperature | | | |
| | Turbidity | | | |
| | Total Dissolved Solids | | | |
| | Electrical Conductivity | | | |
| | Colour | | | |
| | Odour | | | |
| | Taste | | | |
| 03 | **Heavy Metals Test** | | | |
| | Copper | | | |
| | Aluminum | | | |
| | Iron | | | |
| | Manganese | | | |
| | Chromium(VI) | | | |
| | Nickel | | | |
| | Boron | | | |
| | Nitrate | | | |
| | Nitrite | | | |
| | **Total: Fourty Eight Thousand Only** | | | 48,000 |

**Note:**
Payable at Treasury/Sub Treasury National Bank of Pakistan Gilgit under the head of account CO-3370.

(SYED JARRAR HUSSAIN)
Assistant Director (Lab/NEQS)

SYED JARRAR HUSSAIN
Assistant Director (Admin/L...
Gilgit-Baltistan Environmental...
Protection Agency (GB-EPA

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Gilgit-Baltistan Environmental Protection Agency

# Drinking Water Quality Test Report

## Chemical Parameters

Doc No: LAB/WQM/001-F
Effective Date: 01/04/2010
Version No: 02
page 1 of 1

| Sampling Date: 5/11/2020 | Location: Hunza | District: Hunza | Union council: |
|---|---|---|---|
| Methodology / Technique: Voltammetry and Photometry ( Metalyser HM 3000 and Metalmeter HM 2000) | | | |

Test Criteria: The water samples are tested against National Standards for Drinking Water Quality of Pakistan

National Standards for Drinking Water Quality of Pakistan ( mg/l)

| Nitrate | Nitrite | Cu | Al | Fe | Mn | Cr6 | Zn | Ni | B | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| <50 | <3 | 2 | ≤0.2 | ---- | ≤0.5 | ≤0.05 | 5.0 | ≤0.02 | 0.3 | | |

| Sr # | Sampling point | Test Results (mg/l) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Nitrate | Nitrite | Cu | Al | Fe | Mn | Cr6 | Zn | Ni | B |
| 1 | Hunza River side before confluence of Ghamubar Nullah | ND | ND | 0.1 | ND | ND | ND | 0.03 | ND | 0.01 | ND |
| 2 | Ghamubar Nullah by entering Hunza | ND | ND | 0.07 | ND | 0.04 | ND | 0.02 | ND | 0.02 | ND |
| 3 | Hunza River side near power house | ND | ND | 0.2 | ND | 0.3 | ND | ND | ND | 0.01 | ND |
| 4 | Attabad lake boating area | 2.3 | 0.3 | ND | ND | ND | ND | 0.02 | ND | 0.02 | ND |

Conclusion: The concentrations of nitrate, copper, iron, chromium & nickel in above samples are within National Standards for Drinking Water Quality of Pakistan.

| Tested By | Verified By | Approved By |
|---|---|---|
| Name: Syed Kashif Hussain | Name: Nasir Hussain | Name: Syed Jaffar Kazmi |
| Designation: Field Monitoring Assistant | Designation: Scientific Officer (Lab/WQM) | Designation: Assistant Director (Lab/WQM) |
| Signature & Date: | Signature & Date: | Signature & Date: |

Gilgit-Baltistan Environmental Protection Agency

# Drinking Water Quality Test Report

## Chemical Parameters

Doc No: LAB/WQM/001-F
Effective Date: 01/04/2010
Version No: 02
page 1 of 1

| Sampling Date: 5/11/2020 | Location: Hunza | District: Hunza | Union council: |
|---|---|---|---|
| Methodology / Technique: Voltammetry and Photometry ( Metalyser HM 3000 and Metalmeter HM 2000) | | | |

Test Criteria: The water samples are tested against National Standards for Drinking Water Quality of Pakistan

National Standards for Drinking Water Quality of Pakistan ( mg/l)

| Nitrate | Nitrite | Cu | Al | Fe | Mn | Cr6 | Zn | Ni | B | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2 | ≤0.2 | ---- | ≤0.5 | ≤0.05 | 5.0 | ≤0.02 | 0.3 | | |

| Sr # | Sampling point | Test Results (mg/l) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Nitrate | Nitrite | Cu | Al | Fe | Mn | Cr6 | Zn | Ni | B |
| 5 | Gulmit tap water | ND | ND | 0.02 | ND | ND | ND | ND | ND | 0.01 | ND |
| 6 | Gulmit Glacier near Hunza river | ND | ND | ND | ND | ND | ND | 0.14 | ND | 0.2 | ND |

Conclusion: The concentration of Cr6 and Ni exceed National Standards for Drinking Water Quality of Pakistan in Gulmit glacier near Hunza water sample.

| Tested By | Verified By | Approved By |
|---|---|---|
| Name: Syed Kashif Hussain | Name: Nasir Hussain | Name: Syed Jaffar Hussain |
| Designation: Field Monitoring Assistant | Designation: Scientific Officer (Lab/WQM) | Designation: Assistant Director (Lab/WQM) |
| Signature & Date: | Signature & Date: | Signature & Date: |



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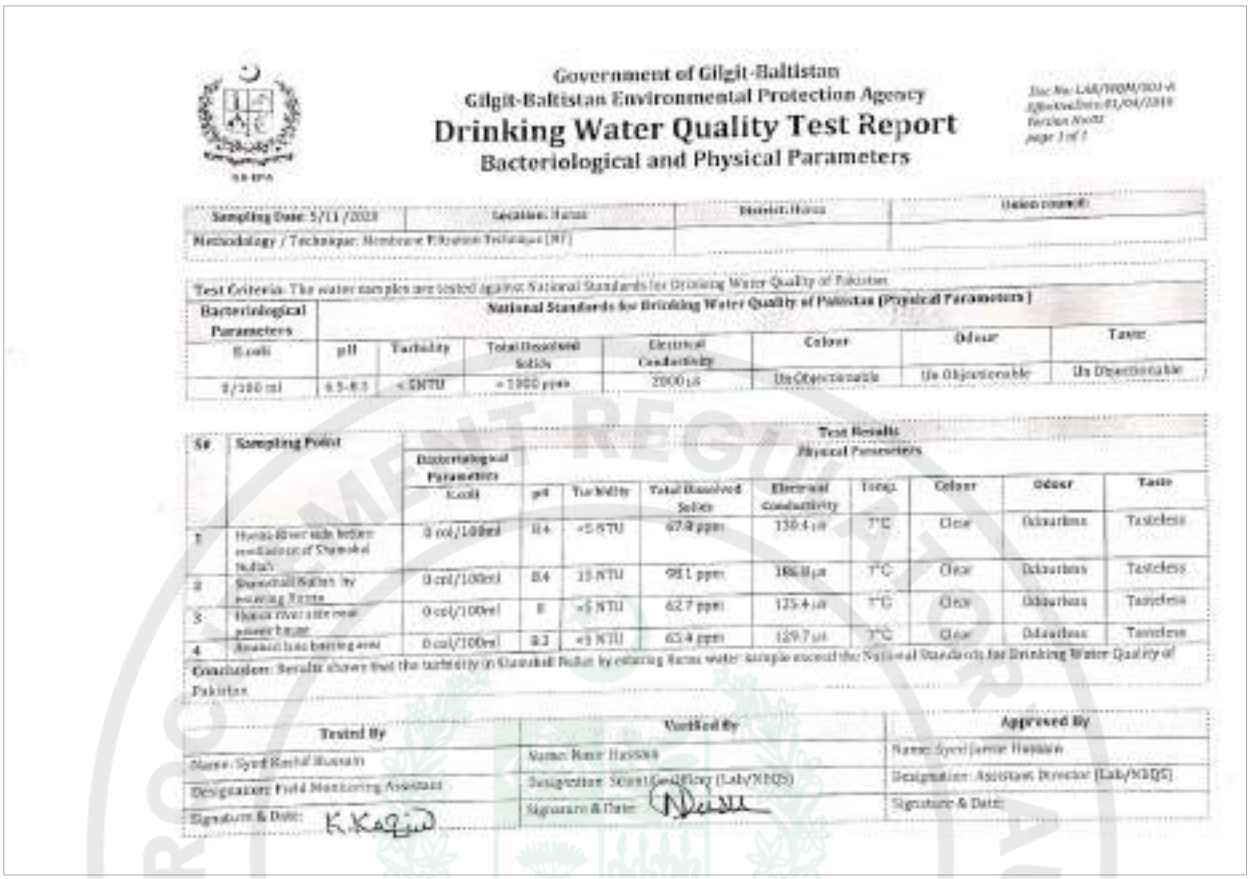

Government of Gilgit-Baltistan
Gilgit-Baltistan Environmental Protection Agency

## Drinking Water Quality Test Report

### Bacteriological and Physical Parameters

Sampling Date: 5/11/2018 | Location: Hunza | District: Hunza | Union council:

Methodology / Technique: Membrane Filtration Technique [MF]

Test Criteria: The water samples are tested against National Standards for Drinking Water Quality of Pakistan

| Bacteriological Parameters | National Standards for Drinking Water Quality of Pakistan (Physical Parameters) | | | | | | |
|---|---|---|---|---|---|---|---|
| E.coli | pH | Turbidity | Total Dissolved Solids | Electrical Conductivity | Colour | Odour | Taste |
| 0/100 ml | 6.5-8.5 | <5NTU | <1000 ppm | 2000 µS | Un Objectionable | Un Objectionable | Un Objectionable |

| Sr# | Sampling Point | Test Results: Bacteriological Parameters | Physical Parameters | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | E.coli | pH | Turbidity | Total Dissolved Solids | Electrical Conductivity | Temp. | Colour | Odour | Taste |
| 1 | Hunza River side before confluence of Shimshal Nullah | 3 col/100ml | 8.4 | <5 NTU | 67.8 ppm | 139.4 µS | 7°C | Clear | Odourless | Tasteless |
| 2 | Shimshal Nullah by entering Hunza | 0 col/100ml | 8.4 | 15 NTU | 98.1 ppm | 186.8 µS | 7°C | Clear | Odourless | Tasteless |
| 3 | Hunza river side near power house | 0 col/100ml | 8 | <5 NTU | 62.7 ppm | 125.4 µS | 7°C | Clear | Odourless | Tasteless |
| 4 | Attabad lake barrier area | 0 col/100ml | 8.3 | <5 NTU | 63.4 ppm | 129.7 µS | 7°C | Clear | Odourless | Tasteless |

Conclusion: Results shows that the turbidity in Shimshal Nullah by entering Hunza water sample exceed the National Standards for Drinking Water Quality of Pakistan

| Tested By | Verified By | Approved By |
|---|---|---|
| Name: Syed Kashif Hussain | Name: Nasir Hussain | Name: Syed Jamat Hussain |
| Designation: Field Monitoring Assistant | Designation: Scientific Officer (Lab/WQS) | Designation: Assistant Director (Lab/WQS) |
| Signature & Date: K.Kashif | Signature & Date: | Signature & Date: |

Government of Gilgit-Baltistan
Gilgit-Baltistan Environmental Protection Agency

## Drinking Water Quality Test Report

### Bacteriological and Physical Parameters

Sampling Date: 5/11/2018 | Location: Hunza | District: Hunza | Union council:

Methodology / Technique: Membrane Filtration Technique [MF]

Test Criteria: The water samples are tested against National Standards for Drinking Water Quality of Pakistan

| Bacteriological Parameters | National Standards for Drinking Water Quality of Pakistan (Physical Parameters) | | | | | | |
|---|---|---|---|---|---|---|---|
| E.coli | pH | Turbidity | Total Dissolved Solids | Electrical Conductivity | Colour | Odour | Taste |
| 0/100 ml | 6.5-8.5 | <5NTU | <1000 ppm | 2000 µS | Un Objectionable | Un Objectionable | Un Objectionable |

| Sr# | Sampling Point | Test Results: Bacteriological Parameters | Physical Parameters | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | E.coli | pH | Turbidity | Total Dissolved Solids | Electrical Conductivity | Temp. | Colour | Odour | Taste |
| 5 | Gulmit tup water from house | 0 col/100ml | 7.4 | <5 NTU | 23.5 ppm | 47.2 µs | 7°C | Clear | Odourless | Tasteless |
| 6 | Gulmit Glacier near Hunza river | 0 col/100ml | 8 | <5 NTU | 29.7 ppm | 59.4 µS | 7°C | Clear | Odourless | Tasteless |

Conclusion: Tested results shows that the samples are within the National Standards for Drinking Water Quality of Pakistan

| Tested By | Verified By | Approved By |
|---|---|---|
| Name: Syed Kashif Hussain | Name: Nasir Hussain | Name: Syed Jamat Hussain |
| Designation: Field Monitoring Assistant | Designation: Scientific Officer (Lab/WQS) | Designation: Assistant Director (Lab/WQS) |
| Signature & Date: K.Kashif | Signature & Date: | Signature & Date: |



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# Drawings

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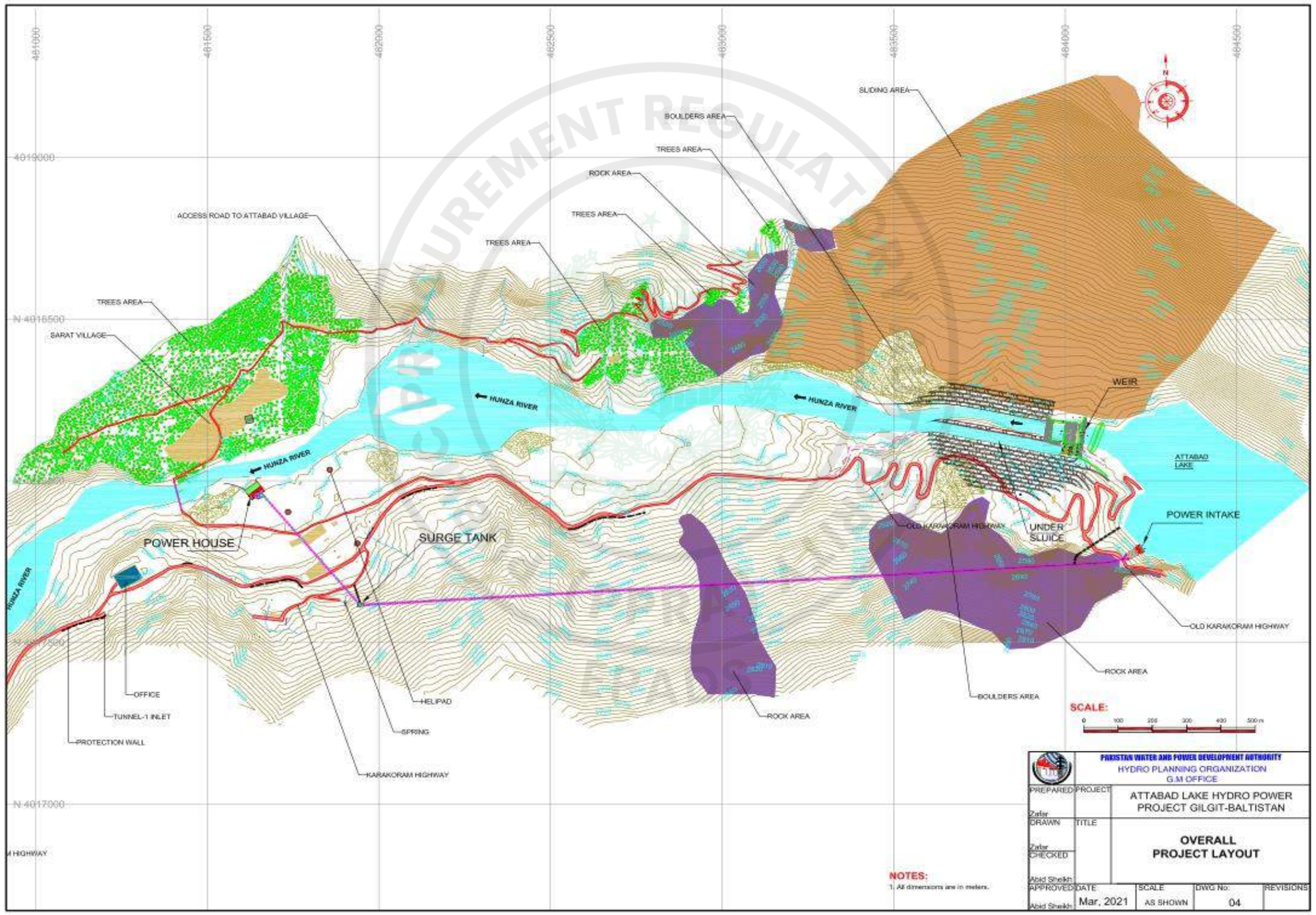
## Drawing I Project Layout

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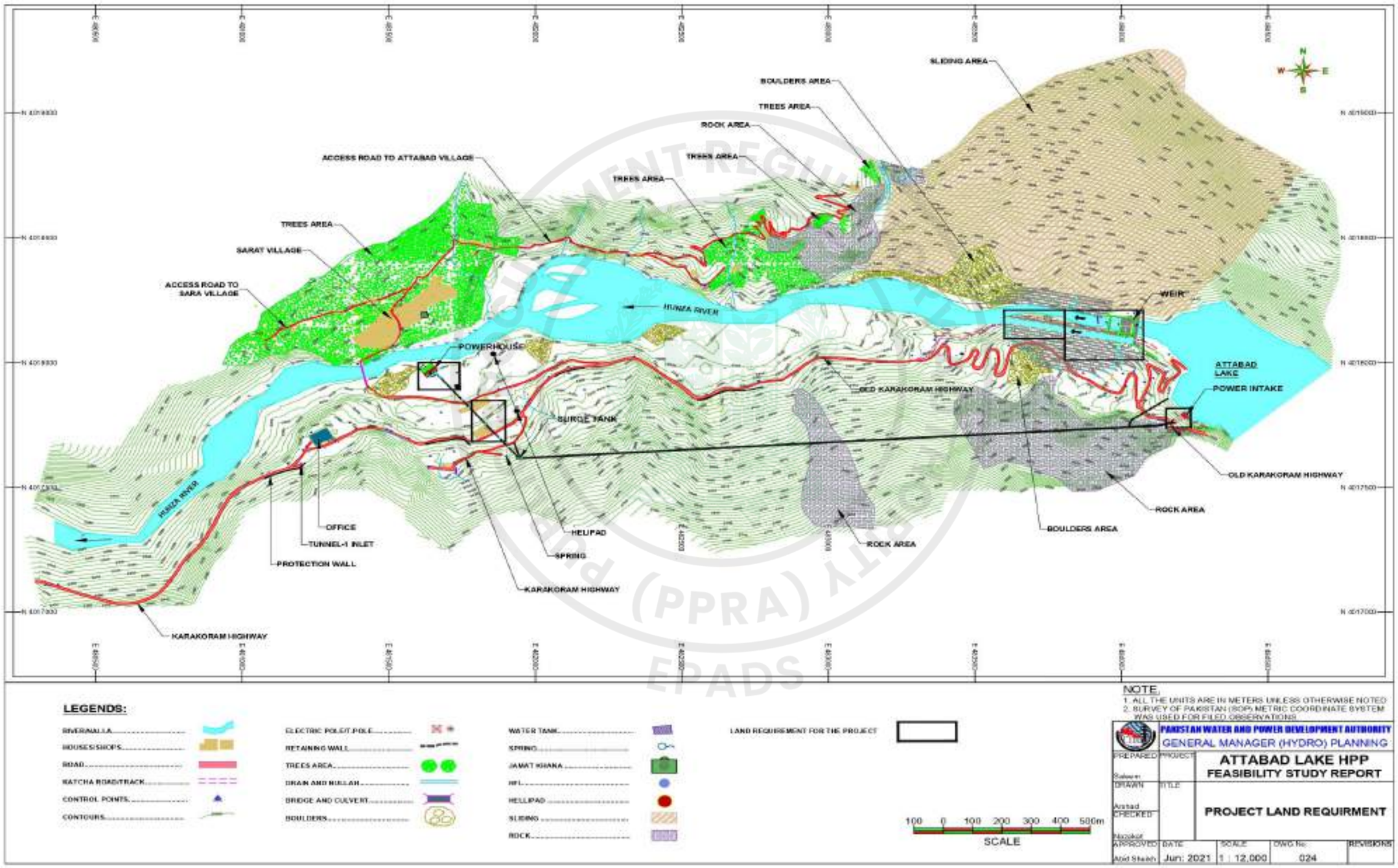
## Drawing II Land Requirement for the Project




**LEGENDS:**

- RIVER/NALLA
- HOUSES/SHOPS
- ROAD
- KATCHA ROAD/TRACK
- CONTROL POINTS
- CONTOURS
- ELECTRIC POLE/T.POLE
- RETAINING WALL
- TREES AREA
- DRAIN AND NULLAH
- BRIDGE AND CULVERT
- BOULDERS
- WATER TANK
- SPRING
- JAMAT KHANA
- RFL
- HELLIPAD
- SLIDING
- ROCK
- LAND REQUIREMENT FOR THE PROJECT

100 0 100 200 300 400 500m
SCALE

NOTE:
1. ALL THE UNITS ARE IN METERS UNLESS OTHERWISE NOTED
2. SURVEY OF PAKISTAN (SOP) METRIC COORDINATE SYSTEM WAS USED FOR FIELD OBSERVATIONS

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
GENERAL MANAGER (HYDRO) PLANNING

| | | |
|---|---|---|
| PREPARED | PROJECT | ATTABAD LAKE HPP FEASIBILITY STUDY REPORT |
| DRAWN Arshad | TITLE | PROJECT LAND REQUIRMENT |
| CHECKED Nazakat | | |
| APPROVED Abid Sheikh | DATE Jun: 2021 | SCALE 1 : 12,000 |
| | DWG No. 024 | REVISIONS |

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

# PAKISTAN

## WATER AND POWER DEVELOPMENT AUTHORITY

# ATTABAD LAKE HYDROPOWER PROJECT

# FEASIBILITY STUDY

# VOLUME 7

# APPENDICES

**June 2021**

## HYDRO PLANNING ORGANIZATION

WAPDA, SUNNY VIEW ESTATE, LAHORE ☎ 99202717 🖷 99202722 ✉ gmhydroplanning@gmail.com

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# ATTABAD LAKE HYDROPOWER PROJECT
# LIST OF VOLUMES

VOLUME – 1 MAIN REPORT

VOLUME – 2 DRAWINGS

VOLUME – 3 GEOLOGICAL AND GEOTECHNICAL STUDIES

VOLUME – 4 NEOTECTONICS STUDIES & SEISMIC HAZARDS ANALYSIS

VOLUME – 5 BOREHOLE LOGS AND LABORATORY TESTING

VOLUME – 6 ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

**VOLUME – 7 APPENDICES**

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

# TABLES OF CONTENTS

**1 HYDROGRAPHIC SURVEY ..... 1-1**

1.1 APPENDIX - I(A): HYDROGRAPHIC SURVEY CROSS SECTIONS OF ATTABAD LAKE.....1-2

1.2 APPENDIX – I(B): AREA AND CAPACITY DATA OF HYDROGRAPHIC SURVEY OF ATTABAD LAKE .....1-54

1.3 APPENDIX – I(C): LONGITUDINAL BED PROFILE OF ATTABAD LAKE.....1-58

1.4 APPENDIX – I(D): THALWEG PROFILE OF ATTABAD LAKE.....1-60

1.5 APPENDIX – I(E): DISCHARGE MEASUREMENT AT GANISH BRIDGE.....1-62

1.6 APPENDIX – I(F): HYDROGRAPHIC SURVEY FIGURES.....1-73

**2 GEOTECHNICAL ANAYLSIS ..... 2-1**

**3 HYDROLOGICAL FLOW DATA..... 3-1**

**4 POWER AND ENERGY POTENTIAL..... 4-1**



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# LIST OF FIGURES

Figure 1-1 The Plan of Contours ..... 1-52
Figure 1-2 Longitudinal Profile Bed ..... 1-58
Figure 1-3 Elevation Band Drawing ..... 1-73
Figure 1-4 Plan of Contours ..... 1-74
Figure 1-5 Plan of X-Section ..... 1-75
Figure 2-1 :Factor of Safety of Critical Slope –Cross Section at Chainage 0+50 ..... 2-2
Figure 2-2 Factor of Safety of Critical Slope–Cross Section at Chainage 0+50 ..... 2-3
Figure 2-3 Factor of Safety of Critical Slope –Cross Section at Chainage 0+50 ..... 2-4
Figure 2-4:Factor of Safety of Critical Slope –Cross Section at Chainage 0+50 ..... 2-5
Figure 2-5 Factor of Safety of Critical Slope –Cross Section at Chainage 0+50 ..... 2-6
Figure 2-6 Factor of Safety of Critical Slope –Cross Section at Chainage 0+50 ..... 2-7
Figure 2-7 Factor of Safety of Critical Slope –Cross Section at Chainage 0+50 ..... 2-8
Figure 2-8 Factor of Safety of Critical Slope –Cross Section at Chainage 0+50 ..... 2-9
Figure 2-9 Factor of Safety of Critical Slope –Cross Section at Chainage 0+50 ..... 2-10
Figure 2-10 Factor of Safety of Critical Slope –Cross Section at Chainage 0+50 ..... 2-11
Figure 2-11 Finalized Weir Cross Section with All Seepage Line of Defenses ..... 2-12
Figure 2-12 Finite Element Model of Weir Cross Section ..... 2-13
Figure 2-13 Pressure Head Profile –Weir Section at Minimum Water El: 2412 m upstream ..... 2-14
Figure 2-14 Critical Hydraulic Gradient Profile –Weir Section at Minimum Water El: 2412 m upstream ..... 2-15
Figure 2-15 Critical Hydraulic Gradient Profile –Weir Section at Minimum Water El: 2424 m upstream ..... 2-16
Figure 2-16 Critical Hydraulic Gradient Profile –Weir Section at Minimum Water El: 2424 m upstream without clay Blanket ..... 2-17
Figure 2-17 Cross section Under sluice/ Sediment Flushing Section ..... 2-18
Figure 2-18 Finite Element Model –Under sluice Section at Maximum Water El: 2424 m upstream ..... 2-19
Figure 2-19 Pressure Head Profile –Under sluice Section at Maximum Water El: 2424 m upstream ..... 2-20
Figure2-20 Critical Hydraulic Gradient Profile –Under sluice Section at Maximum Water El: 2424 m upstream ..... 2-21
Figure 2-21 Critical Hydraulic Gradient Profile –Under sluice Section at Maximum Water El: 2424 m upstream without clay Blanket ..... 2-22



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# LIST OF TABLES

Table 1-1 Cross Sectional Coordinates, Cross Section 1 ..... 1-2
Table 1-2 Cross Sectional Coordinates, Cross Section 2 ..... 1-4
Table 1-3 Cross Sectional Coordinates, Cross Section 3 ..... 1-5
Table 1-4 Cross Sectional Coordinates, Cross Section 4 ..... 1-6
Table 1-5 Cross Sectional Coordinates, Cross Section 5 ..... 1-8
Table 1-6 Cross Sectional Coordinates, Cross Section 6 ..... 1-9
Table 1-7 Cross Sectional Coordinates, Cross Section 6A ..... 1-10
Table 1-8 Cross Sectional Coordinates, Cross Section 6B ..... 1-11
Table 1-9 Cross Sectional Coordinates, Cross Section 7 ..... 1-12
Table 1-10 Cross Sectional Coordinates, Cross Section 8 ..... 1-13
Table 1-11 Cross Sectional Coordinates, Cross Section 9 ..... 1-14
Table 1-12 Cross Sectional Coordinates, Cross Section 9A ..... 1-15
Table 1-13 Cross Sectional Coordinates, Cross Section 9B ..... 1-16
Table 1-14 Cross Sectional Coordinates, Cross Section 10 ..... 1-17
Table 1-15 Cross Sectional Coordinates, Cross Section 11 ..... 1-18
Table 1-16 Cross Sectional Coordinates, Cross Section 12 ..... 1-19
Table 1-17 Cross Sectional Coordinates, Cross Section 13 ..... 1-20
Table 1-18 Cross Sectional Coordinates, Cross Section 14 ..... 1-21
Table 1-19 Cross Sectional Coordinates, Cross Section 15 ..... 1-23
Table 1-20 Cross Sectional Coordinates, Cross Section 16 ..... 1-25
Table 1-21 Cross Sectional Coordinates, Cross Section 17 ..... 1-27
Table 1-22 Cross Sectional Coordinates, Cross Section 18 ..... 1-29
Table 1-23 Cross Sectional Coordinates, Cross Section 18 A ..... 1-30
Table 1-24 Cross Sectional Coordinates, Cross Section 18 B ..... 1-31
Table 1-25 Cross Sectional Coordinates, Cross Section 18 C ..... 1-32
Table 1-26 Cross Sectional Coordinates, Cross Section 19 ..... 1-33
Table 1-27 Cross Sectional Coordinates, Cross Section 19 A ..... 1-34
Table 1-28 Cross Sectional Coordinates, Cross Section 20 ..... 1-35
Table 1-29 Cross Sectional Coordinates, Cross Section 21 ..... 1-37
Table 1-30 Cross Sectional Coordinates, Cross Section 22 ..... 1-39



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Table 1-31 Cross Sectional Coordinates, Cross Section 23 ..... 1-41
Table 1-32 Cross Sectional Coordinates, Cross Section 23 A ..... 1-43
Table 1-33 Cross Sectional Coordinates, Cross Section 24 ..... 1-44
Table 1-34 Cross Sectional Coordinates, Cross Section 25 ..... 1-45
Table 1-35 Cross Sectional Coordinates, Cross Section 26 ..... 1-46
Table 1-36 Cross Sectional Coordinates, Cross Section 27 ..... 1-47
Table 1-37 Cross Sectional Coordinates, Cross Section 28 ..... 1-48
Table 1-38 Cross Sectional Coordinates, Cross Section 29 ..... 1-49
Table 1-39 Cross Sectional Coordinates, Cross Section 30 ..... 1-50
Table 1-40 Cross Sectional Coordinates, Cross Section 31 ..... 1-51
Table 1-41 Area and Capacity Data ..... 1-54
Table 1-42: Thalweg Profile of Attabad Lake ..... 1-60
Table 1-43 Cross Section at Ganish Bridge ..... 1-71
Table 1-44 Discharge Measurements Readings ..... 1-71



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# APPENDIX – I:

# 1 HYDROGRAPHIC SURVEY

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# APPENDIX – I(A):

# HYDROGRAPHIC SURVEY CROSS SECTIONS OF ATTABAD LAKE



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## 1.1 APPENDIX - I(A): HYDROGRAPHIC SURVEY CROSS SECTIONS OF ATTABAD LAKE

### Table 1-1 Cross Sectional Coordinates, Cross Section 1

| Sr. No. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 484167.25 | 4017847.23 | 0.0 | 0.00 | | | 5548.887 | 2433.210 | T,B.M on Left Bank |
| 2 | 484169.06 | 4017850.80 | 13.1 | 4.00 | | | 5533.174 | 2426.320 | Slope |
| 3 | 484170.88 | 4017854.37 | 26.2 | 8.00 | | | 5513.380 | 2417.640 | " |
| 4 | 484171.78 | 4017856.15 | 32.8 | 10.00 | | | 5495.038 | 2409.597 | " |
| 5 | 484172.01 | 4017856.59 | 34.4 | 10.50 | 0.0 | 0.00 | 5493.872 | 2409.086 | Water Edge on Left Bank Creek-I |
| 6 | 484176.54 | 4017865.51 | 67.3 | 20.50 | 27.7 | 8.45 | 5474.602 | 2400.636 | Bed |
| 7 | 484181.07 | 4017874.42 | 100.1 | 30.50 | 27.0 | 8.22 | 5475.127 | 2400.866 | " |
| 8 | 484185.60 | 4017883.34 | 132.9 | 40.50 | 35.5 | 10.83 | 5469.175 | 2398.256 | " |
| 9 | 484190.13 | 4017892.25 | 165.7 | 50.50 | 34.7 | 10.57 | 5469.768 | 2398.516 | " |
| 10 | 484198.29 | 4017908.30 | 224.7 | 68.50 | 32.5 | 9.91 | 5471.273 | 2399.176 | " |
| 11 | 484199.20 | 4017910.08 | 231.3 | 70.50 | 27.3 | 8.32 | 5474.899 | 2400.766 | " |
| 12 | 484203.73 | 4017919.00 | 264.1 | 80.50 | 20.8 | 6.34 | 5479.414 | 2402.746 | " |
| 13 | 484208.26 | 4017927.91 | 296.9 | 90.50 | 16.6 | 5.05 | 5482.356 | 2404.036 | " |
| 14 | 484212.79 | 4017936.82 | 329.7 | 100.50 | 13.3 | 4.06 | 5484.614 | 2405.026 | " |
| 15 | 484217.00 | 4017945.11 | 360.2 | 109.80 | 0.0 | 0.00 | 5493.872 | 2409.086 | Water Edge on Right Bank Creek-I |
| 16 | 484222.54 | 4017956.00 | 400.3 | 122.01 | | | 5497.471 | 2410.664 | Slope |
| 17 | 484228.90 | 4017968.52 | 446.4 | 136.06 | | | 5501.079 | 2412.246 | " |
| 18 | 484231.70 | 4017974.02 | 466.6 | 142.23 | | | 5498.785 | 2411.240 | " |
| 19 | 484233.40 | 4017977.37 | 478.9 | 145.98 | 0.0 | 0.00 | 5493.859 | 2409.080 | Water Edge on Left Bank Creek-II |
| 20 | 484235.66 | 4017981.83 | 495.3 | 150.98 | 10.0 | 3.04 | 5486.926 | 2406.040 | Bed |
| 21 | 484240.19 | 4017990.74 | 528.1 | 160.98 | 28.8 | 8.78 | 5473.836 | 2400.300 | " |
| 22 | 484244.73 | 4017999.65 | 561.0 | 170.98 | 51.7 | 15.75 | 5457.941 | 2393.330 | " |
| 23 | 484249.26 | 4018008.57 | 593.8 | 180.98 | 74.7 | 22.77 | 5441.932 | 2386.310 | " |
| 24 | 484253.79 | 4018017.48 | 626.6 | 190.98 | 94.3 | 28.75 | 5428.295 | 2380.330 | " |
| 25 | 484258.32 | 4018026.40 | 659.4 | 200.98 | 112.5 | 34.28 | 5415.684 | 2374.800 | " |
| 26 | 484262.85 | 4018035.31 | 692.2 | 210.98 | 132.5 | 40.38 | 5401.773 | 2368.700 | " |
| 27 | 484267.38 | 4018044.23 | 725.0 | 220.98 | 134.0 | 40.84 | 5400.724 | 2368.240 | " |
| 28 | 484271.91 | 4018053.14 | 757.8 | 230.98 | 134.0 | 40.83 | 5400.747 | 2368.250 | " |
| 29 | 484276.44 | 4018062.06 | 790.6 | 240.98 | 134.2 | 40.91 | 5400.564 | 2368.170 | " |
| 30 | 484280.97 | 4018070.97 | 823.4 | 250.98 | 134.1 | 40.88 | 5400.633 | 2368.200 | " |
| 31 | 484285.51 | 4018079.88 | 856.2 | 260.98 | 134.2 | 40.89 | 5400.610 | 2368.190 | " |
| 32 | 484290.04 | 4018088.80 | 889.0 | 270.98 | 134.4 | 40.98 | 5400.405 | 2368.100 | " |
| 33 | 484294.57 | 4018097.71 | 921.9 | 280.98 | 134.0 | 40.85 | 5400.701 | 2368.230 | " |
| 34 | 484299.10 | 4018106.63 | 954.7 | 290.98 | 134.0 | 40.84 | 5400.724 | 2368.240 | " |
| 35 | 484303.63 | 4018115.54 | 987.5 | 300.98 | 134.0 | 40.84 | 5400.724 | 2368.240 | " |



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| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 36 | 484308.16 | 4018124.46 | 1020.3 | 310.98 | 134.0 | 40.83 | 5400.747 | 2368.250 | Bed |
| 37 | 484312.69 | 4018133.37 | 1053.1 | 320.98 | 133.9 | 40.81 | 5400.792 | 2368.270 | " |
| 38 | 484317.22 | 4018142.29 | 1085.9 | 330.98 | 133.9 | 40.80 | 5400.815 | 2368.280 | " |
| 39 | 484321.75 | 4018151.20 | 1118.7 | 340.98 | 133.8 | 40.79 | 5400.838 | 2368.290 | " |
| 40 | 484326.29 | 4018160.12 | 1151.5 | 350.98 | 133.9 | 40.82 | 5400.770 | 2368.260 | " |
| 41 | 484330.82 | 4018169.03 | 1184.3 | 360.98 | 133.9 | 40.81 | 5400.792 | 2368.270 | " |
| 42 | 484335.35 | 4018177.94 | 1217.1 | 370.98 | 133.9 | 40.80 | 5400.815 | 2368.280 | " |
| 43 | 484339.88 | 4018186.86 | 1249.9 | 380.98 | 134.0 | 40.84 | 5400.724 | 2368.240 | " |
| 44 | 484344.41 | 4018195.77 | 1282.7 | 390.98 | 134.1 | 40.86 | 5400.678 | 2368.220 | " |
| 45 | 484348.94 | 4018204.69 | 1315.6 | 400.98 | 134.0 | 40.85 | 5400.701 | 2368.230 | " |
| 46 | 484353.47 | 4018213.60 | 1348.4 | 410.98 | 60.6 | 18.48 | 5451.715 | 2390.600 | " |
| 47 | 484358.00 | 4018222.52 | 1381.2 | 420.98 | 44.7 | 13.63 | 5462.776 | 2395.450 | " |
| 48 | 484361.18 | 4018228.76 | 1404.1 | 427.98 | 0.0 | 0.00 | 5493.859 | 2409.080 | Water Edge on Right Bank Creek-II |
| 49 | 484362.06 | 4018230.50 | 1410.5 | 429.93 | | | 5495.131 | 2409.638 | Slope |
| 50 | 484363.10 | 4018232.54 | 1418.0 | 432.22 | | | 5504.281 | 2413.650 | " |
| 51 | 484365.52 | 4018237.30 | 1435.6 | 437.56 | | | 5514.702 | 2418.220 | " |
| 52 | 484366.78 | 4018239.79 | 1444.8 | 440.36 | | | 5533.744 | 2426.570 | " |
| 53 | 484367.62 | 4018241.44 | 1450.8 | 442.21 | | | 5546.355 | 2432.100 | T.B.M on Right Bank Vertical Cut |



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## Table 1-2 Cross Sectional Coordinates, Cross Section 2

| Sr. No. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 484363.74 | 4017689.24 | 0.0 | 0.00 | | | 7987.271 | 2434.520 | T,B.M on Left Bank |
| 2 | 484366.04 | 4017693.68 | 16.4 | 5.00 | | | 7972.835 | 2430.120 | Slope |
| 3 | 484368.33 | 4017698.12 | 32.8 | 10.00 | | | 7952.625 | 2423.960 | " |
| 4 | 484370.63 | 4017702.56 | 49.2 | 15.00 | | | 7921.785 | 2414.560 | " |
| 5 | 484370.84 | 4017702.97 | 50.7 | 15.46 | 0.0 | 0.00 | 7903.783 | 2409.073 | Water Edge on Left Bank |
| 6 | 484375.43 | 4017711.85 | 83.5 | 25.46 | 36.2 | 11.03 | 7867.595 | 2398.043 | Bed |
| 7 | 484380.03 | 4017720.73 | 116.3 | 35.46 | 48.5 | 14.78 | 7855.292 | 2394.293 | " |
| 8 | 484384.62 | 4017729.62 | 149.1 | 45.46 | 72.6 | 22.12 | 7831.211 | 2386.953 | " |
| 9 | 484389.22 | 4017738.50 | 182.0 | 55.46 | 98.5 | 30.02 | 7805.292 | 2379.053 | " |
| 10 | 484393.81 | 4017747.38 | 214.8 | 65.46 | 129.1 | 39.36 | 7774.649 | 2369.713 | " |
| 11 | 484398.40 | 4017756.26 | 247.6 | 75.46 | 134.9 | 41.11 | 7768.908 | 2367.963 | " |
| 12 | 484407.59 | 4017774.03 | 313.2 | 95.46 | 134.7 | 41.06 | 7769.072 | 2368.013 | " |
| 13 | 484416.78 | 4017791.79 | 378.8 | 115.46 | 134.8 | 41.10 | 7768.941 | 2367.973 | " |
| 14 | 484425.97 | 4017809.56 | 444.4 | 135.46 | 135.9 | 41.41 | 7767.923 | 2367.663 | " |
| 15 | 484435.15 | 4017827.32 | 510.0 | 155.46 | 135.0 | 41.15 | 7768.776 | 2367.923 | " |
| 16 | 484444.34 | 4017845.09 | 575.7 | 175.46 | 135.0 | 41.14 | 7768.809 | 2367.933 | " |
| 17 | 484453.53 | 4017862.85 | 641.3 | 195.46 | 135.2 | 41.22 | 7768.547 | 2367.853 | " |
| 18 | 484462.72 | 4017880.62 | 706.9 | 215.46 | 135.4 | 41.26 | 7768.416 | 2367.813 | " |
| 19 | 484471.90 | 4017898.38 | 772.5 | 235.46 | 135.3 | 41.25 | 7768.448 | 2367.823 | " |
| 20 | 484481.09 | 4017916.15 | 838.1 | 255.46 | 135.4 | 41.26 | 7768.416 | 2367.813 | " |
| 21 | 484490.28 | 4017933.91 | 903.7 | 275.46 | 135.5 | 41.29 | 7768.317 | 2367.783 | " |
| 22 | 484499.46 | 4017951.68 | 969.4 | 295.46 | 135.6 | 41.32 | 7768.219 | 2367.753 | " |
| 23 | 484508.65 | 4017969.44 | 1035.0 | 315.46 | 135.4 | 41.28 | 7768.350 | 2367.793 | " |
| 24 | 484517.84 | 4017987.21 | 1100.6 | 335.46 | 135.2 | 41.21 | 7768.580 | 2367.863 | " |
| 25 | 484527.03 | 4018004.97 | 1166.2 | 355.46 | 135.3 | 41.24 | 7768.481 | 2367.833 | " |
| 26 | 484536.21 | 4018022.74 | 1231.8 | 375.46 | 135.3 | 41.24 | 7768.481 | 2367.833 | " |
| 27 | 484545.40 | 4018040.50 | 1297.4 | 395.46 | 135.1 | 41.17 | 7768.711 | 2367.903 | " |
| 28 | 484554.59 | 4018058.27 | 1363.1 | 415.46 | 134.7 | 41.06 | 7769.072 | 2368.013 | " |
| 29 | 484559.18 | 4018067.15 | 1395.9 | 425.46 | 86.9 | 26.50 | 7816.841 | 2382.573 | " |
| 30 | 484562.40 | 4018073.37 | 1418.8 | 432.46 | 50.0 | 15.24 | 7853.783 | 2393.833 | " |
| 31 | 484565.36 | 4018079.10 | 1440.0 | 438.91 | 0.0 | 0.00 | 7903.783 | 2409.073 | Water Edge on Right bank |
| 32 | 484565.36 | 4018079.10 | 1440.0 | 438.91 | | | 7907.448 | 2410.190 | Slope |
| 33 | 484568.09 | 4018084.37 | 1459.5 | 444.85 | | | 7918.373 | 2413.520 | " |
| 34 | 484569.24 | 4018086.60 | 1467.7 | 447.36 | | | 7939.141 | 2419.850 | " |
| 35 | 484570.39 | 4018088.81 | 1475.9 | 449.85 | | | 7961.155 | 2426.560 | " |
| 36 | 484571.02 | 4018090.04 | 1480.4 | 451.23 | | | 7977.986 | 2431.690 | T.B.M on Right Bank (Vertical Cut) |



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## Table 1-3 Cross Sectional Coordinates, Cross Section 3

| Sr. No. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 484558.94 | 4017504.41 | 0.0 | 0.00 | | | 7978.675 | 2431.900 | T,B.M on Left Bank |
| 2 | 484561.20 | 4017508.88 | 16.4 | 5.00 | | | 7951.608 | 2423.650 | |
| 3 | 484563.46 | 4017513.34 | 32.8 | 10.00 | | | 7923.950 | 2415.220 | |
| 4 | 484564.36 | 4017515.12 | 39.4 | 12.00 | | | 7913.747 | 2412.110 | |
| 5 | 484564.99 | 4017516.37 | 44.0 | 13.40 | 0.0 | 0.00 | 7903.826 | 2409.086 | Water Edge on Left Bank |
| 6 | 484569.51 | 4017525.29 | 76.8 | 23.40 | 39.5 | 12.04 | 7864.324 | 2397.046 | Bed |
| 7 | 484574.03 | 4017534.21 | 109.6 | 33.40 | 81.6 | 24.88 | 7822.198 | 2384.206 | " |
| 8 | 484578.55 | 4017543.13 | 142.4 | 43.40 | 121.0 | 36.88 | 7782.828 | 2372.206 | " |
| 9 | 484583.07 | 4017552.05 | 175.2 | 53.40 | 135.3 | 41.23 | 7768.557 | 2367.856 | " |
| 10 | 484587.59 | 4017560.97 | 208.0 | 63.40 | 135.5 | 41.31 | 7768.294 | 2367.776 | " |
| 11 | 484592.10 | 4017569.89 | 240.8 | 73.40 | 135.6 | 41.34 | 7768.196 | 2367.746 | " |
| 12 | 484601.14 | 4017587.74 | 306.4 | 93.40 | 135.8 | 41.38 | 7768.065 | 2367.706 | " |
| 13 | 484610.18 | 4017605.58 | 372.0 | 113.40 | 135.8 | 41.38 | 7768.065 | 2367.706 | " |
| 14 | 484619.22 | 4017623.42 | 437.7 | 133.40 | 135.9 | 41.43 | 7767.901 | 2367.656 | " |
| 15 | 484628.25 | 4017641.26 | 503.3 | 153.40 | 136.0 | 41.46 | 7767.802 | 2367.626 | " |
| 16 | 484637.29 | 4017659.10 | 568.9 | 173.40 | 136.0 | 41.46 | 7767.802 | 2367.626 | " |
| 17 | 484646.33 | 4017676.94 | 634.5 | 193.40 | 136.1 | 41.48 | 7767.736 | 2367.606 | " |
| 18 | 484655.36 | 4017694.79 | 700.1 | 213.40 | 136.2 | 41.50 | 7767.671 | 2367.586 | " |
| 19 | 484664.40 | 4017712.63 | 765.7 | 233.40 | 136.1 | 41.49 | 7767.704 | 2367.596 | " |
| 20 | 484673.44 | 4017730.47 | 831.4 | 253.40 | 136.2 | 41.52 | 7767.605 | 2367.566 | " |
| 21 | 484682.48 | 4017748.31 | 897.0 | 273.40 | 137.7 | 41.98 | 7766.096 | 2367.106 | " |
| 22 | 484691.51 | 4017766.15 | 962.6 | 293.40 | 136.3 | 41.55 | 7767.507 | 2367.536 | " |
| 23 | 484700.55 | 4017784.00 | 1028.2 | 313.40 | 136.2 | 41.51 | 7767.638 | 2367.576 | " |
| 24 | 484709.59 | 4017801.84 | 1093.8 | 333.40 | 136.1 | 41.47 | 7767.769 | 2367.616 | " |
| 25 | 484718.62 | 4017819.68 | 1159.4 | 353.40 | 136.3 | 41.54 | 7767.540 | 2367.546 | " |
| 26 | 484727.66 | 4017837.52 | 1225.1 | 373.40 | 136.2 | 41.50 | 7767.671 | 2367.586 | " |
| 27 | 484736.70 | 4017855.36 | 1290.7 | 393.40 | 136.0 | 41.45 | 7767.835 | 2367.636 | " |
| 28 | 484745.74 | 4017873.20 | 1356.3 | 413.40 | 136.0 | 41.45 | 7767.835 | 2367.636 | " |
| 29 | 484750.26 | 4017882.13 | 1389.1 | 423.40 | 136.0 | 41.44 | 7767.868 | 2367.646 | " |
| 30 | 484754.77 | 4017891.05 | 1421.9 | 433.40 | 36.7 | 11.20 | 7867.080 | 2397.886 | " |
| 31 | 484759.29 | 4017899.97 | 1454.7 | 443.40 | 14.5 | 4.43 | 7889.292 | 2404.656 | " |
| 32 | 484763.81 | 4017908.89 | 1487.5 | 453.40 | 45.5 | 13.86 | 7858.353 | 2395.226 | " |
| 33 | 484767.15 | 4017915.49 | 1511.8 | 460.80 | 0.0 | 0.00 | 7903.826 | 2409.086 | Water Edge on Right bank |
| 34 | 484768.56 | 4017918.26 | 1522.0 | 463.90 | | | 7910.378 | 2411.083 | Slope |
| 35 | 484769.75 | 4017920.62 | 1530.7 | 466.55 | | | 7924.278 | 2415.320 | " |
| 36 | 484770.70 | 4017922.49 | 1537.6 | 468.65 | | | 7934.449 | 2418.420 | Slope |
| 37 | 484772.36 | 4017925.78 | 1549.6 | 472.33 | | | 7961.089 | 2426.540 | " |
| 38 | 484774.68 | 4017930.34 | 1566.4 | 477.45 | | | 7980.807 | 2432.550 | T.B.M on Right Bank |



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## Table 1-4 Cross Sectional Coordinates, Cross Section 4

| Sr. No. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 484814.82 | 4017421.67 | 0.0 | 0.00 | | | 7978.019 | 2431.700 | T,B.M on Left Bank |
| 2 | 484816.16 | 4017424.36 | 9.8 | 3.00 | | | 7958.170 | 2425.650 | Slope |
| 3 | 484818.39 | 4017428.83 | 26.2 | 8.00 | | | 7927.592 | 2416.330 | " |
| 4 | 484819.29 | 4017430.62 | 32.8 | 10.00 | 0.0 | 0.00 | 7903.708 | 2409.050 | Water Edge on Left Bank |
| 5 | 484823.76 | 4017439.57 | 65.6 | 20.00 | 25.3 | 7.70 | 7878.445 | 2401.350 | Bed |
| 6 | 484828.22 | 4017448.51 | 98.4 | 30.00 | 48.5 | 14.77 | 7855.250 | 2394.280 | " |
| 7 | 484832.69 | 4017457.46 | 131.2 | 40.00 | 67.0 | 20.42 | 7836.713 | 2388.630 | " |
| 8 | 484837.16 | 4017466.41 | 164.0 | 50.00 | 136.8 | 41.70 | 7766.897 | 2367.350 | " |
| 9 | 484841.63 | 4017475.35 | 196.9 | 60.00 | 136.7 | 41.68 | 7766.962 | 2367.370 | " |
| 10 | 484846.10 | 4017484.30 | 229.7 | 70.00 | 136.8 | 41.69 | 7766.929 | 2367.360 | " |
| 11 | 484855.03 | 4017502.19 | 295.3 | 90.00 | 137.4 | 41.87 | 7766.339 | 2367.180 | " |
| 12 | 484863.97 | 4017520.08 | 360.9 | 110.00 | 137.0 | 41.77 | 7766.667 | 2367.280 | " |
| 13 | 484872.90 | 4017537.98 | 426.5 | 130.00 | 137.3 | 41.86 | 7766.372 | 2367.190 | " |
| 14 | 484881.84 | 4017555.87 | 492.1 | 150.00 | 137.9 | 42.02 | 7765.847 | 2367.030 | " |
| 15 | 484890.78 | 4017573.76 | 557.7 | 170.00 | 137.0 | 41.76 | 7766.700 | 2367.290 | " |
| 16 | 484899.71 | 4017591.65 | 623.4 | 190.00 | 137.1 | 41.79 | 7766.601 | 2367.260 | " |
| 17 | 484908.65 | 4017609.55 | 689.0 | 210.00 | 136.9 | 41.72 | 7766.831 | 2367.330 | " |
| 18 | 484917.59 | 4017627.44 | 754.6 | 230.00 | 136.8 | 41.71 | 7766.864 | 2367.340 | " |
| 19 | 484926.52 | 4017645.33 | 820.2 | 250.00 | 137.3 | 41.84 | 7766.437 | 2367.210 | " |
| 20 | 484935.46 | 4017663.22 | 885.8 | 270.00 | 137.7 | 41.98 | 7765.978 | 2367.070 | " |
| 21 | 484944.39 | 4017681.12 | 951.4 | 290.00 | 136.4 | 41.57 | 7767.323 | 2367.480 | " |
| 22 | 484953.33 | 4017699.01 | 1017.1 | 310.00 | 122.4 | 37.31 | 7781.299 | 2371.740 | " |
| 23 | 484957.80 | 4017707.95 | 1049.9 | 320.00 | 96.7 | 29.47 | 7807.021 | 2379.580 | " |
| 24 | 484962.27 | 4017716.90 | 1082.7 | 330.00 | 80.7 | 24.59 | 7823.032 | 2384.460 | " |
| 25 | 484966.74 | 4017725.85 | 1115.5 | 340.00 | 64.7 | 19.73 | 7838.977 | 2389.320 | " |
| 26 | 484971.20 | 4017734.79 | 1148.3 | 350.00 | 42.7 | 13.02 | 7860.991 | 2396.030 | " |
| 27 | 484975.67 | 4017743.74 | 1181.1 | 360.00 | 28.2 | 8.59 | 7875.525 | 2400.460 | " |
| 28 | 484980.14 | 4017752.69 | 1213.9 | 370.00 | 21.5 | 6.54 | 7882.251 | 2402.510 | " |



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| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 29 | 484984.61 | 4017761.63 | 1246.7 | 380.00 | 30.5 | 9.29 | 7873.229 | 2399.760 | " |
| 30 | 484989.08 | 4017770.58 | 1279.5 | 390.00 | 10.1 | 3.07 | 7893.635 | 2405.980 | " |
| 31 | 484991.92 | 4017776.28 | 1300.4 | 396.37 | 0.0 | 0.00 | 7903.708 | 2409.050 | Water Edge on Right bank |
| 32 | 484992.86 | 4017778.16 | 1307.3 | 398.47 | | | 7908.294 | 2410.448 | Slope |
| 33 | 484993.99 | 4017780.42 | 1315.6 | 401.00 | | | 7926.149 | 2415.890 | " |
| 34 | 484996.32 | 4017785.08 | 1332.7 | 406.21 | | | 7958.596 | 2425.780 | " |
| 35 | 484998.62 | 4017789.68 | 1349.6 | 411.35 | | | 7974.705 | 2430.690 | " |
| 36 | 485001.40 | 4017795.25 | 1370.0 | 417.58 | | | 7987.402 | 2434.560 | T.B.M on Right Bank |



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## Table 1-5 Cross Sectional Coordinates, Cross Section 5

| Sr. No. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 485160.40 | 4017206.51 | 0.0 | 0.00 | | | 7986.385 | 2434.250 | T,B.M on Left Bank |
| 2 | 485161.90 | 4017228.22 | 71.4 | 21.76 | | | 7914.233 | 2412.258 | Slope |
| 3 | 485162.21 | 4017232.65 | 86.0 | 26.20 | 0.0 | 0.0 | 7903.708 | 2409.050 | Water Edge on Left Bank |
| 4 | 485162.90 | 4017242.63 | 118.8 | 36.20 | 31.4 | 9.6 | 7872.343 | 2399.490 | Bed |
| 5 | 485163.59 | 4017252.60 | 151.6 | 46.20 | 57.3 | 17.5 | 7846.424 | 2391.590 | " |
| 6 | 485164.28 | 4017262.58 | 184.4 | 56.20 | 75.6 | 23.1 | 7828.084 | 2386.000 | " |
| 7 | 485164.97 | 4017272.56 | 217.2 | 66.20 | 89.1 | 27.2 | 7814.633 | 2381.900 | " |
| 8 | 485165.66 | 4017282.53 | 250.0 | 76.20 | 111.0 | 33.8 | 7792.750 | 2375.230 | " |
| 9 | 485166.35 | 4017292.51 | 282.8 | 86.20 | 125.3 | 38.2 | 7778.380 | 2370.850 | " |
| 10 | 485167.72 | 4017312.46 | 348.4 | 106.20 | 137.5 | 41.9 | 7766.240 | 2367.150 | " |
| 11 | 485169.10 | 4017332.41 | 414.0 | 126.20 | 137.7 | 42.0 | 7766.044 | 2367.090 | " |
| 12 | 485170.48 | 4017352.36 | 479.7 | 146.20 | 137.7 | 42.0 | 7765.978 | 2367.070 | " |
| 13 | 485171.86 | 4017372.32 | 545.3 | 166.20 | 137.8 | 42.0 | 7765.945 | 2367.060 | " |
| 14 | 485173.24 | 4017392.27 | 610.9 | 186.20 | 137.9 | 42.0 | 7765.781 | 2367.010 | " |
| 15 | 485174.62 | 4017412.22 | 676.5 | 206.20 | 138.1 | 42.1 | 7765.650 | 2366.970 | " |
| 16 | 485176.00 | 4017432.17 | 742.1 | 226.20 | 138.0 | 42.1 | 7765.715 | 2366.990 | " |
| 17 | 485177.38 | 4017452.13 | 807.7 | 246.20 | 138.1 | 42.1 | 7765.584 | 2366.950 | " |
| 18 | 485178.76 | 4017472.08 | 873.4 | 266.20 | 138.0 | 42.1 | 7765.683 | 2366.980 | " |
| 19 | 485180.14 | 4017492.03 | 939.0 | 286.20 | 137.9 | 42.0 | 7765.847 | 2367.030 | " |
| 20 | 485181.52 | 4017511.98 | 1004.6 | 306.20 | 138.0 | 42.1 | 7765.748 | 2367.000 | " |
| 21 | 485182.90 | 4017531.94 | 1070.2 | 326.20 | 137.8 | 42.0 | 7765.945 | 2367.060 | " |
| 22 | 485184.28 | 4017551.89 | 1135.8 | 346.20 | 137.4 | 41.9 | 7766.306 | 2367.170 | " |
| 23 | 485185.66 | 4017571.84 | 1201.4 | 366.20 | 137.4 | 41.9 | 7766.306 | 2367.170 | " |
| 24 | 485187.04 | 4017591.79 | 1267.1 | 386.20 | 137.3 | 41.8 | 7766.437 | 2367.210 | " |
| 25 | 485188.41 | 4017611.75 | 1332.7 | 406.20 | 137.3 | 41.8 | 7766.437 | 2367.210 | " |
| 26 | 485189.79 | 4017631.70 | 1398.3 | 426.20 | 137.3 | 41.9 | 7766.404 | 2367.200 | " |
| 27 | 485190.48 | 4017641.67 | 1431.1 | 436.20 | 137.5 | 41.9 | 7766.240 | 2367.150 | " |
| 28 | 485191.17 | 4017651.65 | 1463.9 | 446.20 | 137.3 | 41.8 | 7766.437 | 2367.210 | " |
| 29 | 485191.86 | 4017661.63 | 1496.7 | 456.20 | 133.3 | 40.6 | 7770.440 | 2368.430 | " |
| 30 | 485192.55 | 4017671.60 | 1529.5 | 466.20 | 114.1 | 34.8 | 7789.567 | 2374.260 | " |
| 31 | 485193.24 | 4017681.58 | 1562.3 | 476.20 | 90.2 | 27.5 | 7813.517 | 2381.560 | " |
| 32 | 485193.93 | 4017691.56 | 1595.1 | 486.20 | 13.3 | 4.0 | 7890.453 | 2405.010 | " |
| 33 | 485194.26 | 4017696.34 | 1610.9 | 491.00 | 0.0 | 0.0 | 7903.708 | 2409.050 | Water Edge on Right bank |
| 34 | 485194.55 | 4017700.53 | 1624.7 | 495.20 | | | 7912.609 | 2411.763 | Slope |
| 35 | 485194.88 | 4017705.32 | 1640.4 | 500.00 | | | 7920.604 | 2414.200 | " |
| 36 | 485195.30 | 4017711.31 | 1660.1 | 506.00 | | | 7937.992 | 2419.500 | Slope |
| 37 | 485195.71 | 4017717.29 | 1679.8 | 512.00 | | | 7963.911 | 2427.400 | " |
| 38 | 485196.06 | 4017722.28 | 1696.2 | 517.00 | | | 7991.470 | 2435.800 | T.B.M on Right Bank |



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## Table 1-6 Cross Sectional Coordinates, Cross Section 6

| Sr. No. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 485442.73 | 4017203.81 | 0.0 | 0.00 | | | 7977.966 | 2431.684 | T,B.M on Left Bank |
| 2 | 485441.13 | 4017226.76 | 75.5 | 23.00 | | | 7912.280 | 2411.663 | Slope |
| 3 | 485440.90 | 4017230.15 | 86.6 | 26.40 | 0.0 | 0.00 | 7903.744 | 2409.061 | Water Edge on Left Bank |
| 4 | 485440.20 | 4017240.12 | 119.4 | 36.40 | 15.2 | 4.63 | 7888.553 | 2404.431 | Bed |
| 5 | 485439.51 | 4017250.10 | 152.2 | 46.40 | 37.2 | 11.33 | 7866.572 | 2397.731 | " |
| 6 | 485438.81 | 4017260.07 | 185.0 | 56.40 | 55.0 | 16.76 | 7848.757 | 2392.301 | " |
| 7 | 485438.12 | 4017270.05 | 217.8 | 66.40 | 75.7 | 23.07 | 7828.055 | 2385.991 | " |
| 8 | 485437.42 | 4017280.03 | 250.7 | 76.40 | 96.1 | 29.29 | 7807.648 | 2379.771 | " |
| 9 | 485436.73 | 4017290.00 | 283.5 | 86.40 | 114.8 | 34.98 | 7788.980 | 2374.081 | " |
| 10 | 485435.34 | 4017309.95 | 349.1 | 106.40 | 137.1 | 41.79 | 7766.637 | 2367.271 | " |
| 11 | 485433.95 | 4017329.91 | 414.7 | 126.40 | 137.2 | 41.82 | 7766.539 | 2367.241 | " |
| 12 | 485432.56 | 4017349.86 | 480.3 | 146.40 | 137.3 | 41.86 | 7766.408 | 2367.201 | " |
| 13 | 485431.17 | 4017369.81 | 545.9 | 166.40 | 137.4 | 41.87 | 7766.375 | 2367.191 | " |
| 14 | 485429.78 | 4017389.76 | 611.5 | 186.40 | 137.5 | 41.92 | 7766.211 | 2367.141 | " |
| 15 | 485428.39 | 4017409.71 | 677.2 | 206.40 | 137.7 | 41.96 | 7766.080 | 2367.101 | " |
| 16 | 485427.00 | 4017429.66 | 742.8 | 226.40 | 137.8 | 41.99 | 7765.981 | 2367.071 | " |
| 17 | 485425.61 | 4017449.62 | 808.4 | 246.40 | 137.7 | 41.96 | 7766.080 | 2367.101 | " |
| 18 | 485424.22 | 4017469.57 | 874.0 | 266.40 | 137.6 | 41.95 | 7766.112 | 2367.111 | " |
| 19 | 485422.83 | 4017489.52 | 939.6 | 286.40 | 137.6 | 41.95 | 7766.112 | 2367.111 | " |
| 20 | 485421.45 | 4017509.47 | 1005.2 | 306.40 | 137.7 | 41.97 | 7766.047 | 2367.091 | " |
| 21 | 485420.06 | 4017529.42 | 1070.9 | 326.40 | 137.8 | 42.01 | 7765.916 | 2367.051 | " |
| 22 | 485418.67 | 4017549.37 | 1136.5 | 346.40 | 137.6 | 41.94 | 7766.145 | 2367.121 | " |
| 23 | 485417.28 | 4017569.33 | 1202.1 | 366.40 | 137.5 | 41.92 | 7766.211 | 2367.141 | " |
| 24 | 485415.89 | 4017589.28 | 1267.7 | 386.40 | 137.4 | 41.89 | 7766.309 | 2367.171 | " |
| 25 | 485414.50 | 4017609.23 | 1333.3 | 406.40 | 137.5 | 41.90 | 7766.276 | 2367.161 | " |
| 26 | 485413.11 | 4017629.18 | 1399.0 | 426.40 | 137.5 | 41.90 | 7766.276 | 2367.161 | " |
| 27 | 485412.41 | 4017639.16 | 1431.8 | 436.40 | 137.6 | 41.94 | 7766.145 | 2367.121 | " |
| 28 | 485411.72 | 4017649.13 | 1464.6 | 446.40 | 137.3 | 41.85 | 7766.441 | 2367.211 | " |
| 29 | 485411.02 | 4017659.11 | 1497.4 | 456.40 | 137.2 | 41.82 | 7766.539 | 2367.241 | " |
| 30 | 485410.33 | 4017669.08 | 1530.2 | 466.40 | 137.1 | 41.80 | 7766.605 | 2367.261 | " |
| 31 | 485409.63 | 4017679.06 | 1563.0 | 476.40 | 137.0 | 41.75 | 7766.769 | 2367.311 | " |
| 32 | 485408.94 | 4017689.04 | 1595.8 | 486.40 | 137.1 | 41.79 | 7766.637 | 2367.271 | " |
| 33 | 485408.25 | 4017699.01 | 1628.6 | 496.40 | 137.1 | 41.79 | 7766.637 | 2367.271 | " |
| 34 | 485407.55 | 4017708.99 | 1661.4 | 506.40 | 28.2 | 8.60 | 7875.528 | 2400.461 | " |
| 35 | 485407.16 | 4017714.61 | 1679.9 | 512.04 | 0.0 | 0.00 | 7903.744 | 2409.061 | Water Edge on Right bank |
| 36 | 485406.92 | 4017718.00 | 1691.1 | 515.44 | | | 7912.845 | 2411.835 | T.B.M on Right Bank |



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## Table 1-7 Cross Sectional Coordinates, Cross Section 6A

| Sr. No. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 485600.17 | 4017332.55 | 0.0 | 0.00 | | | 7983.078 | 2433.242 | T,B.M on Left Bank |
| 2 | 485590.81 | 4017351.07 | 68.1 | 20.75 | | | 7909.997 | 2410.967 | Slope |
| 3 | 485589.69 | 4017353.30 | 76.3 | 23.25 | 0.0 | 0.00 | 7903.740 | 2409.060 | Water Edge on Left Bank |
| 4 | 485585.18 | 4017362.22 | 109.1 | 33.25 | 24.0 | 7.33 | 7879.692 | 2401.730 | Bed |
| 5 | 485580.67 | 4017371.15 | 141.9 | 43.25 | 89.5 | 27.27 | 7814.272 | 2381.790 | " |
| 6 | 485576.16 | 4017380.07 | 174.7 | 53.25 | 108.5 | 33.07 | 7795.243 | 2375.990 | " |
| 7 | 485571.65 | 4017389.00 | 207.5 | 63.25 | 124.2 | 37.86 | 7779.528 | 2371.200 | " |
| 8 | 485567.14 | 4017397.93 | 240.3 | 73.25 | 133.6 | 40.71 | 7770.177 | 2368.350 | " |
| 9 | 485562.63 | 4017406.85 | 273.1 | 83.25 | 136.5 | 41.62 | 7767.192 | 2367.440 | " |
| 10 | 485553.61 | 4017424.70 | 338.7 | 103.25 | 137.2 | 41.82 | 7766.536 | 2367.240 | " |
| 11 | 485544.60 | 4017442.55 | 404.4 | 123.25 | 137.3 | 41.85 | 7766.437 | 2367.210 | " |
| 12 | 485535.58 | 4017460.41 | 470.0 | 143.25 | 137.3 | 41.86 | 7766.404 | 2367.200 | " |
| 13 | 485526.56 | 4017478.26 | 535.6 | 163.25 | 137.4 | 41.88 | 7766.339 | 2367.180 | " |
| 14 | 485517.54 | 4017496.11 | 601.2 | 183.25 | 137.4 | 41.87 | 7766.372 | 2367.190 | " |
| 15 | 485508.52 | 4017513.96 | 666.8 | 203.25 | 137.5 | 41.92 | 7766.208 | 2367.140 | " |
| 16 | 485499.51 | 4017531.81 | 732.4 | 223.25 | 137.6 | 41.95 | 7766.109 | 2367.110 | " |
| 17 | 485490.49 | 4017549.66 | 798.1 | 243.25 | 137.6 | 41.95 | 7766.109 | 2367.110 | " |
| 18 | 485481.47 | 4017567.51 | 863.7 | 263.25 | 137.4 | 41.89 | 7766.306 | 2367.170 | " |
| 19 | 485472.45 | 4017585.37 | 929.3 | 283.25 | 137.4 | 41.88 | 7766.339 | 2367.180 | " |
| 20 | 485463.43 | 4017603.22 | 994.9 | 303.25 | 137.5 | 41.90 | 7766.273 | 2367.160 | " |
| 21 | 485454.42 | 4017621.07 | 1060.5 | 323.25 | 137.4 | 41.88 | 7766.339 | 2367.180 | " |
| 22 | 485449.91 | 4017629.99 | 1093.3 | 333.25 | 137.3 | 41.84 | 7766.470 | 2367.220 | " |
| 23 | 485445.40 | 4017638.92 | 1126.1 | 343.25 | 137.3 | 41.85 | 7766.437 | 2367.210 | " |
| 24 | 485440.89 | 4017647.85 | 1159.0 | 353.25 | 137.5 | 41.90 | 7766.273 | 2367.160 | " |
| 25 | 485436.38 | 4017656.77 | 1191.8 | 363.25 | 137.4 | 41.89 | 7766.306 | 2367.170 | " |
| 26 | 485431.87 | 4017665.70 | 1224.6 | 373.25 | 137.2 | 41.81 | 7766.568 | 2367.250 | " |
| 27 | 485427.36 | 4017674.62 | 1257.4 | 383.25 | 137.0 | 41.76 | 7766.733 | 2367.300 | " |
| 28 | 485422.85 | 4017683.55 | 1290.2 | 393.25 | 136.9 | 41.72 | 7766.864 | 2367.340 | " |
| 29 | 485418.34 | 4017692.47 | 1323.0 | 403.25 | 137.0 | 41.75 | 7766.765 | 2367.310 | " |
| 30 | 485413.83 | 4017701.40 | 1355.8 | 413.25 | 15.6 | 4.76 | 7888.124 | 2404.300 | " |
| 31 | 485409.33 | 4017710.33 | 1388.6 | 423.25 | 9.5 | 2.90 | 7894.226 | 2406.160 | " |
| 32 | 485407.16 | 4017714.61 | 1404.4 | 428.05 | 0.0 | 0.00 | 7903.740 | 2409.060 | Water Edge on Right bank |
| 33 | 485405.63 | 4017717.65 | 1415.5 | 431.45 | | | 7913.009 | 2411.885 | Slope |
| 34 | 485403.85 | 4017721.17 | 1428.5 | 435.40 | | | 7932.415 | 2417.800 | " |
| 35 | 485401.04 | 4017726.72 | 1448.9 | 441.62 | | | 7944.062 | 2421.350 | " |
| 36 | 485399.41 | 4017729.95 | 1460.7 | 445.23 | | | 7964.403 | 2427.550 | Slope |
| 37 | 485397.17 | 4017734.38 | 1477.0 | 450.20 | | | 7986.614 | 2434.320 | T.B.M on Right Bank |



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## Table 1-8 Cross Sectional Coordinates, Cross Section 6B

| Sr. No. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 485711.73 | 4017632.28 | 0.0 | 0.00 | | | 7905.899 | 2409.718 | T,B.M on Left Bank (Vertical Cut) |
| 2 | 485710.22 | 4017632.69 | 5.1 | 1.56 | 0.0 | 0.00 | 7903.458 | 2408.974 | Water Edge on Left Bank |
| 3 | 485700.57 | 4017635.30 | 37.9 | 11.56 | 53.9 | 16.44 | 7849.521 | 2392.534 | Bed |
| 4 | 485690.92 | 4017637.91 | 70.7 | 21.56 | 76.4 | 23.29 | 7827.047 | 2385.684 | " |
| 5 | 485681.26 | 4017640.52 | 103.5 | 31.56 | 136.7 | 41.66 | 7766.778 | 2367.314 | " |
| 6 | 485671.61 | 4017643.13 | 136.4 | 41.56 | 137.1 | 41.79 | 7766.352 | 2367.184 | " |
| 7 | 485661.95 | 4017645.74 | 169.2 | 51.56 | 137.0 | 41.76 | 7766.450 | 2367.214 | " |
| 8 | 485652.30 | 4017648.35 | 202.0 | 61.56 | 137.0 | 41.76 | 7766.450 | 2367.214 | " |
| 9 | 485632.99 | 4017653.57 | 267.6 | 81.56 | 137.1 | 41.79 | 7766.352 | 2367.184 | " |
| 10 | 485613.69 | 4017658.78 | 333.2 | 101.56 | 137.1 | 41.78 | 7766.385 | 2367.194 | " |
| 11 | 485594.38 | 4017664.00 | 398.8 | 121.56 | 137.1 | 41.79 | 7766.352 | 2367.184 | " |
| 12 | 485575.07 | 4017669.22 | 464.4 | 141.56 | 137.1 | 41.79 | 7766.352 | 2367.184 | " |
| 13 | 485555.77 | 4017674.44 | 530.1 | 161.56 | 137.2 | 41.82 | 7766.254 | 2367.154 | " |
| 14 | 485536.46 | 4017679.66 | 595.7 | 181.56 | 137.3 | 41.84 | 7766.188 | 2367.134 | " |
| 15 | 485517.15 | 4017684.88 | 661.3 | 201.56 | 137.3 | 41.84 | 7766.188 | 2367.134 | " |
| 16 | 485497.84 | 4017690.10 | 726.9 | 221.56 | 137.4 | 41.89 | 7766.024 | 2367.084 | " |
| 17 | 485478.54 | 4017695.32 | 792.5 | 241.56 | 137.5 | 41.92 | 7765.925 | 2367.054 | " |
| 18 | 485459.23 | 4017700.54 | 858.1 | 261.56 | 137.1 | 41.79 | 7766.352 | 2367.184 | " |
| 19 | 485449.58 | 4017703.15 | 890.9 | 271.56 | 136.9 | 41.73 | 7766.549 | 2367.244 | " |
| 20 | 485439.92 | 4017705.76 | 923.8 | 281.56 | 137.0 | 41.77 | 7766.418 | 2367.204 | " |
| 21 | 485430.27 | 4017708.37 | 956.6 | 291.56 | 136.8 | 41.69 | 7766.680 | 2367.284 | " |
| 22 | 485420.62 | 4017710.98 | 989.4 | 301.56 | 131.0 | 39.94 | 7772.422 | 2369.034 | " |
| 23 | 485410.96 | 4017713.58 | 1022.2 | 311.56 | 77.3 | 23.55 | 7826.194 | 2385.424 | " |
| 24 | 485407.10 | 4017714.63 | 1035.3 | 315.56 | 0.0 | 0.00 | 7903.458 | 2408.974 | Water Edge on Right bank |
| 25 | 485403.78 | 4017715.53 | 1046.6 | 319.00 | | | 7913.370 | 2411.995 | T.B.M on Right Bank |



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## Table 1-9 Cross Sectional Coordinates, Cross Section 7

| Sr. No. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 485770.58 | 4017887.39 | 0.0 | 0.00 | | | 7984.121 | 2433.560 | T,B.M on Left Bank (Vertical Cut) |
| 2 | 485764.70 | 4017888.56 | 19.7 | 6.00 | | | 7957.481 | 2425.440 | Slope |
| 3 | 485757.83 | 4017889.93 | 42.7 | 13.00 | | | 7907.356 | 2410.162 | " |
| 4 | 485757.15 | 4017890.07 | 44.9 | 13.70 | 0.0 | 0.00 | 7903.314 | 2408.930 | Water Edge on Left Bank |
| 5 | 485747.34 | 4017892.03 | 77.8 | 23.70 | 41.3 | 12.60 | 7861.975 | 2396.330 | Bed |
| 6 | 485737.53 | 4017893.99 | 110.6 | 33.70 | 53.6 | 16.34 | 7849.705 | 2392.590 | " |
| 7 | 485727.73 | 4017895.95 | 143.4 | 43.70 | 68.9 | 20.99 | 7834.449 | 2387.940 | " |
| 8 | 485717.92 | 4017897.90 | 176.2 | 53.70 | 99.2 | 30.24 | 7804.101 | 2378.690 | " |
| 9 | 485708.12 | 4017899.86 | 209.0 | 63.70 | 136.5 | 41.60 | 7766.831 | 2367.330 | " |
| 10 | 485698.31 | 4017901.82 | 241.8 | 73.70 | 136.3 | 41.54 | 7767.028 | 2367.390 | " |
| 11 | 485678.70 | 4017905.74 | 307.4 | 93.70 | 136.3 | 41.55 | 7766.995 | 2367.380 | " |
| 12 | 485659.08 | 4017909.66 | 373.0 | 113.70 | 136.4 | 41.57 | 7766.929 | 2367.360 | " |
| 13 | 485639.47 | 4017913.58 | 438.6 | 133.70 | 136.6 | 41.64 | 7766.700 | 2367.290 | " |
| 14 | 485619.86 | 4017917.49 | 504.3 | 153.70 | 136.6 | 41.65 | 7766.667 | 2367.280 | " |
| 15 | 485600.25 | 4017921.41 | 569.9 | 173.70 | 136.8 | 41.69 | 7766.536 | 2367.240 | " |
| 16 | 485580.63 | 4017925.33 | 635.5 | 193.70 | 136.8 | 41.69 | 7766.536 | 2367.240 | " |
| 17 | 485561.02 | 4017929.25 | 701.1 | 213.70 | 136.7 | 41.68 | 7766.568 | 2367.250 | " |
| 18 | 485541.41 | 4017933.17 | 766.7 | 233.70 | 136.7 | 41.67 | 7766.601 | 2367.260 | " |
| 19 | 485521.80 | 4017937.08 | 832.3 | 253.70 | 136.8 | 41.69 | 7766.536 | 2367.240 | " |
| 20 | 485502.18 | 4017941.00 | 898.0 | 273.70 | 136.8 | 41.71 | 7766.470 | 2367.220 | " |
| 21 | 485482.57 | 4017944.92 | 963.6 | 293.70 | 136.8 | 41.70 | 7766.503 | 2367.230 | " |
| 22 | 485462.96 | 4017948.84 | 1029.2 | 313.70 | 136.9 | 41.74 | 7766.372 | 2367.190 | " |
| 23 | 485453.15 | 4017950.80 | 1062.0 | 323.70 | 136.9 | 41.74 | 7766.372 | 2367.190 | " |
| 24 | 485443.35 | 4017952.76 | 1094.8 | 333.70 | 136.9 | 41.74 | 7766.372 | 2367.190 | " |
| 25 | 485433.54 | 4017954.71 | 1127.6 | 343.70 | 137.2 | 41.81 | 7766.142 | 2367.120 | " |
| 26 | 485423.73 | 4017956.67 | 1160.4 | 353.70 | 137.4 | 41.88 | 7765.912 | 2367.050 | " |
| 27 | 485413.93 | 4017958.63 | 1193.2 | 363.70 | 137.2 | 41.82 | 7766.109 | 2367.110 | " |
| 28 | 485408.04 | 4017959.81 | 1212.9 | 369.70 | 83.0 | 25.30 | 7820.309 | 2383.630 | " |
| 29 | 485405.43 | 4017960.33 | 1221.7 | 372.37 | 0.0 | 0.00 | 7903.314 | 2408.930 | Water Edge on Right bank |
| 30 | 485401.47 | 4017961.12 | 1234.9 | 376.40 | | | 7914.534 | 2412.350 | Slope |
| 31 | 485397.50 | 4017961.91 | 1248.2 | 380.45 | | | 7935.335 | 2418.690 | " |
| 32 | 485392.36 | 4017962.94 | 1265.4 | 385.69 | | | 7962.599 | 2427.000 | " |
| 33 | 485387.91 | 4017963.83 | 1280.3 | 390.23 | | | 7980.775 | 2432.540 | T.B.M on Right Bank (Vertical Cut) |



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## Table 1-10 Cross Sectional Coordinates, Cross Section 8

| Sr. No. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 485876.55 | 4018088.07 | 0.0 | 0.00 | | | 7989.567 | 2435.220 | T,B.M on Left Bank |
| 2 | 485872.83 | 4018089.55 | 13.1 | 4.00 | | | 7937.402 | 2419.320 | Slope |
| 3 | 485869.12 | 4018091.03 | 26.2 | 8.00 | 0.0 | 0.00 | 7903.320 | 2408.932 | Water Edge on Left Bank |
| 4 | 485859.83 | 4018094.73 | 59.1 | 18.00 | 71.1 | 21.67 | 7832.225 | 2387.262 | Bed |
| 5 | 485850.54 | 4018098.43 | 91.9 | 28.00 | 103.7 | 31.60 | 7799.646 | 2377.332 | " |
| 6 | 485841.25 | 4018102.13 | 124.7 | 38.00 | 112.5 | 34.28 | 7790.853 | 2374.652 | " |
| 7 | 485831.96 | 4018105.83 | 157.5 | 48.00 | 126.2 | 38.48 | 7777.074 | 2370.452 | " |
| 8 | 485822.66 | 4018109.53 | 190.3 | 58.00 | 135.2 | 41.20 | 7768.150 | 2367.732 | " |
| 9 | 485813.37 | 4018113.23 | 223.1 | 68.00 | 135.2 | 41.22 | 7768.084 | 2367.712 | " |
| 10 | 485794.79 | 4018120.63 | 288.7 | 88.00 | 135.5 | 41.30 | 7767.822 | 2367.632 | " |
| 11 | 485776.21 | 4018128.03 | 354.3 | 108.00 | 135.7 | 41.35 | 7767.658 | 2367.582 | " |
| 12 | 485757.63 | 4018135.43 | 419.9 | 128.00 | 135.9 | 41.42 | 7767.428 | 2367.512 | " |
| 13 | 485739.05 | 4018142.83 | 485.6 | 148.00 | 135.8 | 41.40 | 7767.494 | 2367.532 | " |
| 14 | 485720.47 | 4018150.23 | 551.2 | 168.00 | 135.9 | 41.41 | 7767.461 | 2367.522 | " |
| 15 | 485701.89 | 4018157.63 | 616.8 | 188.00 | 135.9 | 41.42 | 7767.428 | 2367.512 | " |
| 16 | 485683.31 | 4018165.03 | 682.4 | 208.00 | 136.0 | 41.45 | 7767.330 | 2367.482 | " |
| 17 | 485664.73 | 4018172.43 | 748.0 | 228.00 | 135.9 | 41.42 | 7767.428 | 2367.512 | " |
| 18 | 485646.15 | 4018179.84 | 813.6 | 248.00 | 135.8 | 41.40 | 7767.494 | 2367.532 | " |
| 19 | 485627.57 | 4018187.24 | 879.3 | 268.00 | 135.8 | 41.39 | 7767.526 | 2367.542 | " |
| 20 | 485608.99 | 4018194.64 | 944.9 | 288.00 | 135.7 | 41.37 | 7767.592 | 2367.562 | " |
| 21 | 485590.41 | 4018202.04 | 1010.5 | 308.00 | 135.7 | 41.36 | 7767.625 | 2367.572 | " |
| 22 | 485571.83 | 4018209.44 | 1076.1 | 328.00 | 135.8 | 41.40 | 7767.494 | 2367.532 | " |
| 23 | 485553.25 | 4018216.84 | 1141.7 | 348.00 | 135.9 | 41.41 | 7767.461 | 2367.522 | " |
| 24 | 485534.67 | 4018224.24 | 1207.3 | 368.00 | 136.0 | 41.45 | 7767.330 | 2367.482 | " |
| 25 | 485516.09 | 4018231.64 | 1273.0 | 388.00 | 136.2 | 41.52 | 7767.100 | 2367.412 | " |
| 26 | 485497.51 | 4018239.04 | 1338.6 | 408.00 | 127.6 | 38.89 | 7775.729 | 2370.042 | " |
| 27 | 485488.22 | 4018242.74 | 1371.4 | 418.00 | 110.9 | 33.79 | 7792.461 | 2375.142 | " |
| 28 | 485478.93 | 4018246.44 | 1404.2 | 428.00 | 91.7 | 27.95 | 7811.621 | 2380.982 | " |
| 29 | 485469.64 | 4018250.14 | 1437.0 | 438.00 | 67.5 | 20.58 | 7835.801 | 2388.352 | " |
| 30 | 485460.35 | 4018253.84 | 1469.8 | 448.00 | 46.7 | 14.23 | 7856.634 | 2394.702 | " |
| 31 | 485451.06 | 4018257.54 | 1502.6 | 458.00 | 24.8 | 7.57 | 7878.485 | 2401.362 | " |
| 32 | 485443.66 | 4018260.49 | 1528.7 | 465.96 | 0.0 | 0.00 | 7903.320 | 2408.932 | Water Edge on Right bank |
| 33 | 485440.71 | 4018261.66 | 1539.2 | 469.14 | | | 7912.507 | 2411.732 | Slope |
| 34 | 485435.56 | 4018263.71 | 1557.3 | 474.68 | | | 7923.822 | 2415.181 | " |
| 35 | 485412.47 | 4018272.91 | 1638.9 | 499.53 | | | 7975.591 | 2430.960 | " |
| 36 | 485407.10 | 4018275.05 | 1657.9 | 505.32 | | | 7987.402 | 2434.560 | T.B.M on Right Bank |



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## Table 1-11 Cross Sectional Coordinates, Cross Section 9

| Sr. No. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 485964.29 | 4018177.21 | 0.0 | 0.00 | | | 7912.212 | 2411.642 | T,B.M on Left Bank (Vertical Cut) |
| 2 | 485960.05 | 4018179.11 | 15.2 | 4.64 | 0.0 | 0.00 | 7903.320 | 2408.932 | Water Edge on Left Bank |
| 3 | 485950.96 | 4018183.19 | 47.9 | 14.60 | 41.0 | 12.50 | 7862.310 | 2396.432 | Bed |
| 4 | 485941.80 | 4018187.30 | 80.8 | 24.64 | 56.1 | 17.10 | 7847.218 | 2391.832 | " |
| 5 | 485932.68 | 4018191.39 | 113.6 | 34.64 | 72.6 | 22.12 | 7830.748 | 2386.812 | " |
| 6 | 485923.65 | 4018195.44 | 146.1 | 44.54 | 134.5 | 40.99 | 7768.839 | 2367.942 | " |
| 7 | 485914.52 | 4018199.53 | 178.9 | 54.54 | 134.9 | 41.13 | 7768.380 | 2367.802 | " |
| 8 | 485905.31 | 4018203.67 | 212.1 | 64.64 | 135.2 | 41.20 | 7768.150 | 2367.732 | " |
| 9 | 485887.06 | 4018211.85 | 277.7 | 84.64 | 135.2 | 41.22 | 7768.084 | 2367.712 | " |
| 10 | 485868.81 | 4018220.04 | 343.3 | 104.64 | 135.5 | 41.30 | 7767.822 | 2367.632 | " |
| 11 | 485850.56 | 4018228.22 | 408.9 | 124.64 | 135.5 | 41.29 | 7767.855 | 2367.642 | " |
| 12 | 485832.31 | 4018236.41 | 474.5 | 144.64 | 135.6 | 41.34 | 7767.691 | 2367.592 | " |
| 13 | 485814.07 | 4018244.59 | 540.2 | 164.64 | 135.6 | 41.33 | 7767.723 | 2367.602 | " |
| 14 | 485795.82 | 4018252.78 | 605.8 | 184.64 | 135.3 | 41.25 | 7767.986 | 2367.682 | " |
| 15 | 485777.57 | 4018260.96 | 671.4 | 204.64 | 135.3 | 41.25 | 7767.986 | 2367.682 | " |
| 16 | 485759.32 | 4018269.15 | 737.0 | 224.64 | 135.2 | 41.21 | 7768.117 | 2367.722 | " |
| 17 | 485741.07 | 4018277.33 | 802.6 | 244.64 | 135.0 | 41.15 | 7768.314 | 2367.782 | " |
| 18 | 485722.82 | 4018285.52 | 868.2 | 264.64 | 135.1 | 41.18 | 7768.215 | 2367.752 | " |
| 19 | 485704.57 | 4018293.70 | 933.9 | 284.64 | 135.1 | 41.17 | 7768.248 | 2367.762 | " |
| 20 | 485686.33 | 4018301.89 | 999.5 | 304.64 | 135.2 | 41.20 | 7768.150 | 2367.732 | " |
| 21 | 485668.08 | 4018310.07 | 1065.1 | 324.64 | 135.1 | 41.17 | 7768.248 | 2367.762 | " |
| 22 | 485649.83 | 4018318.26 | 1130.7 | 344.64 | 135.2 | 41.20 | 7768.150 | 2367.732 | " |
| 23 | 485631.58 | 4018326.44 | 1196.3 | 364.64 | 135.1 | 41.19 | 7768.183 | 2367.742 | " |
| 24 | 485613.33 | 4018334.63 | 1261.9 | 384.64 | 135.2 | 41.20 | 7768.150 | 2367.732 | " |
| 25 | 485595.08 | 4018342.82 | 1327.6 | 404.64 | 125.9 | 38.38 | 7777.402 | 2370.552 | " |
| 26 | 485585.96 | 4018346.91 | 1360.4 | 414.64 | 118.6 | 36.15 | 7784.718 | 2372.782 | " |
| 27 | 485576.84 | 4018351.00 | 1393.2 | 424.64 | 108.3 | 33.02 | 7794.987 | 2375.912 | " |
| 28 | 485567.71 | 4018355.09 | 1426.0 | 434.64 | 80.5 | 24.55 | 7822.776 | 2384.382 | " |
| 29 | 485558.59 | 4018359.19 | 1458.8 | 444.64 | 58.9 | 17.95 | 7844.429 | 2390.982 | " |
| 30 | 485549.46 | 4018363.28 | 1491.6 | 454.64 | 48.2 | 14.69 | 7855.125 | 2394.242 | " |
| 31 | 485540.56 | 4018367.27 | 1523.6 | 464.40 | 32.2 | 9.81 | 7871.135 | 2399.122 | " |
| 32 | 485531.10 | 4018371.52 | 1557.6 | 474.77 | 0.0 | 0.00 | 7903.320 | 2408.932 | Water Edge on Right bank |
| 33 | 485526.47 | 4018373.59 | 1574.3 | 479.84 | | | 7913.340 | 2411.986 | Slope |
| 34 | 485521.11 | 4018375.99 | 1593.5 | 485.71 | | | 7922.763 | 2414.858 | " |
| 35 | 485492.25 | 4018388.94 | 1697.3 | 517.34 | | | 7976.772 | 2431.320 | T.B.M on Right Bank |



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## Table 1-12 Cross Sectional Coordinates, Cross Section 9A

| Sr. No. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 485973.66 | 4018164.95 | 0.0 | 0.00 | | | 7980.807 | 2432.550 | T,B.M on Left Bank |
| 2 | 485970.20 | 4018168.56 | 16.4 | 5.00 | | | 7950.230 | 2423.230 | Slope |
| 3 | 485966.73 | 4018172.16 | 32.8 | 10.00 | | | 7927.592 | 2416.330 | " |
| 4 | 485963.27 | 4018175.77 | 49.2 | 15.00 | | | 7912.162 | 2411.627 | " |
| 5 | 485960.05 | 4018179.11 | 64.4 | 19.64 | 0.0 | 0.00 | 7903.320 | 2408.932 | Water Edge on Left Bank |
| 6 | 485953.12 | 4018186.32 | 97.2 | 29.64 | 65.9 | 20.08 | 7837.441 | 2388.852 | Bed |
| 7 | 485946.19 | 4018193.53 | 130.1 | 39.64 | 133.8 | 40.79 | 7769.495 | 2368.142 | " |
| 8 | 485939.26 | 4018200.74 | 162.9 | 49.64 | 134.9 | 41.11 | 7768.445 | 2367.822 | " |
| 9 | 485932.33 | 4018207.95 | 195.7 | 59.64 | 135.0 | 41.15 | 7768.314 | 2367.782 | " |
| 10 | 485925.40 | 4018215.16 | 228.5 | 69.64 | 134.9 | 41.13 | 7768.380 | 2367.802 | " |
| 11 | 485918.47 | 4018222.37 | 261.3 | 79.64 | 135.1 | 41.18 | 7768.215 | 2367.752 | " |
| 12 | 485911.54 | 4018229.58 | 294.1 | 89.64 | 135.3 | 41.23 | 7768.051 | 2367.702 | " |
| 13 | 485904.61 | 4018236.79 | 326.9 | 99.64 | 135.3 | 41.24 | 7768.019 | 2367.692 | " |
| 14 | 485890.75 | 4018251.20 | 392.5 | 119.64 | 135.5 | 41.30 | 7767.822 | 2367.632 | " |
| 15 | 485876.89 | 4018265.62 | 458.1 | 139.64 | 135.0 | 41.16 | 7768.281 | 2367.772 | " |
| 16 | 485863.03 | 4018280.04 | 523.8 | 159.64 | 135.0 | 41.16 | 7768.281 | 2367.772 | " |
| 17 | 485849.17 | 4018294.46 | 589.4 | 179.64 | 134.9 | 41.11 | 7768.445 | 2367.822 | " |
| 18 | 485835.31 | 4018308.88 | 655.0 | 199.64 | 134.7 | 41.06 | 7768.609 | 2367.872 | " |
| 19 | 485821.45 | 4018323.30 | 720.6 | 219.64 | 134.8 | 41.09 | 7768.511 | 2367.842 | " |
| 20 | 485807.59 | 4018337.71 | 786.2 | 239.64 | 134.6 | 41.03 | 7768.708 | 2367.902 | " |
| 21 | 485793.73 | 4018352.13 | 851.8 | 259.64 | 134.3 | 40.92 | 7769.068 | 2368.012 | " |
| 22 | 485779.87 | 4018366.55 | 917.5 | 279.64 | 134.6 | 41.02 | 7768.740 | 2367.912 | " |
| 23 | 485766.01 | 4018380.97 | 983.1 | 299.64 | 134.6 | 41.04 | 7768.675 | 2367.892 | " |
| 24 | 485752.15 | 4018395.39 | 1048.7 | 319.64 | 133.8 | 40.79 | 7769.495 | 2368.142 | " |
| 25 | 485738.28 | 4018409.81 | 1114.3 | 339.64 | 133.7 | 40.76 | 7769.593 | 2368.172 | " |
| 26 | 485724.42 | 4018424.22 | 1179.9 | 359.64 | 130.1 | 39.64 | 7773.268 | 2369.292 | " |
| 27 | 485710.56 | 4018438.64 | 1245.5 | 379.64 | 93.0 | 28.36 | 7810.276 | 2380.572 | " |
| 28 | 485696.70 | 4018453.06 | 1311.2 | 399.64 | 66.3 | 20.22 | 7836.982 | 2388.712 | " |
| 29 | 485682.84 | 4018467.48 | 1376.8 | 419.64 | 38.8 | 11.83 | 7864.508 | 2397.102 | " |
| 30 | 485675.91 | 4018474.69 | 1409.6 | 429.64 | 31.6 | 9.64 | 7871.693 | 2399.292 | " |
| 31 | 485668.98 | 4018481.90 | 1442.4 | 439.64 | 26.4 | 8.05 | 7876.910 | 2400.882 | " |
| 32 | 485662.05 | 4018489.11 | 1475.2 | 449.64 | 26.3 | 8.01 | 7877.041 | 2400.922 | " |
| 33 | 485655.12 | 4018496.32 | 1508.0 | 459.64 | 25.9 | 7.88 | 7877.467 | 2401.052 | " |
| 34 | 485648.19 | 4018503.52 | 1540.8 | 469.64 | 22.6 | 6.90 | 7880.683 | 2402.032 | " |
| 35 | 485641.26 | 4018510.73 | 1573.6 | 479.64 | 17.4 | 5.31 | 7885.899 | 2403.622 | " |
| 36 | 485634.33 | 4018517.94 | 1606.4 | 489.64 | 13.8 | 4.21 | 7889.508 | 2404.722 | Bed |
| 37 | 485625.71 | 4018526.91 | 1647.2 | 502.08 | 0.0 | 0.00 | 7903.320 | 2408.932 | Water Edge on Right bank |
| 38 | 485617.98 | 4018534.95 | 1683.8 | 513.23 | | | 7916.280 | 2412.882 | Slope |
| 39 | 485614.09 | 4018538.99 | 1702.2 | 518.84 | | | 7925.788 | 2415.780 | " |
| 40 | 485586.59 | 4018567.61 | 1832.4 | 558.53 | | | 7978.281 | 2431.780 | T.B.M on Right Bank |



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## Table 1-13 Cross Sectional Coordinates, Cross Section 9B

| Sr. No. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 485962.25 | 4018175.03 | 0.0 | 0.00 | | | 7912.162 | 2411.627 | T,B.M on Left Bank |
| 2 | 485960.05 | 4018179.11 | 15.2 | 4.64 | 0.0 | 0.00 | 7903.320 | 2408.932 | Water Edge on Left Bank |
| 3 | 485955.32 | 4018187.92 | 48.0 | 14.64 | 132.8 | 40.48 | 7770.512 | 2368.452 | Bed |
| 4 | 485950.59 | 4018196.73 | 80.8 | 24.64 | 134.8 | 41.09 | 7768.511 | 2367.842 | " |
| 5 | 485945.86 | 4018205.54 | 113.6 | 34.64 | 135.0 | 41.16 | 7768.281 | 2367.772 | " |
| 6 | 485941.13 | 4018214.35 | 146.5 | 44.64 | 135.0 | 41.16 | 7768.281 | 2367.772 | " |
| 7 | 485936.39 | 4018223.16 | 179.3 | 54.64 | 135.1 | 41.17 | 7768.248 | 2367.762 | " |
| 8 | 485931.66 | 4018231.97 | 212.1 | 64.64 | 135.1 | 41.17 | 7768.248 | 2367.762 | " |
| 9 | 485922.20 | 4018249.59 | 277.7 | 84.64 | 135.0 | 41.16 | 7768.281 | 2367.772 | " |
| 10 | 485912.73 | 4018267.21 | 343.3 | 104.64 | 134.9 | 41.13 | 7768.380 | 2367.802 | " |
| 11 | 485903.27 | 4018284.83 | 408.9 | 124.64 | 134.9 | 41.13 | 7768.380 | 2367.802 | " |
| 12 | 485893.81 | 4018302.45 | 474.5 | 144.64 | 135.1 | 41.18 | 7768.215 | 2367.752 | " |
| 13 | 485884.34 | 4018320.07 | 540.2 | 164.64 | 134.6 | 41.04 | 7768.675 | 2367.892 | " |
| 14 | 485874.88 | 4018337.69 | 605.8 | 184.64 | 134.5 | 41.00 | 7768.806 | 2367.932 | " |
| 15 | 485865.42 | 4018355.31 | 671.4 | 204.64 | 134.5 | 41.01 | 7768.773 | 2367.922 | " |
| 16 | 485855.95 | 4018372.93 | 737.0 | 224.64 | 134.5 | 40.99 | 7768.839 | 2367.942 | " |
| 17 | 485846.49 | 4018390.54 | 802.6 | 244.64 | 134.4 | 40.96 | 7768.937 | 2367.972 | " |
| 18 | 485837.03 | 4018408.16 | 868.2 | 264.64 | 134.2 | 40.89 | 7769.167 | 2368.042 | " |
| 19 | 485827.56 | 4018425.78 | 933.9 | 284.64 | 134.2 | 40.90 | 7769.134 | 2368.032 | " |
| 20 | 485818.10 | 4018443.40 | 999.5 | 304.64 | 133.8 | 40.79 | 7769.495 | 2368.142 | " |
| 21 | 485808.64 | 4018461.02 | 1065.1 | 324.64 | 131.4 | 40.04 | 7771.956 | 2368.892 | " |
| 22 | 485799.17 | 4018478.64 | 1130.7 | 344.64 | 106.8 | 32.54 | 7796.562 | 2376.392 | " |
| 23 | 485789.71 | 4018496.26 | 1196.3 | 364.64 | 94.6 | 28.83 | 7808.734 | 2380.102 | " |
| 24 | 485780.24 | 4018513.88 | 1261.9 | 384.64 | 71.9 | 21.92 | 7831.404 | 2387.012 | " |
| 25 | 485770.78 | 4018531.50 | 1327.6 | 404.64 | 42.0 | 12.79 | 7861.359 | 2396.142 | " |
| 26 | 485766.05 | 4018540.31 | 1360.4 | 414.64 | 29.8 | 9.08 | 7873.530 | 2399.852 | " |
| 27 | 485761.32 | 4018549.12 | 1393.2 | 424.64 | 15.8 | 4.82 | 7887.507 | 2404.112 | " |
| 28 | 485756.59 | 4018557.93 | 1426.0 | 434.64 | 13.0 | 3.97 | 7890.296 | 2404.962 | " |
| 29 | 485751.85 | 4018566.74 | 1458.8 | 444.64 | 7.3 | 2.24 | 7895.971 | 2406.692 | " |
| 30 | 485747.77 | 4018574.35 | 1487.1 | 453.28 | 0.0 | 0.00 | 7903.320 | 2408.932 | Water Edge on Right bank |
| 31 | 485744.52 | 4018580.38 | 1509.6 | 460.13 | | | 7911.667 | 2411.476 | Slope |
| 32 | 485738.73 | 4018591.18 | 1549.8 | 472.38 | | | 7922.700 | 2414.839 | " |
| 33 | 485712.30 | 4018640.38 | 1733.0 | 528.23 | | | 7980.263 | 2432.384 | T.B.M on Right Bank |



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**Table 1-14 Cross Sectional Coordinates, Cross Section 10**

| Sr. No. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 486126.43 | 4018135.22 | 0.0 | 0.00 | | | 7977.428 | 2431.520 | T,B.M on Left Bank (Vertical Cut) |
| 2 | 486125.61 | 4018140.15 | 16.4 | 5.00 | | | 7962.303 | 2426.910 | Slope |
| 3 | 486124.78 | 4018145.08 | 32.8 | 10.00 | | | 7944.062 | 2421.350 | " |
| 4 | 486123.95 | 4018150.01 | 49.2 | 15.00 | | | 7933.429 | 2418.109 | " |
| 5 | 486122.96 | 4018155.93 | 68.9 | 21.00 | | | 7913.222 | 2411.950 | " |
| 6 | 486122.12 | 4018160.96 | 85.6 | 26.10 | 0.0 | 0.00 | 7903.320 | 2408.932 | Water Edge on Left Bank |
| 7 | 486120.47 | 4018170.82 | 118.4 | 36.10 | 105.3 | 32.10 | 7798.005 | 2376.832 | Bed |
| 8 | 486118.81 | 4018180.68 | 151.2 | 46.10 | 134.5 | 41.00 | 7768.806 | 2367.932 | " |
| 9 | 486117.16 | 4018190.55 | 184.1 | 56.10 | 134.6 | 41.02 | 7768.740 | 2367.912 | " |
| 10 | 486115.51 | 4018200.41 | 216.9 | 66.10 | 134.6 | 41.04 | 7768.675 | 2367.892 | " |
| 11 | 486113.86 | 4018210.27 | 249.7 | 76.10 | 134.5 | 41.00 | 7768.806 | 2367.932 | " |
| 12 | 486112.20 | 4018220.13 | 282.5 | 86.10 | 134.7 | 41.06 | 7768.609 | 2367.872 | " |
| 13 | 486108.90 | 4018239.86 | 348.1 | 106.10 | 134.8 | 41.08 | 7768.544 | 2367.852 | " |
| 14 | 486105.60 | 4018259.58 | 413.7 | 126.10 | 134.9 | 41.11 | 7768.445 | 2367.822 | " |
| 15 | 486102.29 | 4018279.31 | 479.3 | 146.10 | 134.9 | 41.11 | 7768.445 | 2367.822 | " |
| 16 | 486098.99 | 4018299.03 | 544.9 | 166.10 | 134.8 | 41.08 | 7768.544 | 2367.852 | " |
| 17 | 486095.68 | 4018318.76 | 610.6 | 186.10 | 134.8 | 41.08 | 7768.544 | 2367.852 | " |
| 18 | 486092.38 | 4018338.48 | 676.2 | 206.10 | 135.2 | 41.20 | 7768.150 | 2367.732 | " |
| 19 | 486089.07 | 4018358.21 | 741.8 | 226.10 | 135.0 | 41.15 | 7768.314 | 2367.782 | " |
| 20 | 486085.77 | 4018377.93 | 807.4 | 246.10 | 134.9 | 41.12 | 7768.412 | 2367.812 | " |
| 21 | 486082.46 | 4018397.66 | 873.0 | 266.10 | 134.4 | 40.97 | 7768.904 | 2367.962 | " |
| 22 | 486079.16 | 4018417.38 | 938.6 | 286.10 | 134.3 | 40.94 | 7769.003 | 2367.992 | " |
| 23 | 486075.85 | 4018437.11 | 1004.3 | 306.10 | 134.4 | 40.98 | 7768.872 | 2367.952 | " |
| 24 | 486072.55 | 4018456.83 | 1069.9 | 326.10 | 134.1 | 40.88 | 7769.200 | 2368.052 | " |
| 25 | 486069.24 | 4018476.56 | 1135.5 | 346.10 | 134.1 | 40.88 | 7769.200 | 2368.052 | " |
| 26 | 486065.94 | 4018496.28 | 1201.1 | 366.10 | 133.7 | 40.76 | 7769.593 | 2368.172 | " |
| 27 | 486062.63 | 4018516.01 | 1266.7 | 386.10 | 133.8 | 40.77 | 7769.561 | 2368.162 | " |
| 28 | 486059.33 | 4018535.73 | 1332.3 | 406.10 | 133.7 | 40.75 | 7769.626 | 2368.182 | " |
| 29 | 486056.03 | 4018555.46 | 1398.0 | 426.10 | 131.9 | 40.19 | 7771.464 | 2368.742 | " |
| 30 | 486054.37 | 4018565.32 | 1430.8 | 436.10 | 119.8 | 36.51 | 7783.537 | 2372.422 | " |
| 31 | 486052.72 | 4018575.18 | 1463.6 | 446.10 | 109.2 | 33.27 | 7794.167 | 2375.662 | " |
| 32 | 486051.07 | 4018585.05 | 1496.4 | 456.10 | 99.0 | 30.17 | 7804.338 | 2378.762 | " |
| 33 | 486049.42 | 4018594.91 | 1529.2 | 466.10 | 90.5 | 27.59 | 7812.802 | 2381.342 | " |
| 34 | 486047.76 | 4018604.77 | 1562.0 | 476.10 | 90.5 | 27.57 | 7812.868 | 2381.362 | " |
| 35 | 486046.11 | 4018614.63 | 1594.8 | 486.10 | 87.1 | 26.55 | 7816.214 | 2382.382 | " |
| 36 | 486044.48 | 4018624.40 | 1627.3 | 496.00 | 81.8 | 24.92 | 7821.562 | 2384.012 | Bed |
| 37 | 486042.81 | 4018634.36 | 1660.4 | 506.10 | 81.3 | 24.78 | 7822.021 | 2384.152 | " |
| 38 | 486041.15 | 4018644.22 | 1693.2 | 516.10 | 67.8 | 20.66 | 7835.538 | 2388.272 | " |
| 39 | 486039.50 | 4018654.08 | 1726.0 | 526.10 | 47.3 | 14.41 | 7856.044 | 2394.522 | " |
| 40 | 486037.85 | 4018663.95 | 1758.9 | 536.10 | 33.5 | 10.20 | 7869.856 | 2398.732 | " |
| 41 | 486036.69 | 4018670.85 | 1781.8 | 543.10 | 15.1 | 4.60 | 7888.229 | 2404.332 | " |
| 42 | 486035.86 | 4018675.80 | 1798.3 | 548.12 | 0.0 | 0.00 | 7903.320 | 2408.932 | Water Edge on Right bank |
| 43 | 486035.09 | 4018680.44 | 1813.7 | 552.82 | | | 7913.255 | 2411.960 | Slope |
| 44 | 486034.16 | 4018685.96 | 1832.1 | 558.42 | | | 7930.679 | 2417.271 | " |
| 45 | 486033.13 | 4018692.11 | 1852.6 | 564.66 | | | 7943.973 | 2421.323 | " |
| 46 | 486028.58 | 4018719.28 | 1942.9 | 592.20 | | | 7959.059 | 2425.921 | " |
| 47 | 486030.89 | 4018705.49 | 1897.0 | 578.22 | | | 7978.701 | 2431.908 | T.B.M on Right Bank |



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## Table 1-15 Cross Sectional Coordinates, Cross Section 11

| Sr. No. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 486441.36 | 4018125.31 | 0.0 | 0.00 | | | 5545.794 | 2431.854 | T,B.M on Left Bank |
| 2 | 486436.30 | 4018142.93 | 60.1 | 18.33 | | | 5519.947 | 2420.520 | Slope |
| 3 | 486434.18 | 4018150.32 | 85.4 | 26.02 | | | 5509.400 | 2415.895 | " |
| 4 | 486432.00 | 4018157.92 | 111.3 | 33.93 | | | 5499.234 | 2411.437 | " |
| 5 | 486431.16 | 4018160.86 | 121.3 | 36.98 | 0.0 | 0.00 | 5493.521 | 2408.932 | Water Edge on Left Bank |
| 6 | 486428.40 | 4018170.47 | 154.1 | 46.98 | 19.4 | 5.92 | 5480.021 | 2403.012 | Bed |
| 7 | 486425.64 | 4018180.08 | 186.9 | 56.98 | 40.0 | 12.19 | 5465.722 | 2396.742 | " |
| 8 | 486422.88 | 4018189.69 | 219.8 | 66.98 | 62.7 | 19.10 | 5449.964 | 2389.832 | " |
| 9 | 486420.12 | 4018199.30 | 252.6 | 76.98 | 75.6 | 23.05 | 5440.956 | 2385.882 | " |
| 10 | 486417.37 | 4018208.92 | 285.4 | 86.98 | 94.4 | 28.77 | 5427.912 | 2380.162 | " |
| 11 | 486414.61 | 4018218.53 | 318.2 | 96.98 | 108.7 | 33.13 | 5417.969 | 2375.802 | " |
| 12 | 486409.09 | 4018237.75 | 383.8 | 116.98 | 132.5 | 40.38 | 5401.435 | 2368.552 | " |
| 13 | 486403.57 | 4018256.98 | 449.4 | 136.98 | 133.6 | 40.71 | 5400.683 | 2368.222 | " |
| 14 | 486398.06 | 4018276.20 | 515.0 | 156.98 | 134.1 | 40.86 | 5400.341 | 2368.072 | " |
| 15 | 486392.54 | 4018295.42 | 580.6 | 176.98 | 134.0 | 40.85 | 5400.364 | 2368.082 | " |
| 16 | 486387.02 | 4018314.65 | 646.3 | 196.98 | 134.2 | 40.90 | 5400.250 | 2368.032 | " |
| 17 | 486381.51 | 4018333.87 | 711.9 | 216.98 | 134.2 | 40.90 | 5400.250 | 2368.032 | " |
| 18 | 486375.99 | 4018353.10 | 777.5 | 236.98 | 134.3 | 40.93 | 5400.181 | 2368.002 | " |
| 19 | 486370.47 | 4018372.32 | 843.1 | 256.98 | 134.3 | 40.94 | 5400.158 | 2367.992 | " |
| 20 | 486364.96 | 4018391.54 | 908.7 | 276.98 | 134.2 | 40.90 | 5400.250 | 2368.032 | " |
| 21 | 486359.44 | 4018410.77 | 974.3 | 296.98 | 134.4 | 40.95 | 5400.136 | 2367.982 | " |
| 22 | 486353.92 | 4018429.99 | 1040.0 | 316.98 | 134.4 | 40.96 | 5400.113 | 2367.972 | " |
| 23 | 486348.41 | 4018449.22 | 1105.6 | 336.98 | 134.3 | 40.93 | 5400.181 | 2368.002 | " |
| 24 | 486342.89 | 4018468.44 | 1171.2 | 356.98 | 134.8 | 41.09 | 5399.816 | 2367.842 | " |
| 25 | 486337.37 | 4018487.67 | 1236.8 | 376.98 | 134.7 | 41.05 | 5399.908 | 2367.882 | " |
| 26 | 486331.86 | 4018506.89 | 1302.4 | 396.98 | 134.4 | 40.95 | 5400.136 | 2367.982 | " |
| 27 | 486326.34 | 4018526.11 | 1368.0 | 416.98 | 134.1 | 40.88 | 5400.295 | 2368.052 | " |
| 28 | 486320.82 | 4018545.34 | 1433.7 | 436.98 | 134.0 | 40.85 | 5400.364 | 2368.082 | " |
| 29 | 486318.07 | 4018554.95 | 1466.5 | 446.98 | 134.0 | 40.84 | 5400.386 | 2368.092 | " |
| 30 | 486315.31 | 4018564.56 | 1499.3 | 456.98 | 134.0 | 40.83 | 5400.409 | 2368.102 | " |
| 31 | 486312.55 | 4018574.17 | 1532.1 | 466.98 | 0.0 | 0.00 | 5493.521 | 2408.932 | Water Edge on Right Bank |
| 32 | 486311.25 | 4018578.71 | 1547.6 | 471.70 | | | 5493.676 | 2409.000 | Slope |
| 33 | 486310.20 | 4018582.36 | 1560.0 | 475.50 | | | 5495.131 | 2409.638 | " |
| 34 | 486308.70 | 4018587.57 | 1577.8 | 480.92 | | | 5504.281 | 2413.650 | " |
| 35 | 486307.39 | 4018592.16 | 1593.5 | 485.69 | | | 5518.442 | 2419.860 | " |
| 36 | 486306.13 | 4018596.53 | 1608.4 | 490.24 | | | 5532.080 | 2425.840 | " |
| 37 | 486304.70 | 4018601.53 | 1625.5 | 495.44 | | | 5546.013 | 2431.950 | T.B.M on Right Bank (Vertical Cut) |



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## Table 1-16 Cross Sectional Coordinates, Cross Section 12

| Sr. No. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 486780.85 | 4018221.48 | 0.0 | 0.00 | | | 7973.918 | 2430.450 | T,B.M on Left Bank |
| 2 | 486776.60 | 4018228.49 | 26.9 | 8.20 | | | 7955.801 | 2424.928 | Slope |
| 3 | 486765.31 | 4018247.10 | 98.3 | 29.97 | | | 7911.803 | 2411.517 | " |
| 4 | 486763.40 | 4018250.24 | 110.4 | 33.64 | 0.0 | 0.00 | 7903.320 | 2408.932 | Water Edge on Left Bank |
| 5 | 486758.22 | 4018258.79 | 143.2 | 43.64 | 18.1 | 5.52 | 7885.210 | 2403.412 | Bed |
| 6 | 486752.51 | 4018268.19 | 179.3 | 54.64 | 28.5 | 8.69 | 7874.810 | 2400.242 | " |
| 7 | 486747.32 | 4018276.74 | 212.1 | 64.64 | 43.8 | 13.34 | 7859.554 | 2395.592 | " |
| 8 | 486742.14 | 4018285.29 | 244.9 | 74.64 | 49.4 | 15.07 | 7853.878 | 2393.862 | " |
| 9 | 486737.47 | 4018292.99 | 274.4 | 83.64 | 66.2 | 20.17 | 7837.146 | 2388.762 | " |
| 10 | 486732.28 | 4018301.54 | 307.2 | 93.64 | 88.0 | 26.82 | 7815.328 | 2382.112 | " |
| 11 | 486721.91 | 4018318.64 | 372.8 | 113.64 | 115.3 | 35.13 | 7788.065 | 2373.802 | " |
| 12 | 486711.54 | 4018335.74 | 438.5 | 133.64 | 127.4 | 38.83 | 7775.925 | 2370.102 | " |
| 13 | 486701.16 | 4018352.84 | 504.1 | 153.64 | 132.9 | 40.52 | 7770.381 | 2368.412 | " |
| 14 | 486690.79 | 4018369.94 | 569.7 | 173.64 | 132.9 | 40.52 | 7770.381 | 2368.412 | " |
| 15 | 486680.42 | 4018387.04 | 635.3 | 193.64 | 133.0 | 40.55 | 7770.282 | 2368.382 | " |
| 16 | 486670.04 | 4018404.14 | 700.9 | 213.64 | 133.2 | 40.59 | 7770.151 | 2368.342 | " |
| 17 | 486659.67 | 4018421.24 | 766.5 | 233.64 | 133.2 | 40.61 | 7770.086 | 2368.322 | " |
| 18 | 486649.30 | 4018438.33 | 832.2 | 253.64 | 133.2 | 40.59 | 7770.151 | 2368.342 | " |
| 19 | 486638.92 | 4018455.43 | 897.8 | 273.64 | 133.5 | 40.68 | 7769.856 | 2368.252 | " |
| 20 | 486628.55 | 4018472.53 | 963.4 | 293.64 | 133.5 | 40.68 | 7769.856 | 2368.252 | " |
| 21 | 486618.18 | 4018489.63 | 1029.0 | 313.64 | 133.5 | 40.69 | 7769.823 | 2368.242 | " |
| 22 | 486607.80 | 4018506.73 | 1094.6 | 333.64 | 133.4 | 40.67 | 7769.889 | 2368.262 | " |
| 23 | 486597.43 | 4018523.83 | 1160.2 | 353.64 | 133.5 | 40.69 | 7769.823 | 2368.242 | " |
| 24 | 486587.06 | 4018540.93 | 1225.9 | 373.64 | 133.5 | 40.68 | 7769.856 | 2368.252 | " |
| 25 | 486576.68 | 4018558.03 | 1291.5 | 393.64 | 133.2 | 40.59 | 7770.151 | 2368.342 | " |
| 26 | 486566.31 | 4018575.13 | 1357.1 | 413.64 | 133.1 | 40.58 | 7770.184 | 2368.352 | " |
| 27 | 486555.94 | 4018592.23 | 1422.7 | 433.64 | 133.2 | 40.59 | 7770.151 | 2368.342 | " |
| 28 | 486550.75 | 4018600.78 | 1455.5 | 443.64 | 133.1 | 40.57 | 7770.217 | 2368.362 | " |
| 29 | 486545.56 | 4018609.33 | 1488.3 | 453.64 | 133.1 | 40.57 | 7770.217 | 2368.362 | " |
| 30 | 486540.38 | 4018617.88 | 1521.1 | 463.64 | 133.1 | 40.56 | 7770.250 | 2368.372 | " |
| 31 | 486535.19 | 4018626.43 | 1553.9 | 473.64 | 133.1 | 40.58 | 7770.184 | 2368.352 | " |
| 32 | 486530.00 | 4018634.98 | 1586.7 | 483.64 | 133.8 | 40.77 | 7769.561 | 2368.162 | " |
| 33 | 486527.41 | 4018639.25 | 1603.1 | 488.64 | 26.0 | 7.93 | 7877.303 | 2401.002 | " |
| 34 | 486524.92 | 4018643.36 | 1618.9 | 493.44 | 0.0 | 0.00 | 7903.320 | 2408.932 | Water Edge on Right Bank |
| 35 | 486523.57 | 4018645.58 | 1627.4 | 496.04 | | | 7913.376 | 2411.997 | Slope |
| 36 | 486518.59 | 4018653.80 | 1659.0 | 505.65 | | | 7936.221 | 2418.960 | Slope |
| 37 | 486516.04 | 4018657.99 | 1675.1 | 510.56 | | | 7955.545 | 2424.850 | " |
| 38 | 486510.81 | 4018666.62 | 1708.2 | 520.65 | | | 7965.814 | 2427.980 | " |
| 39 | 486508.32 | 4018670.73 | 1723.9 | 525.45 | | | 7980.906 | 2432.580 | T.B.M on Right Bank (Vertical Cut) |



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## Table 1-17 Cross Sectional Coordinates, Cross Section 13

| Sr. No. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 487056.26 | 4018368.24 | 0.0 | 0.00 | | | 7987.103 | 2434.469 | T,B.M on Left Bank |
| 2 | 487049.38 | 4018376.68 | 35.7 | 10.89 | | | 7961.529 | 2426.674 | Slope |
| 3 | 487042.70 | 4018384.89 | 70.5 | 21.48 | | | 7940.259 | 2420.191 | " |
| 4 | 487034.89 | 4018394.49 | 111.1 | 33.85 | | | 7911.943 | 2411.560 | " |
| 5 | 487031.89 | 4018398.17 | 126.6 | 38.60 | 0.0 | 0.00 | 7903.281 | 2408.920 | Water Edge on Left Bank |
| 6 | 487025.58 | 4018405.93 | 159.4 | 48.60 | 29.2 | 8.89 | 7874.114 | 2400.030 | Bed |
| 7 | 487019.27 | 4018413.68 | 192.3 | 58.60 | 43.3 | 13.21 | 7859.941 | 2395.710 | " |
| 8 | 487012.95 | 4018421.44 | 225.1 | 68.60 | 58.8 | 17.92 | 7844.488 | 2391.000 | " |
| 9 | 487006.64 | 4018429.19 | 257.9 | 78.60 | 75.5 | 23.01 | 7827.789 | 2385.910 | " |
| 10 | 487000.33 | 4018436.95 | 290.7 | 88.60 | 100.3 | 30.56 | 7803.019 | 2378.360 | " |
| 11 | 486994.02 | 4018444.71 | 323.5 | 98.60 | 112.1 | 34.18 | 7791.142 | 2374.740 | " |
| 12 | 486981.39 | 4018460.22 | 389.1 | 118.60 | 131.9 | 40.19 | 7771.424 | 2368.730 | " |
| 13 | 486968.76 | 4018475.73 | 454.7 | 138.60 | 132.2 | 40.30 | 7771.063 | 2368.620 | " |
| 14 | 486956.14 | 4018491.24 | 520.3 | 158.60 | 132.3 | 40.32 | 7770.998 | 2368.600 | " |
| 15 | 486943.51 | 4018506.75 | 586.0 | 178.60 | 132.4 | 40.35 | 7770.899 | 2368.570 | " |
| 16 | 486937.20 | 4018514.51 | 618.8 | 188.60 | 132.3 | 40.34 | 7770.932 | 2368.580 | " |
| 17 | 486918.26 | 4018537.77 | 717.2 | 218.60 | 132.5 | 40.39 | 7770.768 | 2368.530 | " |
| 18 | 486905.64 | 4018553.28 | 782.8 | 238.60 | 132.5 | 40.40 | 7770.735 | 2368.520 | " |
| 19 | 486893.01 | 4018568.80 | 848.4 | 258.60 | 132.8 | 40.48 | 7770.473 | 2368.440 | " |
| 20 | 486880.39 | 4018584.31 | 914.0 | 278.60 | 132.7 | 40.46 | 7770.538 | 2368.460 | " |
| 21 | 486867.76 | 4018599.82 | 979.7 | 298.60 | 132.9 | 40.51 | 7770.374 | 2368.410 | " |
| 22 | 486855.14 | 4018615.33 | 1045.3 | 318.60 | 132.9 | 40.51 | 7770.374 | 2368.410 | " |
| 23 | 486842.51 | 4018630.84 | 1110.9 | 338.60 | 132.7 | 40.44 | 7770.604 | 2368.480 | " |
| 24 | 486829.89 | 4018646.35 | 1176.5 | 358.60 | 132.6 | 40.42 | 7770.670 | 2368.500 | " |
| 25 | 486817.26 | 4018661.86 | 1242.1 | 378.60 | 132.3 | 40.33 | 7770.965 | 2368.590 | " |
| 26 | 486804.63 | 4018677.37 | 1307.7 | 398.60 | 132.7 | 40.44 | 7770.604 | 2368.480 | " |
| 27 | 486792.01 | 4018692.89 | 1373.4 | 418.60 | 132.6 | 40.41 | 7770.702 | 2368.510 | " |
| 28 | 486779.38 | 4018708.40 | 1439.0 | 438.60 | 132.5 | 40.38 | 7770.801 | 2368.540 | " |
| 29 | 486766.76 | 4018723.91 | 1504.6 | 458.60 | 132.2 | 40.30 | 7771.063 | 2368.620 | " |
| 30 | 486754.13 | 4018739.42 | 1570.2 | 478.60 | 131.9 | 40.21 | 7771.359 | 2368.710 | " |
| 31 | 486741.51 | 4018754.93 | 1635.8 | 498.60 | 131.6 | 40.12 | 7771.654 | 2368.800 | " |
| 32 | 486728.88 | 4018770.44 | 1701.4 | 518.60 | 122.5 | 37.35 | 7780.742 | 2371.570 | " |
| 33 | 486716.26 | 4018785.95 | 1767.1 | 538.60 | 84.2 | 25.67 | 7819.062 | 2383.250 | " |
| 34 | 486709.94 | 4018793.71 | 1799.9 | 548.60 | 65.6 | 20.01 | 7837.631 | 2388.910 | " |
| 35 | 486703.63 | 4018801.46 | 1832.7 | 558.60 | 43.2 | 13.17 | 7860.072 | 2395.750 | " |
| 36 | 486697.32 | 4018809.22 | 1865.5 | 568.60 | 35.5 | 10.82 | 7867.782 | 2398.100 | Bed |
| 37 | 486691.01 | 4018816.98 | 1898.3 | 578.60 | 27.0 | 8.23 | 7876.280 | 2400.690 | " |
| 38 | 486684.69 | 4018824.73 | 1931.1 | 588.60 | 10.9 | 3.32 | 7892.389 | 2405.600 | " |
| 39 | 486679.95 | 4018830.56 | 1955.7 | 596.11 | 0.0 | 0.00 | 7903.281 | 2408.920 | Water Edge on Right Bank |
| 40 | 486669.23 | 4018843.72 | 2011.5 | 613.09 | | | 7929.757 | 2416.990 | Slope |
| 41 | 486662.59 | 4018851.88 | 2046.0 | 623.61 | | | 7946.739 | 2422.166 | " |
| 42 | 486644.98 | 4018873.52 | 2137.5 | 651.51 | | | 7977.021 | 2431.396 | " |
| 43 | 486639.49 | 4018880.26 | 2166.0 | 660.20 | | | 7993.891 | 2436.538 | T.B.M on Right Bank |



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## Table 1-18 Cross Sectional Coordinates, Cross Section 14

| Sr. No. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 487174.43 | 4018460.56 | 0.0 | 0.00 | | | 7983.514 | 2433.375 | T,B.M on Left Bank |
| 2 | 487166.70 | 4018473.09 | 48.3 | 14.72 | | | 7954.508 | 2424.534 | Slope |
| 3 | 487160.73 | 4018482.76 | 85.6 | 26.09 | | | 7936.004 | 2418.894 | " |
| 4 | 487155.28 | 4018491.61 | 119.7 | 36.48 | | | 7917.743 | 2413.328 | " |
| 5 | 487151.46 | 4018497.80 | 143.5 | 43.75 | 0.0 | 0.00 | 7903.183 | 2408.890 | Water Edge on Left Bank |
| 6 | 487146.22 | 4018506.31 | 176.3 | 53.75 | 10.3 | 3.15 | 7892.848 | 2405.740 | Bed |
| 7 | 487140.97 | 4018514.82 | 209.2 | 63.75 | 27.2 | 8.30 | 7875.952 | 2400.590 | " |
| 8 | 487135.72 | 4018523.33 | 242.0 | 73.75 | 49.1 | 14.96 | 7854.101 | 2393.930 | " |
| 9 | 487130.47 | 4018531.84 | 274.8 | 83.75 | 75.9 | 23.13 | 7827.297 | 2385.760 | " |
| 10 | 487125.22 | 4018540.35 | 307.6 | 93.75 | 98.4 | 30.00 | 7804.757 | 2378.890 | " |
| 11 | 487119.97 | 4018548.87 | 340.4 | 103.75 | 111.7 | 34.06 | 7791.437 | 2374.830 | " |
| 12 | 487109.47 | 4018565.89 | 406.0 | 123.75 | 131.7 | 40.14 | 7771.490 | 2368.750 | " |
| 13 | 487098.98 | 4018582.91 | 471.6 | 143.75 | 131.8 | 40.16 | 7771.424 | 2368.730 | " |
| 14 | 487088.48 | 4018599.94 | 537.2 | 163.75 | 131.8 | 40.18 | 7771.359 | 2368.710 | " |
| 15 | 487077.98 | 4018616.96 | 602.9 | 183.75 | 131.8 | 40.17 | 7771.391 | 2368.720 | " |
| 16 | 487067.48 | 4018633.98 | 668.5 | 203.75 | 133.0 | 40.54 | 7770.177 | 2368.350 | " |
| 17 | 487056.98 | 4018651.01 | 734.1 | 223.75 | 132.1 | 40.26 | 7771.096 | 2368.630 | " |
| 18 | 487046.49 | 4018668.03 | 799.7 | 243.75 | 132.3 | 40.32 | 7770.899 | 2368.570 | " |
| 19 | 487035.99 | 4018685.05 | 865.3 | 263.75 | 132.2 | 40.29 | 7770.998 | 2368.600 | " |
| 20 | 487025.49 | 4018702.08 | 930.9 | 283.75 | 132.2 | 40.29 | 7770.998 | 2368.600 | " |
| 21 | 487014.99 | 4018719.10 | 996.6 | 303.75 | 132.3 | 40.31 | 7770.932 | 2368.580 | " |
| 22 | 487004.49 | 4018736.12 | 1062.2 | 323.75 | 132.3 | 40.34 | 7770.834 | 2368.550 | " |
| 23 | 486994.00 | 4018753.15 | 1127.8 | 343.75 | 132.3 | 40.33 | 7770.866 | 2368.560 | " |
| 24 | 486983.50 | 4018770.17 | 1193.4 | 363.75 | 132.2 | 40.29 | 7770.998 | 2368.600 | " |
| 25 | 486973.00 | 4018787.19 | 1259.0 | 383.75 | 132.4 | 40.36 | 7770.768 | 2368.530 | " |
| 26 | 486962.50 | 4018804.22 | 1324.6 | 403.75 | 132.1 | 40.27 | 7771.063 | 2368.620 | " |
| 27 | 486952.01 | 4018821.24 | 1390.3 | 423.75 | 132.2 | 40.29 | 7770.998 | 2368.600 | " |
| 28 | 486941.51 | 4018838.26 | 1455.9 | 443.75 | 131.8 | 40.18 | 7771.359 | 2368.710 | " |
| 29 | 486931.01 | 4018855.29 | 1521.5 | 463.75 | 131.7 | 40.13 | 7771.523 | 2368.760 | " |
| 30 | 486920.51 | 4018872.31 | 1587.1 | 483.75 | 131.8 | 40.17 | 7771.391 | 2368.720 | " |
| 31 | 486910.01 | 4018889.33 | 1652.7 | 503.75 | 119.2 | 36.32 | 7784.023 | 2372.570 | " |
| 32 | 486899.52 | 4018906.36 | 1718.3 | 523.75 | 78.9 | 24.05 | 7824.278 | 2384.840 | " |
| 33 | 486889.02 | 4018923.38 | 1784.0 | 543.75 | 56.4 | 17.20 | 7846.752 | 2391.690 | " |
| 34 | 486878.52 | 4018940.40 | 1849.6 | 563.75 | 52.3 | 15.94 | 7850.886 | 2392.950 | " |
| 35 | 486868.02 | 4018957.43 | 1915.2 | 583.75 | 34.5 | 10.51 | 7868.701 | 2398.380 | " |
| 36 | 486857.52 | 4018974.45 | 1980.8 | 603.75 | 34.2 | 10.41 | 7869.029 | 2398.480 | Bed |
| 37 | 486852.28 | 4018982.96 | 2013.6 | 613.75 | 32.9 | 10.04 | 7870.243 | 2398.850 | " |
| 38 | 486847.03 | 4018991.47 | 2046.4 | 623.75 | 28.9 | 8.81 | 7874.278 | 2400.080 | " |
| 39 | 486841.78 | 4018999.99 | 2079.2 | 633.75 | 25.5 | 7.78 | 7877.658 | 2401.110 | " |
| 40 | 486836.53 | 4019008.50 | 2112.0 | 643.75 | 21.6 | 6.58 | 7881.595 | 2402.310 | " |
| 41 | 486831.28 | 4019017.01 | 2144.8 | 653.75 | 19.7 | 6.00 | 7883.498 | 2402.890 | " |



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| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 42 | 486826.03 | 4019025.52 | 2177.7 | 663.75 | 25.3 | 7.72 | 7877.855 | 2401.170 | " |
| 43 | 486820.78 | 4019034.03 | 2210.5 | 673.75 | 25.1 | 7.66 | 7878.051 | 2401.230 | " |
| 44 | 486815.53 | 4019042.54 | 2243.3 | 683.75 | 23.4 | 7.13 | 7879.790 | 2401.760 | " |
| 45 | 486810.28 | 4019051.06 | 2276.1 | 693.75 | 20.4 | 6.22 | 7882.776 | 2402.670 | " |
| 46 | 486805.03 | 4019059.57 | 2308.9 | 703.75 | 14.8 | 4.50 | 7888.419 | 2404.390 | " |
| 47 | 486801.36 | 4019065.53 | 2331.9 | 710.75 | 12.5 | 3.81 | 7890.683 | 2405.080 | " |
| 48 | 486798.68 | 4019069.87 | 2348.6 | 715.85 | 0.0 | 0.00 | 7903.183 | 2408.890 | Water Edge on Right Bank |
| 49 | 486788.29 | 4019086.72 | 2413.5 | 735.65 | | | 7914.032 | 2412.197 | Slope |
| 50 | 486786.77 | 4019089.19 | 2423.1 | 738.55 | | | 7939.272 | 2419.890 | " |
| 51 | 486784.88 | 4019092.25 | 2434.9 | 742.15 | | | 7958.301 | 2425.690 | " |
| 52 | 486782.55 | 4019096.02 | 2449.4 | 746.58 | | | 7969.029 | 2428.960 | " |
| 53 | 486780.52 | 4019099.32 | 2462.1 | 750.45 | | | 7984.121 | 2433.560 | T.B.M on Right Bank (Vertical Cut) |



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## Table 1-19 Cross Sectional Coordinates, Cross Section 15

| Sr. No. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 487611.92 | 4018761.59 | 0.0 | 0.00 | | | 7981.135 | 2432.650 | T,B.M on Left Bank (House Wall) |
| 2 | 487610.81 | 4018763.26 | 6.6 | 2.00 | | | 7953.937 | 2424.360 | Slope |
| 3 | 487609.70 | 4018764.92 | 13.1 | 4.00 | | | 7944.751 | 2421.560 | " |
| 4 | 487608.60 | 4018766.59 | 19.7 | 6.00 | | | 7927.592 | 2416.330 | " |
| 5 | 487607.49 | 4018768.26 | 26.2 | 8.00 | | | 7911.418 | 2411.400 | " |
| 6 | 487606.34 | 4018769.99 | 33.1 | 10.08 | 0.0 | 0.00 | 7903.183 | 2408.890 | Water Edge on Left Bank |
| 7 | 487600.80 | 4018778.31 | 65.9 | 20.08 | 84.2 | 25.66 | 7818.996 | 2383.230 | Bed |
| 8 | 487595.26 | 4018786.64 | 98.7 | 30.08 | 101.7 | 31.00 | 7801.477 | 2377.890 | " |
| 9 | 487589.72 | 4018794.97 | 131.5 | 40.08 | 119.0 | 36.26 | 7784.219 | 2372.630 | " |
| 10 | 487584.19 | 4018803.29 | 164.3 | 50.08 | 128.2 | 39.07 | 7775.000 | 2369.820 | " |
| 11 | 487578.65 | 4018811.62 | 197.1 | 60.08 | 128.9 | 39.30 | 7774.246 | 2369.590 | " |
| 12 | 487573.11 | 4018819.95 | 229.9 | 70.08 | 129.1 | 39.36 | 7774.049 | 2369.530 | " |
| 13 | 487567.57 | 4018828.27 | 262.7 | 80.08 | 129.2 | 39.38 | 7773.983 | 2369.510 | " |
| 14 | 487562.03 | 4018836.60 | 295.5 | 90.08 | 129.2 | 39.39 | 7773.950 | 2369.500 | " |
| 15 | 487550.96 | 4018853.25 | 361.2 | 110.08 | 129.4 | 39.43 | 7773.819 | 2369.460 | " |
| 16 | 487539.88 | 4018869.91 | 426.8 | 130.08 | 129.6 | 39.50 | 7773.589 | 2369.390 | " |
| 17 | 487534.34 | 4018878.23 | 459.6 | 140.08 | 129.8 | 39.55 | 7773.425 | 2369.340 | " |
| 18 | 487517.73 | 4018903.21 | 558.0 | 170.08 | 130.0 | 39.62 | 7773.196 | 2369.270 | " |
| 19 | 487506.66 | 4018919.87 | 623.6 | 190.08 | 129.9 | 39.58 | 7773.327 | 2369.310 | " |
| 20 | 487495.58 | 4018936.52 | 689.2 | 210.08 | 130.1 | 39.65 | 7773.097 | 2369.240 | " |
| 21 | 487484.50 | 4018953.17 | 754.9 | 230.08 | 129.8 | 39.57 | 7773.360 | 2369.320 | " |
| 22 | 487473.43 | 4018969.82 | 820.5 | 250.08 | 130.7 | 39.84 | 7772.474 | 2369.050 | " |
| 23 | 487462.35 | 4018986.48 | 886.1 | 270.08 | 130.5 | 39.79 | 7772.638 | 2369.100 | " |
| 24 | 487451.28 | 4019003.13 | 951.7 | 290.08 | 130.5 | 39.79 | 7772.638 | 2369.100 | " |
| 25 | 487440.20 | 4019019.78 | 1017.3 | 310.08 | 130.5 | 39.79 | 7772.638 | 2369.100 | " |
| 26 | 487429.13 | 4019036.44 | 1082.9 | 330.08 | 130.7 | 39.84 | 7772.474 | 2369.050 | " |
| 27 | 487418.05 | 4019053.09 | 1148.6 | 350.08 | 130.9 | 39.89 | 7772.310 | 2369.000 | " |
| 28 | 487406.97 | 4019069.74 | 1214.2 | 370.08 | 131.1 | 39.97 | 7772.047 | 2368.920 | " |
| 29 | 487395.90 | 4019086.40 | 1279.8 | 390.08 | 131.7 | 40.13 | 7771.523 | 2368.760 | " |
| 30 | 487384.82 | 4019103.05 | 1345.4 | 410.08 | 131.3 | 40.02 | 7771.883 | 2368.870 | " |
| 31 | 487373.75 | 4019119.70 | 1411.0 | 430.08 | 131.5 | 40.09 | 7771.654 | 2368.800 | " |
| 32 | 487362.67 | 4019136.36 | 1476.6 | 450.08 | 131.5 | 40.08 | 7771.687 | 2368.810 | " |
| 33 | 487351.60 | 4019153.01 | 1542.3 | 470.08 | 131.6 | 40.11 | 7771.588 | 2368.780 | " |
| 34 | 487340.52 | 4019169.66 | 1607.9 | 490.08 | 131.9 | 40.19 | 7771.326 | 2368.700 | " |
| 35 | 487329.44 | 4019186.32 | 1673.5 | 510.08 | 131.8 | 40.16 | 7771.424 | 2368.730 | " |
| 36 | 487318.37 | 4019202.97 | 1739.1 | 530.08 | 131.8 | 40.18 | 7771.359 | 2368.710 | Bed |
| 37 | 487307.29 | 4019219.62 | 1804.7 | 550.08 | 131.6 | 40.12 | 7771.555 | 2368.770 | " |
| 38 | 487296.22 | 4019236.28 | 1870.3 | 570.08 | 130.9 | 39.9 | 7772.277 | 2368.990 | " |
| 39 | 487285.14 | 4019252.93 | 1936.0 | 590.08 | 114.1 | 34.8 | 7789.108 | 2374.120 | " |
| 40 | 487274.06 | 4019269.58 | 2001.6 | 610.08 | 89.1 | 27.2 | 7814.042 | 2381.720 | " |



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| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 41 | 487268.53 | 4019277.91 | 2034.4 | 620.08 | 84.5 | 25.8 | 7818.668 | 2383.130 | " |
| 42 | 487262.99 | 4019286.24 | 2067.2 | 630.08 | 73.8 | 22.5 | 7829.364 | 2386.390 | " |
| 43 | 487257.45 | 4019294.56 | 2100.0 | 640.08 | 61.9 | 18.88 | 7841.240 | 2390.010 | " |
| 44 | 487251.91 | 4019302.89 | 2132.8 | 650.08 | 58.1 | 17.71 | 7845.079 | 2391.180 | " |
| 45 | 487246.38 | 4019311.21 | 2165.6 | 660.08 | 53.2 | 16.23 | 7849.935 | 2392.660 | " |
| 46 | 487240.84 | 4019319.54 | 2198.4 | 670.08 | 49.9 | 15.20 | 7853.314 | 2393.690 | " |
| 47 | 487235.30 | 4019327.87 | 2231.2 | 680.08 | 41.5 | 12.65 | 7861.680 | 2396.240 | " |
| 48 | 487229.76 | 4019336.19 | 2264.0 | 690.08 | 35.5 | 10.81 | 7867.717 | 2398.080 | " |
| 49 | 487224.22 | 4019344.52 | 2296.9 | 700.08 | 29.1 | 8.88 | 7874.049 | 2400.010 | " |
| 50 | 487218.69 | 4019352.85 | 2329.7 | 710.08 | 22.4 | 6.83 | 7880.775 | 2402.060 | " |
| 51 | 487213.15 | 4019361.17 | 2362.5 | 720.08 | 17.2 | 5.23 | 7886.024 | 2403.660 | " |
| 52 | 487207.61 | 4019369.50 | 2395.3 | 730.08 | 10.3 | 3.15 | 7892.848 | 2405.740 | " |
| 53 | 487200.65 | 4019379.97 | 2436.5 | 742.65 | 0.0 | 0.00 | 7903.183 | 2408.890 | Water Edge on Right Bank |
| 54 | 487195.55 | 4019387.64 | 2466.7 | 751.86 | | | 7910.610 | 2411.154 | Slope |
| 55 | 487174.27 | 4019419.63 | 2592.8 | 790.28 | | | 7930.548 | 2417.231 | " |
| 56 | 487136.50 | 4019476.42 | 2816.6 | 858.49 | | | 7964.774 | 2427.663 | " |
| 57 | 487125.64 | 4019492.75 | 2880.9 | 878.10 | | | 7977.313 | 2431.485 | T.B.M on Right Bank |



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## Table 1-20 Cross Sectional Coordinates, Cross Section 16

| Sr. No. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 488067.42 | 4018935.26 | 0.0 | 0.00 | | | 7977.303 | 2431.482 | T,B.M on Left Bank |
| 2 | 488043.73 | 4018967.85 | 132.2 | 40.29 | | | 7948.537 | 2422.714 | Slope |
| 3 | 488015.39 | 4019006.85 | 290.4 | 88.50 | | | 7937.769 | 2419.432 | " |
| 4 | 488009.54 | 4019014.89 | 323.0 | 98.44 | | | 7922.536 | 2414.789 | " |
| 5 | 487999.22 | 4019029.09 | 380.6 | 116.00 | | | 7911.559 | 2411.443 | " |
| 6 | 487981.88 | 4019052.96 | 477.4 | 145.50 | 0.0 | 0.00 | 7903.101 | 2408.865 | Water Edge on Left Bank |
| 7 | 487976.00 | 4019061.05 | 510.2 | 155.50 | 9.3 | 2.82 | 7893.849 | 2406.045 | Bed |
| 8 | 487970.12 | 4019069.14 | 543.0 | 165.50 | 14.7 | 4.48 | 7888.402 | 2404.385 | " |
| 9 | 487964.24 | 4019077.22 | 575.8 | 175.50 | 15.3 | 4.66 | 7887.812 | 2404.205 | " |
| 10 | 487958.36 | 4019085.31 | 608.6 | 185.50 | 24.3 | 7.41 | 7878.790 | 2401.455 | " |
| 11 | 487952.48 | 4019093.40 | 641.4 | 195.50 | 40.4 | 12.31 | 7862.714 | 2396.555 | " |
| 12 | 487946.60 | 4019101.49 | 674.2 | 205.50 | 51.3 | 15.63 | 7851.821 | 2393.235 | " |
| 13 | 487934.85 | 4019117.67 | 739.8 | 225.50 | 78.6 | 23.96 | 7824.492 | 2384.905 | " |
| 14 | 487923.09 | 4019133.85 | 805.4 | 245.50 | 86.4 | 26.33 | 7816.716 | 2382.535 | " |
| 15 | 487911.33 | 4019150.03 | 871.1 | 265.50 | 104.4 | 31.83 | 7798.672 | 2377.035 | " |
| 16 | 487899.57 | 4019166.21 | 936.7 | 285.50 | 114.8 | 35.00 | 7788.271 | 2373.865 | " |
| 17 | 487887.82 | 4019182.39 | 1002.3 | 305.50 | 118.3 | 36.05 | 7784.826 | 2372.815 | " |
| 18 | 487876.06 | 4019198.57 | 1067.9 | 325.50 | 120.6 | 36.76 | 7782.497 | 2372.105 | " |
| 19 | 487864.30 | 4019214.74 | 1133.5 | 345.50 | 125.2 | 38.15 | 7777.937 | 2370.715 | " |
| 20 | 487852.54 | 4019230.92 | 1199.1 | 365.50 | 123.6 | 37.66 | 7779.544 | 2371.205 | " |
| 21 | 487840.78 | 4019247.10 | 1264.8 | 385.50 | 125.4 | 38.22 | 7777.707 | 2370.645 | " |
| 22 | 487829.03 | 4019263.28 | 1330.4 | 405.50 | 127.7 | 38.92 | 7775.410 | 2369.945 | " |
| 23 | 487817.27 | 4019279.46 | 1396.0 | 425.50 | 128.1 | 39.03 | 7775.049 | 2369.835 | " |
| 24 | 487805.51 | 4019295.64 | 1461.6 | 445.50 | 128.3 | 39.11 | 7774.787 | 2369.755 | " |
| 25 | 487793.75 | 4019311.82 | 1527.2 | 465.50 | 128.6 | 39.20 | 7774.492 | 2369.665 | " |
| 26 | 487781.99 | 4019328.00 | 1592.8 | 485.50 | 129.1 | 39.35 | 7774.000 | 2369.515 | " |
| 27 | 487770.24 | 4019344.17 | 1658.5 | 505.50 | 129.7 | 39.52 | 7773.442 | 2369.345 | " |
| 28 | 487758.48 | 4019360.35 | 1724.1 | 525.50 | 130.0 | 39.62 | 7773.114 | 2369.245 | " |
| 29 | 487746.72 | 4019376.53 | 1789.7 | 545.50 | 130.4 | 39.75 | 7772.687 | 2369.115 | " |
| 30 | 487734.96 | 4019392.71 | 1855.3 | 565.50 | 130.5 | 39.79 | 7772.556 | 2369.075 | " |
| 31 | 487723.20 | 4019408.89 | 1920.9 | 585.50 | 130.7 | 39.84 | 7772.392 | 2369.025 | " |
| 32 | 487711.45 | 4019425.07 | 1986.5 | 605.50 | 130.8 | 39.86 | 7772.326 | 2369.005 | " |
| 33 | 487699.69 | 4019441.25 | 2052.2 | 625.50 | 130.9 | 39.90 | 7772.195 | 2368.965 | " |
| 34 | 487687.93 | 4019457.42 | 2117.8 | 645.50 | 130.9 | 39.90 | 7772.195 | 2368.965 | " |
| 35 | 487676.17 | 4019473.60 | 2183.4 | 665.50 | 130.9 | 39.89 | 7772.228 | 2368.975 | " |
| 36 | 487664.41 | 4019489.78 | 2249.0 | 685.50 | 130.8 | 39.88 | 7772.261 | 2368.985 | Bed |
| 37 | 487652.66 | 4019505.96 | 2314.6 | 705.50 | 130.7 | 39.84 | 7772.392 | 2369.025 | " |
| 38 | 487640.90 | 4019522.14 | 2380.2 | 725.50 | 130.7 | 39.83 | 7772.425 | 2369.035 | " |
| 39 | 487629.14 | 4019538.32 | 2445.9 | 745.50 | 130.5 | 39.77 | 7772.622 | 2369.095 | " |
| 40 | 487623.26 | 4019546.41 | 2478.7 | 755.50 | 116.8 | 35.61 | 7786.270 | 2373.255 | " |
| 41 | 487617.38 | 4019554.50 | 2511.5 | 765.50 | 106.7 | 32.53 | 7796.375 | 2376.335 | " |



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| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 42 | 487611.50 | 4019562.59 | 2544.3 | 775.50 | 76.5 | 23.33 | 7826.559 | 2385.535 | " |
| 43 | 487605.63 | 4019570.68 | 2577.1 | 785.50 | 51.8 | 15.80 | 7851.263 | 2393.065 | " |
| 44 | 487599.75 | 4019578.77 | 2609.9 | 795.50 | 33.5 | 10.20 | 7869.636 | 2398.665 | " |
| 45 | 487596.81 | 4019582.81 | 2626.3 | 800.50 | 18.8 | 5.72 | 7884.334 | 2403.145 | " |
| 46 | 487592.83 | 4019588.28 | 2648.5 | 807.26 | 0.0 | 0.00 | 7903.101 | 2408.865 | Water Edge on Right Bank |
| 47 | 487589.86 | 4019592.37 | 2665.1 | 812.32 | | | 7910.561 | 2411.139 | Slope |
| 48 | 487579.21 | 4019607.02 | 2724.5 | 830.43 | | | 7930.919 | 2417.344 | " |
| 49 | 487570.49 | 4019619.02 | 2773.2 | 845.26 | | | 7947.041 | 2422.258 | " |
| 50 | 487555.68 | 4019639.40 | 2855.8 | 870.45 | | | 7958.537 | 2425.762 | " |
| 51 | 487537.06 | 4019665.02 | 2959.7 | 902.13 | | | 7980.479 | 2432.450 | T.B.M on Right Bank |

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## Table 1-21 Cross Sectional Coordinates, Cross Section 17

| Sr. No. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 488362.80 | 4019198.00 | 0.0 | 0.00 | | | 7978.806 | 2431.940 | T,B.M on Left Bank (House Wall) |
| 2 | 488361.95 | 4019199.81 | 6.6 | 2.00 | | | 7941.060 | 2420.435 | Slope |
| 3 | 488358.81 | 4019206.51 | 30.8 | 9.40 | | | 7932.671 | 2417.878 | " |
| 4 | 488352.04 | 4019220.99 | 83.3 | 25.38 | | | 7917.930 | 2413.385 | " |
| 5 | 488341.03 | 4019244.52 | 168.5 | 51.36 | | | 7908.586 | 2410.537 | " |
| 6 | 488336.25 | 4019254.74 | 205.5 | 62.64 | 0.0 | 0.00 | 7903.101 | 2408.865 | Water Edge on Left Bank |
| 7 | 488332.02 | 4019263.80 | 238.3 | 72.64 | 10.9 | 3.32 | 7892.208 | 2405.545 | Bed |
| 8 | 488327.78 | 4019272.85 | 271.1 | 82.64 | 11.2 | 3.41 | 7891.913 | 2405.455 | " |
| 9 | 488323.54 | 4019281.91 | 303.9 | 92.64 | 11.8 | 3.60 | 7891.290 | 2405.265 | " |
| 10 | 488319.31 | 4019290.97 | 336.7 | 102.64 | 12.5 | 3.82 | 7890.568 | 2405.045 | " |
| 11 | 488315.07 | 4019300.03 | 369.6 | 112.64 | 14.6 | 4.45 | 7888.501 | 2404.415 | " |
| 12 | 488310.83 | 4019309.09 | 402.4 | 122.64 | 17.7 | 5.41 | 7885.351 | 2403.455 | " |
| 13 | 488302.36 | 4019327.20 | 468.0 | 142.64 | 21.1 | 6.44 | 7881.972 | 2402.425 | " |
| 14 | 488293.88 | 4019345.32 | 533.6 | 162.64 | 24.7 | 7.53 | 7878.396 | 2401.335 | " |
| 15 | 488285.41 | 4019363.43 | 599.2 | 182.64 | 30.0 | 9.15 | 7873.081 | 2399.715 | " |
| 16 | 488276.93 | 4019381.55 | 664.8 | 202.64 | 33.0 | 10.06 | 7870.095 | 2398.805 | " |
| 17 | 488268.46 | 4019399.66 | 730.4 | 222.64 | 34.8 | 10.60 | 7868.324 | 2398.265 | " |
| 18 | 488259.99 | 4019417.78 | 796.1 | 242.64 | 36.6 | 11.16 | 7866.486 | 2397.705 | " |
| 19 | 488251.51 | 4019435.90 | 861.7 | 262.64 | 35.2 | 10.73 | 7867.897 | 2398.135 | " |
| 20 | 488243.04 | 4019454.01 | 927.3 | 282.64 | 36.0 | 10.98 | 7867.077 | 2397.885 | " |
| 21 | 488234.56 | 4019472.13 | 992.9 | 302.64 | 32.6 | 9.94 | 7870.489 | 2398.925 | " |
| 22 | 488226.09 | 4019490.24 | 1058.5 | 322.64 | 36.9 | 11.26 | 7866.158 | 2397.605 | " |
| 23 | 488217.61 | 4019508.36 | 1124.1 | 342.64 | 68.2 | 20.79 | 7834.892 | 2388.075 | " |
| 24 | 488209.14 | 4019526.48 | 1189.8 | 362.64 | 119.9 | 36.56 | 7783.153 | 2372.305 | " |
| 25 | 488200.67 | 4019544.59 | 1255.4 | 382.64 | 129.9 | 39.58 | 7773.245 | 2369.285 | " |
| 26 | 488192.19 | 4019562.71 | 1321.0 | 402.64 | 129.9 | 39.60 | 7773.179 | 2369.265 | " |
| 27 | 488183.72 | 4019580.82 | 1386.6 | 422.64 | 130.0 | 39.61 | 7773.147 | 2369.255 | " |
| 28 | 488175.24 | 4019598.94 | 1452.2 | 442.64 | 129.9 | 39.59 | 7773.212 | 2369.275 | " |
| 29 | 488166.77 | 4019617.06 | 1517.8 | 462.64 | 129.7 | 39.52 | 7773.442 | 2369.345 | " |
| 30 | 488158.29 | 4019635.17 | 1583.5 | 482.64 | 129.9 | 39.58 | 7773.245 | 2369.285 | " |
| 31 | 488149.82 | 4019653.29 | 1649.1 | 502.64 | 129.8 | 39.55 | 7773.343 | 2369.315 | " |
| 32 | 488141.35 | 4019671.40 | 1714.7 | 522.64 | 129.5 | 39.46 | 7773.639 | 2369.405 | " |
| 33 | 488132.87 | 4019689.52 | 1780.3 | 542.64 | 129.2 | 39.37 | 7773.934 | 2369.495 | " |
| 34 | 488124.40 | 4019707.63 | 1845.9 | 562.64 | 128.7 | 39.24 | 7774.360 | 2369.625 | " |
| 35 | 488115.92 | 4019725.75 | 1911.5 | 582.64 | 128.5 | 39.17 | 7774.590 | 2369.695 | " |
| 36 | 488107.45 | 4019743.87 | 1977.2 | 602.64 | 128.1 | 39.04 | 7775.017 | 2369.825 | Bed |
| 37 | 488098.97 | 4019761.98 | 2042.8 | 622.64 | 127.8 | 38.96 | 7775.279 | 2369.905 | " |
| 38 | 488094.74 | 4019771.04 | 2075.6 | 632.64 | 127.8 | 38.94 | 7775.345 | 2369.925 | " |
| 39 | 488090.50 | 4019780.10 | 2108.4 | 642.64 | 127.7 | 38.93 | 7775.378 | 2369.935 | " |
| 40 | 488086.26 | 4019789.16 | 2141.2 | 652.64 | 127.6 | 38.89 | 7775.509 | 2369.975 | " |



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| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 41 | 488082.02 | 4019798.21 | 2174.0 | 662.64 | 127.5 | 38.87 | 7775.574 | 2369.995 | " |
| 42 | 488077.79 | 4019807.27 | 2206.8 | 672.64 | 127.5 | 38.86 | 7775.607 | 2370.005 | " |
| 43 | 488073.55 | 4019816.33 | 2239.6 | 682.64 | 127.6 | 38.88 | 7775.542 | 2369.985 | " |
| 44 | 488069.31 | 4019825.39 | 2272.4 | 692.64 | 127.6 | 38.88 | 7775.542 | 2369.985 | " |
| 45 | 488067.45 | 4019829.37 | 2286.9 | 697.04 | 127.9 | 38.98 | 7775.214 | 2369.885 | " |
| 46 | 488067.21 | 4019829.88 | 2288.7 | 697.60 | 0.0 | 0.00 | 7903.101 | 2408.865 | Water Edge on Right Bank |
| 47 | 488065.06 | 4019834.49 | 2305.4 | 702.69 | | | 7925.492 | 2415.690 | Slope |
| 48 | 488063.00 | 4019838.89 | 2321.4 | 707.55 | | | 7958.170 | 2425.650 | " |
| 49 | 488061.96 | 4019841.10 | 2329.4 | 709.99 | | | 7967.684 | 2428.550 | " |
| 50 | 488061.01 | 4019843.13 | 2336.7 | 712.23 | | | 7981.792 | 2432.850 | T.B.M on Right Bank (Vertical Cut) |

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## Table 1-22 Cross Sectional Coordinates, Cross Section 18

| Sr. No. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 488720.98 | 4019350.99 | 0.0 | 0.00 | | | 7977.674 | 2431.595 | T,B.M on Left Bank |
| 2 | 488707.82 | 4019374.46 | 88.3 | 26.91 | | | 7964.347 | 2427.533 | Slope |
| 3 | 488696.63 | 4019394.42 | 163.4 | 49.79 | | | 7954.193 | 2424.438 | " |
| 4 | 488690.47 | 4019405.42 | 204.7 | 62.40 | | | 7945.151 | 2421.682 | " |
| 5 | 488662.35 | 4019455.59 | 393.4 | 119.91 | | | 7937.097 | 2419.227 | " |
| 6 | 488660.56 | 4019458.79 | 405.4 | 123.58 | | | 7925.978 | 2415.838 | " |
| 7 | 488654.02 | 4019470.46 | 449.3 | 136.95 | | | 7922.727 | 2414.847 | " |
| 8 | 488636.77 | 4019501.24 | 565.1 | 172.24 | | | 7911.995 | 2411.576 | " |
| 9 | 488631.90 | 4019509.93 | 597.8 | 182.20 | 0.0 | 0.00 | 7903.019 | 2408.840 | Water Edge on Left Bank |
| 10 | 488627.01 | 4019518.65 | 630.6 | 192.20 | 9.2 | 2.79 | 7893.865 | 2406.050 | Bed |
| 11 | 488622.12 | 4019527.38 | 663.4 | 202.20 | 12.1 | 3.68 | 7890.945 | 2405.160 | " |
| 12 | 488617.23 | 4019536.10 | 696.2 | 212.20 | 14.4 | 4.40 | 7888.583 | 2404.440 | " |
| 13 | 488612.34 | 4019544.82 | 729.0 | 222.20 | 15.6 | 4.74 | 7887.467 | 2404.100 | " |
| 14 | 488607.45 | 4019553.55 | 761.8 | 232.20 | 21.0 | 6.41 | 7881.988 | 2402.430 | " |
| 15 | 488602.56 | 4019562.27 | 794.6 | 242.20 | 23.9 | 7.28 | 7879.134 | 2401.560 | " |
| 16 | 488597.67 | 4019570.99 | 827.4 | 252.20 | 21.1 | 6.42 | 7881.956 | 2402.420 | " |
| 17 | 488592.78 | 4019579.72 | 860.2 | 262.20 | 25.7 | 7.83 | 7877.330 | 2401.010 | " |
| 18 | 488587.89 | 4019588.44 | 893.0 | 272.20 | 21.9 | 6.68 | 7881.103 | 2402.160 | " |
| 19 | 488583.00 | 4019597.16 | 925.9 | 282.20 | 22.5 | 6.87 | 7880.479 | 2401.970 | " |
| 20 | 488573.23 | 4019614.61 | 991.5 | 302.20 | 44.7 | 13.61 | 7858.366 | 2395.230 | " |
| 21 | 488563.45 | 4019632.06 | 1057.1 | 322.20 | 48.3 | 14.71 | 7854.757 | 2394.130 | " |
| 22 | 488553.67 | 4019649.50 | 1122.7 | 342.20 | 50.4 | 15.37 | 7852.592 | 2393.470 | " |
| 23 | 488543.89 | 4019666.95 | 1188.3 | 362.20 | 58.1 | 17.71 | 7844.915 | 2391.130 | " |
| 24 | 488534.11 | 4019684.40 | 1253.9 | 382.20 | 54.0 | 16.47 | 7848.983 | 2392.370 | " |
| 25 | 488524.34 | 4019701.84 | 1319.6 | 402.20 | 83.9 | 25.57 | 7819.128 | 2383.270 | " |
| 26 | 488514.56 | 4019719.29 | 1385.2 | 422.20 | 102.5 | 31.23 | 7800.558 | 2377.610 | " |
| 27 | 488504.78 | 4019736.74 | 1450.8 | 442.20 | 128.0 | 39.02 | 7775.000 | 2369.820 | " |
| 28 | 488495.00 | 4019754.18 | 1516.4 | 462.20 | 128.0 | 39.02 | 7775.000 | 2369.820 | " |
| 29 | 488485.22 | 4019771.63 | 1582.0 | 482.20 | 126.7 | 38.61 | 7776.345 | 2370.230 | " |
| 30 | 488475.44 | 4019789.08 | 1647.6 | 502.20 | 126.1 | 38.45 | 7776.870 | 2370.390 | " |
| 31 | 488465.67 | 4019806.52 | 1713.3 | 522.20 | 125.9 | 38.38 | 7777.100 | 2370.460 | " |
| 32 | 488455.89 | 4019823.97 | 1778.9 | 542.20 | 125.6 | 38.29 | 7777.395 | 2370.550 | " |
| 33 | 488446.11 | 4019841.42 | 1844.5 | 562.20 | 125.7 | 38.32 | 7777.297 | 2370.520 | " |
| 34 | 488436.33 | 4019858.86 | 1910.1 | 582.20 | 126.1 | 38.44 | 7776.903 | 2370.400 | " |
| 35 | 488426.55 | 4019876.31 | 1975.7 | 602.20 | 126.1 | 38.44 | 7776.903 | 2370.400 | " |
| 36 | 488416.77 | 4019893.76 | 2041.3 | 622.20 | 125.7 | 38.31 | 7777.330 | 2370.530 | Bed |
| 37 | 488407.00 | 4019911.20 | 2107.0 | 642.20 | 125.7 | 38.30 | 7777.362 | 2370.540 | " |
| 38 | 488397.22 | 4019928.65 | 2172.6 | 662.20 | 126.0 | 38.40 | 7777.034 | 2370.440 | " |
| 39 | 488392.33 | 4019937.37 | 2205.4 | 672.20 | 125.9 | 38.38 | 7777.100 | 2370.460 | " |
| 40 | 488387.44 | 4019946.10 | 2238.2 | 682.20 | 125.8 | 38.34 | 7777.231 | 2370.500 | " |
| 41 | 488382.55 | 4019954.82 | 2271.0 | 692.20 | 126.1 | 38.43 | 7776.936 | 2370.410 | " |
| 42 | 488377.66 | 4019963.54 | 2303.8 | 702.20 | 126.2 | 38.48 | 7776.772 | 2370.360 | " |
| 43 | 488372.77 | 4019972.27 | 2336.6 | 712.20 | 126.5 | 38.56 | 7776.509 | 2370.280 | " |
| 44 | 488368.86 | 4019979.24 | 2362.9 | 720.20 | 126.0 | 38.42 | 7776.969 | 2370.420 | " |
| 45 | 488367.46 | 4019981.74 | 2372.2 | 723.06 | 0.0 | 0.00 | 7903.019 | 2408.840 | Water Edge on Right Bank |
| 46 | 488367.21 | 4019982.18 | 2373.9 | 723.57 | | | 7905.942 | 2409.731 | T.B.M on Right Bank |



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## Table 1-23 Cross Sectional Coordinates, Cross Section 18 A

| Sr. No. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 488924.82 | 4019809.66 | 0.0 | 0.00 | | | 7983.990 | 2433.520 | T,B.M on Left Bank |
| 2 | 488911.75 | 4019813.69 | 44.9 | 13.68 | | | 7969.052 | 2428.967 | Slope |
| 3 | 488872.42 | 4019825.83 | 179.9 | 54.84 | | | 7914.023 | 2412.194 | " |
| 4 | 488864.94 | 4019828.14 | 205.6 | 62.67 | 0.0 | 0.00 | 7902.887 | 2408.800 | Water Edge on Left Bank |
| 5 | 488855.38 | 4019831.09 | 238.4 | 72.67 | 9.6 | 2.94 | 7893.242 | 2405.860 | Bed |
| 6 | 488845.83 | 4019834.04 | 271.2 | 82.67 | 18.5 | 5.64 | 7884.383 | 2403.160 | " |
| 7 | 488836.27 | 4019836.99 | 304.0 | 92.67 | 25.1 | 7.64 | 7877.822 | 2401.160 | " |
| 8 | 488826.72 | 4019839.94 | 336.8 | 102.67 | 30.3 | 9.23 | 7872.605 | 2399.570 | " |
| 9 | 488817.16 | 4019842.89 | 369.7 | 112.67 | 33.2 | 10.13 | 7869.652 | 2398.670 | " |
| 10 | 488807.61 | 4019845.84 | 402.5 | 122.67 | 32.0 | 9.75 | 7870.899 | 2399.050 | " |
| 11 | 488798.05 | 4019848.79 | 435.3 | 132.67 | 37.9 | 11.54 | 7865.026 | 2397.260 | " |
| 12 | 488788.50 | 4019851.74 | 468.1 | 142.67 | 38.6 | 11.77 | 7864.272 | 2397.030 | " |
| 13 | 488778.94 | 4019854.69 | 500.9 | 152.67 | 40.5 | 12.35 | 7862.369 | 2396.450 | " |
| 14 | 488769.39 | 4019857.64 | 533.7 | 162.67 | 44.7 | 13.61 | 7858.235 | 2395.190 | " |
| 15 | 488750.28 | 4019863.54 | 599.3 | 182.67 | 52.7 | 16.07 | 7850.164 | 2392.730 | " |
| 16 | 488731.17 | 4019869.44 | 664.9 | 202.67 | 59.5 | 18.15 | 7843.340 | 2390.650 | " |
| 17 | 488712.06 | 4019875.34 | 730.5 | 222.67 | 53.8 | 16.40 | 7849.082 | 2392.400 | " |
| 18 | 488692.95 | 4019881.24 | 796.2 | 242.67 | 64.6 | 19.69 | 7838.288 | 2389.110 | " |
| 19 | 488673.84 | 4019887.14 | 861.8 | 262.67 | 66.1 | 20.14 | 7836.811 | 2388.660 | " |
| 20 | 488654.73 | 4019893.05 | 927.4 | 282.67 | 75.9 | 23.12 | 7827.034 | 2385.680 | " |
| 21 | 488635.62 | 4019898.95 | 993.0 | 302.67 | 90.9 | 27.70 | 7812.008 | 2381.100 | " |
| 22 | 488616.51 | 4019904.85 | 1058.6 | 322.67 | 103.6 | 31.58 | 7799.278 | 2377.220 | " |
| 23 | 488597.40 | 4019910.75 | 1124.2 | 342.67 | 109.1 | 33.25 | 7793.799 | 2375.550 | " |
| 24 | 488578.29 | 4019916.65 | 1189.9 | 362.67 | 110.6 | 33.70 | 7792.323 | 2375.100 | " |
| 25 | 488559.18 | 4019922.55 | 1255.5 | 382.67 | 113.6 | 34.63 | 7789.272 | 2374.170 | " |
| 26 | 488540.07 | 4019928.45 | 1321.1 | 402.67 | 118.4 | 36.10 | 7784.449 | 2372.700 | " |
| 27 | 488520.96 | 4019934.35 | 1386.7 | 422.67 | 120.0 | 36.58 | 7782.874 | 2372.220 | " |
| 28 | 488501.85 | 4019940.25 | 1452.3 | 442.67 | 122.0 | 37.20 | 7780.840 | 2371.600 | " |
| 29 | 488482.74 | 4019946.15 | 1517.9 | 462.67 | 124.3 | 37.88 | 7778.609 | 2370.920 | " |
| 30 | 488463.63 | 4019952.05 | 1583.6 | 482.67 | 124.3 | 37.89 | 7778.576 | 2370.910 | " |
| 31 | 488444.52 | 4019957.95 | 1649.2 | 502.67 | 124.7 | 38.01 | 7778.183 | 2370.790 | " |
| 32 | 488425.41 | 4019963.85 | 1714.8 | 522.67 | 125.0 | 38.10 | 7777.887 | 2370.700 | " |
| 33 | 488415.86 | 4019966.80 | 1747.6 | 532.67 | 125.2 | 38.16 | 7777.691 | 2370.640 | " |
| 34 | 488406.30 | 4019969.75 | 1780.4 | 542.67 | 125.3 | 38.19 | 7777.592 | 2370.610 | " |
| 35 | 488396.75 | 4019972.70 | 1813.2 | 552.67 | 125.5 | 38.26 | 7777.362 | 2370.540 | " |
| 36 | 488387.19 | 4019975.65 | 1846.0 | 562.67 | 125.6 | 38.28 | 7777.297 | 2370.520 | Bed |
| 37 | 488377.64 | 4019978.60 | 1878.8 | 572.67 | 126.0 | 38.40 | 7776.903 | 2370.400 | " |
| 38 | 488368.08 | 4019981.55 | 1911.6 | 582.67 | 126.4 | 38.54 | 7776.444 | 2370.260 | " |
| 39 | 488367.47 | 4019981.74 | 1913.7 | 583.31 | 0.0 | 0.00 | 7902.887 | 2408.800 | Water Edge on Right Bank |
| 40 | 488366.98 | 4019981.89 | 1915.4 | 583.82 | | | 7905.939 | 2409.730 | T.B.M on Right Bank |



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## Table 1-24 Cross Sectional Coordinates, Cross Section 18 B

| Sr. No. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 488871.55 | 4020224.61 | 0.0 | 0.00 | | | 7986.053 | 2434.149 | T,B.M on Left Bank |
| 2 | 488870.43 | 4020224.07 | 4.1 | 1.24 | | | 7965.079 | 2427.756 | Slope |
| 3 | 488856.31 | 4020217.27 | 55.5 | 16.91 | | | 7951.815 | 2423.713 | " |
| 4 | 488846.49 | 4020212.53 | 91.3 | 27.82 | | | 7946.621 | 2422.130 | " |
| 5 | 488829.78 | 4020204.49 | 152.1 | 46.36 | | | 7939.859 | 2420.069 | " |
| 6 | 488809.75 | 4020194.83 | 225.1 | 68.60 | | | 7923.353 | 2415.038 | " |
| 7 | 488781.57 | 4020181.26 | 327.7 | 99.88 | 0.0 | 0.00 | 7902.887 | 2408.800 | Water Edge on Left Bank |
| 8 | 488772.56 | 4020176.92 | 360.5 | 109.88 | 5.1 | 1.55 | 7897.802 | 2407.250 | Bed |
| 9 | 488763.55 | 4020172.57 | 393.3 | 119.88 | 8.6 | 2.62 | 7894.292 | 2406.180 | " |
| 10 | 488754.54 | 4020168.23 | 426.1 | 129.88 | 14.2 | 4.33 | 7888.681 | 2404.470 | " |
| 11 | 488745.53 | 4020163.89 | 458.9 | 139.88 | 15.2 | 4.62 | 7887.730 | 2404.180 | " |
| 12 | 488736.52 | 4020159.55 | 491.7 | 149.88 | 32.7 | 9.96 | 7870.210 | 2398.840 | " |
| 13 | 488727.52 | 4020155.21 | 524.5 | 159.88 | 37.5 | 11.42 | 7865.420 | 2397.380 | " |
| 14 | 488718.51 | 4020150.87 | 557.3 | 169.88 | 44.3 | 13.51 | 7858.563 | 2395.290 | " |
| 15 | 488709.50 | 4020146.53 | 590.2 | 179.88 | 45.4 | 13.85 | 7857.448 | 2394.950 | " |
| 16 | 488700.49 | 4020142.19 | 623.0 | 189.88 | 47.8 | 14.58 | 7855.053 | 2394.220 | " |
| 17 | 488691.48 | 4020137.85 | 655.8 | 199.88 | 50.1 | 15.26 | 7852.822 | 2393.540 | " |
| 18 | 488673.46 | 4020129.17 | 721.4 | 219.88 | 69.0 | 21.02 | 7833.924 | 2387.780 | " |
| 19 | 488655.44 | 4020120.49 | 787.0 | 239.88 | 80.5 | 24.53 | 7822.408 | 2384.270 | " |
| 20 | 488637.43 | 4020111.81 | 852.6 | 259.88 | 63.9 | 19.47 | 7839.009 | 2389.330 | " |
| 21 | 488619.41 | 4020103.13 | 918.2 | 279.88 | 58.5 | 17.82 | 7844.423 | 2390.980 | " |
| 22 | 488601.39 | 4020094.44 | 983.9 | 299.88 | 87.2 | 26.59 | 7815.650 | 2382.210 | " |
| 23 | 488583.37 | 4020085.76 | 1049.5 | 319.88 | 110.2 | 33.58 | 7792.717 | 2375.220 | " |
| 24 | 488565.36 | 4020077.08 | 1115.1 | 339.88 | 121.1 | 36.90 | 7781.824 | 2371.900 | " |
| 25 | 488547.34 | 4020068.40 | 1180.7 | 359.88 | 121.6 | 37.06 | 7781.299 | 2371.740 | " |
| 26 | 488529.32 | 4020059.72 | 1246.3 | 379.88 | 121.8 | 37.13 | 7781.070 | 2371.670 | " |
| 27 | 488511.30 | 4020051.04 | 1311.9 | 399.88 | 121.9 | 37.14 | 7781.037 | 2371.660 | " |
| 28 | 488493.36 | 4020042.39 | 1377.3 | 419.80 | 122.5 | 37.33 | 7780.414 | 2371.470 | " |
| 29 | 488475.27 | 4020033.68 | 1443.2 | 439.88 | 123.6 | 37.68 | 7779.265 | 2371.120 | " |
| 30 | 488457.25 | 4020025.00 | 1508.8 | 459.88 | 123.7 | 37.70 | 7779.200 | 2371.100 | " |
| 31 | 488439.23 | 4020016.31 | 1574.4 | 479.88 | 124.3 | 37.90 | 7778.544 | 2370.900 | " |
| 32 | 488421.21 | 4020007.63 | 1640.0 | 499.88 | 124.6 | 37.99 | 7778.248 | 2370.810 | " |
| 33 | 488412.21 | 4020003.29 | 1672.8 | 509.88 | 125.2 | 38.15 | 7777.723 | 2370.650 | " |
| 34 | 488403.20 | 4019998.95 | 1705.6 | 519.88 | 125.6 | 38.27 | 7777.330 | 2370.530 | " |
| 35 | 488394.19 | 4019994.61 | 1738.5 | 529.88 | 125.9 | 38.37 | 7777.002 | 2370.430 | " |
| 36 | 488385.18 | 4019990.27 | 1771.3 | 539.88 | 126.1 | 38.45 | 7776.739 | 2370.350 | Bed |
| 37 | 488376.17 | 4019985.93 | 1804.1 | 549.88 | 126.6 | 38.58 | 7776.313 | 2370.220 | " |
| 38 | 488367.47 | 4019981.74 | 1835.8 | 559.54 | 0.0 | 0.00 | 7902.887 | 2408.800 | Water Edge on Right Bank |
| 39 | 488363.76 | 4019979.95 | 1849.2 | 563.65 | | | 7925.000 | 2415.540 | Slope |
| 40 | 488361.24 | 4019978.74 | 1858.4 | 566.45 | | | 7959.121 | 2425.940 | " |
| 41 | 488358.36 | 4019977.35 | 1868.9 | 569.65 | | | 7967.684 | 2428.550 | " |
| 42 | 488353.95 | 4019975.23 | 1885.0 | 574.54 | | | 7982.087 | 2432.940 | T.B.M on Right Bank (Vertical Cut) |



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## Table 1-25 Cross Sectional Coordinates, Cross Section 18 C

| Sr. No. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 488596.26 | 4019748.04 | 0.0 | 0.00 | | | 7921.733 | 2414.544 | T,B.M on Left Bank (House Wall) |
| 2 | 488595.41 | 4019748.92 | 4.0 | 1.22 | | | 7910.627 | 2411.159 | Slope |
| 3 | 488592.25 | 4019752.14 | 18.8 | 5.73 | 0.0 | 0.00 | 7902.625 | 2408.720 | Water Edge on Left Bank |
| 4 | 488585.25 | 4019759.28 | 51.6 | 15.73 | 7.5 | 2.30 | 7895.079 | 2406.420 | Bed |
| 5 | 488578.26 | 4019766.43 | 84.4 | 25.73 | 32.1 | 9.78 | 7870.538 | 2398.940 | " |
| 6 | 488571.26 | 4019773.58 | 117.2 | 35.73 | 50.6 | 15.42 | 7852.034 | 2393.300 | " |
| 7 | 488564.27 | 4019780.72 | 150.0 | 45.73 | 68.4 | 20.86 | 7834.187 | 2387.860 | " |
| 8 | 488557.27 | 4019787.87 | 182.8 | 55.73 | 93.9 | 28.61 | 7808.760 | 2380.110 | " |
| 9 | 488550.28 | 4019795.01 | 215.6 | 65.73 | 111.5 | 33.98 | 7791.142 | 2374.740 | " |
| 10 | 488543.28 | 4019802.16 | 248.5 | 75.73 | 118.9 | 36.24 | 7783.727 | 2372.480 | " |
| 11 | 488536.28 | 4019809.30 | 281.3 | 85.73 | 120.8 | 36.81 | 7781.857 | 2371.910 | " |
| 12 | 488529.29 | 4019816.45 | 314.1 | 95.73 | 122.4 | 37.32 | 7780.184 | 2371.400 | " |
| 13 | 488522.29 | 4019823.59 | 346.9 | 105.73 | 122.1 | 37.21 | 7780.545 | 2371.510 | " |
| 14 | 488508.30 | 4019837.89 | 412.5 | 125.73 | 124.8 | 38.03 | 7777.855 | 2370.690 | " |
| 15 | 488494.31 | 4019852.18 | 478.1 | 145.73 | 125.4 | 38.23 | 7777.198 | 2370.490 | " |
| 16 | 488480.32 | 4019866.47 | 543.7 | 165.73 | 126.2 | 38.48 | 7776.378 | 2370.240 | " |
| 17 | 488466.33 | 4019880.76 | 609.4 | 185.73 | 126.4 | 38.52 | 7776.247 | 2370.200 | " |
| 18 | 488452.34 | 4019895.05 | 675.0 | 205.73 | 126.7 | 38.62 | 7775.919 | 2370.100 | " |
| 19 | 488424.35 | 4019923.63 | 806.2 | 245.73 | 126.4 | 38.52 | 7776.247 | 2370.200 | " |
| 20 | 488410.36 | 4019937.92 | 871.8 | 265.73 | 126.3 | 38.51 | 7776.280 | 2370.210 | " |
| 21 | 488396.37 | 4019952.21 | 937.4 | 285.73 | 126.4 | 38.52 | 7776.247 | 2370.200 | " |
| 22 | 488382.38 | 4019966.51 | 1003.1 | 305.73 | 126.4 | 38.54 | 7776.181 | 2370.180 | " |
| 23 | 488375.38 | 4019973.65 | 1035.9 | 315.73 | 126.5 | 38.57 | 7776.083 | 2370.150 | " |
| 24 | 488368.39 | 4019980.80 | 1068.7 | 325.73 | 126.0 | 38.42 | 7776.575 | 2370.300 | " |
| 25 | 488367.46 | 4019981.74 | 1073.0 | 327.05 | 0.0 | 0.00 | 7902.625 | 2408.720 | Water Edge on Right Bank |
| 26 | 488367.08 | 4019982.13 | 1074.8 | 327.60 | | | 7905.939 | 2409.730 | T.B.M on Right Bank |



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## Table 1-26 Cross Sectional Coordinates, Cross Section 19

| Sr. No. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 488656.14 | 4020641.51 | 0.0 | 0.00 | | | 7977.454 | 2431.528 | T,B.M on Left Bank |
| 2 | 488653.23 | 4020640.39 | 10.2 | 3.12 | | | 7960.797 | 2426.451 | Slope |
| 3 | 488632.95 | 4020632.62 | 81.5 | 24.84 | | | 7954.521 | 2424.538 | " |
| 4 | 488604.82 | 4020621.85 | 180.3 | 54.96 | | | 7952.773 | 2424.005 | " |
| 5 | 488592.05 | 4020616.95 | 225.2 | 68.64 | | | 7947.051 | 2422.261 | " |
| 6 | 488587.04 | 4020615.04 | 242.8 | 74.00 | | | 7932.497 | 2417.825 | " |
| 7 | 488582.82 | 4020613.42 | 257.6 | 78.52 | | | 7927.208 | 2416.213 | " |
| 8 | 488562.61 | 4020605.68 | 328.6 | 100.16 | | | 7915.023 | 2412.499 | " |
| 9 | 488547.45 | 4020599.87 | 381.9 | 116.40 | 0.0 | 0.00 | 7902.920 | 2408.810 | Water Edge on Left Bank |
| 10 | 488538.11 | 4020596.29 | 414.7 | 126.40 | 4.1 | 1.24 | 7898.852 | 2407.570 | Bed |
| 11 | 488528.77 | 4020592.72 | 447.5 | 136.40 | 5.2 | 1.59 | 7897.704 | 2407.220 | " |
| 12 | 488519.43 | 4020589.14 | 480.3 | 146.40 | 12.6 | 3.85 | 7890.289 | 2404.960 | " |
| 13 | 488510.09 | 4020585.56 | 513.1 | 156.40 | 16.1 | 4.90 | 7886.844 | 2403.910 | " |
| 14 | 488500.75 | 4020581.98 | 545.9 | 166.40 | 22.1 | 6.75 | 7880.775 | 2402.060 | " |
| 15 | 488491.42 | 4020578.41 | 578.7 | 176.40 | 29.7 | 9.06 | 7873.196 | 2399.750 | " |
| 16 | 488482.08 | 4020574.83 | 611.5 | 186.40 | 42.1 | 12.82 | 7860.860 | 2395.990 | " |
| 17 | 488472.74 | 4020571.25 | 644.4 | 196.40 | 48.9 | 14.89 | 7854.068 | 2393.920 | " |
| 18 | 488463.40 | 4020567.68 | 677.2 | 206.40 | 57.9 | 17.64 | 7845.046 | 2391.170 | " |
| 19 | 488454.06 | 4020564.10 | 710.0 | 216.40 | 67.2 | 20.49 | 7835.696 | 2388.320 | " |
| 20 | 488435.39 | 4020556.94 | 775.6 | 236.40 | 91.6 | 27.92 | 7811.319 | 2380.890 | " |
| 21 | 488416.71 | 4020549.79 | 841.2 | 256.40 | 99.4 | 30.29 | 7803.544 | 2378.520 | " |
| 22 | 488398.03 | 4020542.64 | 906.8 | 276.40 | 119.3 | 36.36 | 7783.629 | 2372.450 | " |
| 23 | 488379.36 | 4020535.48 | 972.4 | 296.40 | 120.0 | 36.59 | 7782.874 | 2372.220 | " |
| 24 | 488360.68 | 4020528.33 | 1038.1 | 316.40 | 120.0 | 36.57 | 7782.940 | 2372.240 | " |
| 25 | 488342.00 | 4020521.17 | 1103.7 | 336.40 | 120.5 | 36.74 | 7782.382 | 2372.070 | " |
| 26 | 488323.33 | 4020514.02 | 1169.3 | 356.40 | 120.8 | 36.83 | 7782.087 | 2371.980 | " |
| 27 | 488304.65 | 4020506.86 | 1234.9 | 376.40 | 121.1 | 36.92 | 7781.792 | 2371.890 | " |
| 28 | 488285.97 | 4020499.71 | 1300.5 | 396.40 | 121.1 | 36.92 | 7781.792 | 2371.890 | " |
| 29 | 488267.30 | 4020492.56 | 1366.1 | 416.40 | 121.0 | 36.89 | 7781.890 | 2371.920 | " |
| 30 | 488248.62 | 4020485.40 | 1431.8 | 436.40 | 121.4 | 37.01 | 7781.496 | 2371.800 | " |
| 31 | 488229.94 | 4020478.25 | 1497.4 | 456.40 | 121.6 | 37.05 | 7781.365 | 2371.760 | " |
| 32 | 488211.27 | 4020471.09 | 1563.0 | 476.40 | 121.6 | 37.07 | 7781.299 | 2371.740 | " |
| 33 | 488201.93 | 4020467.52 | 1595.8 | 486.40 | 121.8 | 37.12 | 7781.135 | 2371.690 | " |
| 34 | 488192.59 | 4020463.94 | 1628.6 | 496.40 | 122.2 | 37.25 | 7780.709 | 2371.560 | " |
| 35 | 488183.25 | 4020460.36 | 1661.4 | 506.40 | 121.9 | 37.15 | 7781.037 | 2371.660 | " |
| 36 | 488173.91 | 4020456.79 | 1694.2 | 516.40 | 121.1 | 36.91 | 7781.824 | 2371.900 | Bed |
| 37 | 488165.36 | 4020453.51 | 1724.3 | 525.56 | 0.0 | 0.00 | 7902.920 | 2408.810 | Water Edge on Right Bank |
| 38 | 488163.41 | 4020452.76 | 1731.1 | 527.65 | | | 7929.725 | 2416.980 | Slope |
| 39 | 488159.45 | 4020451.24 | 1745.0 | 531.89 | | | 7953.150 | 2424.120 | " |
| 40 | 488157.15 | 4020450.36 | 1753.1 | 534.35 | | | 7968.865 | 2428.910 | " |
| 41 | 488154.35 | 4020449.29 | 1763.0 | 537.35 | | | 7981.135 | 2432.650 | T.B.M on Right Bank (Vertical Cut) |



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## Table 1-27 Cross Sectional Coordinates, Cross Section 19 A

| Sr. No. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 488526.42 | 4020814.53 | 0.0 | 0.00 | | | 7974.000 | 2430.475 | T,B.M on Left Bank |
| 2 | 488506.57 | 4020810.67 | 66.4 | 20.23 | | | 7962.441 | 2426.952 | Slope |
| 3 | 488496.92 | 4020808.79 | 98.6 | 30.06 | | | 7952.966 | 2424.064 | " |
| 4 | 488489.03 | 4020807.26 | 125.0 | 38.10 | | | 7946.191 | 2421.999 | " |
| 5 | 488466.64 | 4020802.90 | 199.8 | 60.91 | | | 7925.873 | 2415.806 | " |
| 6 | 488450.31 | 4020799.72 | 254.4 | 77.54 | | | 7913.002 | 2411.883 | " |
| 7 | 488435.51 | 4020796.84 | 303.9 | 92.62 | 0.0 | 0.00 | 7902.494 | 2408.680 | Water Edge on Left Bank |
| 8 | 488425.69 | 4020794.93 | 336.7 | 102.62 | 6.1 | 1.86 | 7896.381 | 2406.817 | Bed |
| 9 | 488415.88 | 4020793.02 | 369.5 | 112.62 | 6.8 | 2.07 | 7895.702 | 2406.610 | " |
| 10 | 488406.06 | 4020791.11 | 402.3 | 122.62 | 17.4 | 5.30 | 7885.105 | 2403.380 | " |
| 11 | 488396.25 | 4020789.20 | 435.1 | 132.62 | 27.3 | 8.32 | 7875.197 | 2400.360 | " |
| 12 | 488386.43 | 4020787.29 | 467.9 | 142.62 | 38.2 | 11.65 | 7864.272 | 2397.030 | " |
| 13 | 488376.61 | 4020785.38 | 500.7 | 152.62 | 49.2 | 14.99 | 7853.314 | 2393.690 | " |
| 14 | 488366.80 | 4020783.47 | 533.5 | 162.62 | 57.7 | 17.58 | 7844.817 | 2391.100 | " |
| 15 | 488356.98 | 4020781.56 | 566.3 | 172.62 | 75.9 | 23.13 | 7826.608 | 2385.550 | " |
| 16 | 488347.17 | 4020779.65 | 599.1 | 182.62 | 80.8 | 24.63 | 7821.687 | 2384.050 | " |
| 17 | 488337.35 | 4020777.74 | 632.0 | 192.62 | 87.2 | 26.58 | 7815.289 | 2382.100 | " |
| 18 | 488317.72 | 4020773.92 | 697.6 | 212.62 | 113.5 | 34.60 | 7788.977 | 2374.080 | " |
| 19 | 488298.09 | 4020770.10 | 763.2 | 232.62 | 116.9 | 35.63 | 7785.597 | 2373.050 | " |
| 20 | 488278.46 | 4020766.28 | 828.8 | 252.62 | 117.7 | 35.86 | 7784.843 | 2372.820 | " |
| 21 | 488258.82 | 4020762.45 | 894.4 | 272.62 | 118.0 | 35.96 | 7784.515 | 2372.720 | " |
| 22 | 488239.19 | 4020758.63 | 960.0 | 292.62 | 118.2 | 36.02 | 7784.318 | 2372.660 | " |
| 23 | 488219.56 | 4020754.81 | 1025.7 | 312.62 | 118.2 | 36.04 | 7784.252 | 2372.640 | " |
| 24 | 488199.93 | 4020750.99 | 1091.3 | 332.62 | 118.4 | 36.08 | 7784.121 | 2372.600 | " |
| 25 | 488180.30 | 4020747.17 | 1156.9 | 352.62 | 118.6 | 36.14 | 7783.924 | 2372.540 | " |
| 26 | 488160.76 | 4020743.37 | 1222.2 | 372.52 | 118.5 | 36.12 | 7783.990 | 2372.560 | " |
| 27 | 488141.03 | 4020739.53 | 1288.1 | 392.62 | 118.8 | 36.20 | 7783.727 | 2372.480 | " |
| 28 | 488121.40 | 4020735.71 | 1353.7 | 412.62 | 118.9 | 36.23 | 7783.629 | 2372.450 | " |
| 29 | 488101.77 | 4020731.89 | 1419.4 | 432.62 | 119.3 | 36.35 | 7783.235 | 2372.330 | " |
| 30 | 488091.96 | 4020729.98 | 1452.2 | 442.62 | 119.6 | 36.45 | 7782.907 | 2372.230 | " |
| 31 | 488062.51 | 4020724.25 | 1550.6 | 472.62 | 120.4 | 36.70 | 7782.087 | 2371.980 | " |
| 32 | 488042.88 | 4020720.43 | 1616.2 | 492.62 | 121.0 | 36.87 | 7781.529 | 2371.810 | " |
| 33 | 488023.24 | 4020716.61 | 1681.8 | 512.62 | 121.3 | 36.98 | 7781.168 | 2371.700 | " |
| 34 | 488003.61 | 4020712.79 | 1747.4 | 532.62 | 120.8 | 36.82 | 7781.693 | 2371.860 | " |
| 35 | 487993.80 | 4020710.88 | 1780.2 | 542.62 | 119.3 | 36.37 | 7783.170 | 2372.310 | " |
| 36 | 487983.98 | 4020708.97 | 1813.1 | 552.62 | 109.6 | 33.40 | 7792.914 | 2375.280 | Bed |
| 37 | 487974.17 | 4020707.06 | 1845.9 | 562.62 | 55.4 | 16.89 | 7847.080 | 2391.790 | " |
| 38 | 487964.35 | 4020705.14 | 1878.7 | 572.62 | 35.6 | 10.84 | 7866.929 | 2397.840 | " |
| 39 | 487954.53 | 4020703.23 | 1911.5 | 582.62 | 28.0 | 8.52 | 7874.541 | 2400.160 | " |
| 40 | 487944.72 | 4020701.32 | 1944.3 | 592.62 | 11.3 | 3.43 | 7891.240 | 2405.250 | " |
| 41 | 487942.37 | 4020700.87 | 1952.1 | 595.01 | 0.0 | 0.00 | 7902.494 | 2408.680 | Water Edge on Right Bank |
| 42 | 487939.36 | 4020700.28 | 1962.2 | 598.08 | | | 7913.544 | 2412.048 | Slope |
| 43 | 487936.75 | 4020699.77 | 1970.9 | 600.74 | | | 7930.092 | 2417.092 | " |
| 44 | 487924.55 | 4020697.40 | 2011.7 | 613.17 | | | 7944.639 | 2421.526 | " |
| 45 | 487918.17 | 4020696.16 | 2033.0 | 619.67 | | | 7957.254 | 2425.371 | " |
| 46 | 487908.86 | 4020694.35 | 2064.1 | 629.15 | | | 7977.549 | 2431.557 | T.B.M on Right Bank |



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## Table 1-28 Cross Sectional Coordinates, Cross Section 20

| Sr. No. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 488607.73 | 4021082.77 | 0.0 | 0.00 | | | 7981.851 | 2432.868 | T,B.M on Left Bank |
| 2 | 488596.42 | 4021079.73 | 38.4 | 11.71 | | | 7966.749 | 2428.265 | Slope |
| 3 | 488584.71 | 4021076.58 | 78.2 | 23.84 | | | 7957.392 | 2425.413 | " |
| 4 | 488566.14 | 4021071.59 | 141.3 | 43.06 | | | 7934.944 | 2418.571 | " |
| 5 | 488529.47 | 4021061.73 | 265.9 | 81.04 | | | 7911.467 | 2411.415 | " |
| 6 | 488514.12 | 4021057.61 | 318.0 | 96.93 | 0.0 | 0.00 | 7902.428 | 2408.660 | Water Edge on Left Bank |
| 7 | 488504.46 | 4021055.01 | 350.8 | 106.93 | 6.8 | 2.07 | 7895.637 | 2406.590 | Bed |
| 8 | 488494.81 | 4021052.42 | 383.6 | 116.93 | 8.9 | 2.72 | 7893.504 | 2405.940 | " |
| 9 | 488485.15 | 4021049.82 | 416.4 | 126.93 | 11.3 | 3.45 | 7891.109 | 2405.210 | " |
| 10 | 488475.49 | 4021047.22 | 449.2 | 136.93 | 20.8 | 6.34 | 7881.628 | 2402.320 | " |
| 11 | 488465.84 | 4021044.63 | 482.1 | 146.93 | 35.1 | 10.69 | 7867.356 | 2397.970 | " |
| 12 | 488456.18 | 4021042.03 | 514.9 | 156.93 | 39.7 | 12.10 | 7862.730 | 2396.560 | " |
| 13 | 488446.52 | 4021039.44 | 547.7 | 166.93 | 54.3 | 16.56 | 7848.097 | 2392.100 | " |
| 14 | 488436.86 | 4021036.84 | 580.5 | 176.93 | 59.6 | 18.18 | 7842.782 | 2390.480 | " |
| 15 | 488427.21 | 4021034.24 | 613.3 | 186.93 | 69.2 | 21.08 | 7833.268 | 2387.580 | " |
| 16 | 488417.55 | 4021031.65 | 646.1 | 196.93 | 68.2 | 20.80 | 7834.187 | 2387.860 | " |
| 17 | 488398.23 | 4021026.46 | 711.7 | 216.93 | 70.1 | 21.38 | 7832.284 | 2387.280 | " |
| 18 | 488378.92 | 4021021.26 | 777.3 | 236.93 | 63.8 | 19.44 | 7838.649 | 2389.220 | " |
| 19 | 488359.61 | 4021016.07 | 842.9 | 256.93 | 73.6 | 22.43 | 7828.839 | 2386.230 | " |
| 20 | 488340.29 | 4021010.88 | 908.6 | 276.93 | 96.6 | 29.45 | 7805.807 | 2379.210 | " |
| 21 | 488320.98 | 4021005.69 | 974.2 | 296.93 | 114.7 | 34.97 | 7787.697 | 2373.690 | " |
| 22 | 488301.66 | 4021000.50 | 1039.8 | 316.93 | 115.0 | 35.04 | 7787.467 | 2373.620 | " |
| 23 | 488282.35 | 4020995.31 | 1105.4 | 336.93 | 115.3 | 35.15 | 7787.107 | 2373.510 | " |
| 24 | 488263.03 | 4020990.11 | 1171.0 | 356.93 | 115.0 | 35.05 | 7787.435 | 2373.610 | " |
| 25 | 488243.72 | 4020984.92 | 1236.6 | 376.93 | 114.7 | 34.97 | 7787.697 | 2373.690 | " |
| 26 | 488224.41 | 4020979.73 | 1302.3 | 396.93 | 115.2 | 35.11 | 7787.238 | 2373.550 | " |
| 27 | 488205.09 | 4020974.54 | 1367.9 | 416.93 | 115.3 | 35.14 | 7787.139 | 2373.520 | " |
| 28 | 488185.78 | 4020969.35 | 1433.5 | 436.93 | 115.4 | 35.16 | 7787.074 | 2373.500 | " |
| 29 | 488166.46 | 4020964.15 | 1499.1 | 456.93 | 115.6 | 35.24 | 7786.811 | 2373.420 | " |
| 30 | 488147.15 | 4020958.96 | 1564.7 | 476.93 | 116.5 | 35.50 | 7785.958 | 2373.160 | " |
| 31 | 488127.83 | 4020953.77 | 1630.3 | 496.93 | 116.5 | 35.52 | 7785.893 | 2373.140 | " |
| 32 | 488108.52 | 4020948.58 | 1696.0 | 516.93 | 116.8 | 35.60 | 7785.630 | 2373.060 | " |
| 33 | 488089.21 | 4020943.39 | 1761.6 | 536.93 | 117.0 | 35.67 | 7785.401 | 2372.990 | " |
| 34 | 488069.89 | 4020938.19 | 1827.2 | 556.93 | 117.2 | 35.73 | 7785.204 | 2372.930 | " |
| 35 | 488050.58 | 4020933.00 | 1892.8 | 576.93 | 117.6 | 35.85 | 7784.810 | 2372.810 | " |
| 36 | 488031.26 | 4020927.81 | 1958.4 | 596.93 | 118.9 | 36.24 | 7783.530 | 2372.420 | Bed |
| 37 | 488011.95 | 4020922.62 | 2024.0 | 616.93 | 119.4 | 36.38 | 7783.071 | 2372.280 | " |
| 38 | 488002.29 | 4020920.02 | 2056.9 | 626.93 | 120.3 | 36.67 | 7782.120 | 2371.990 | " |
| 39 | 487992.63 | 4020917.43 | 2089.7 | 636.93 | 120.6 | 36.76 | 7781.824 | 2371.900 | " |
| 40 | 487982.98 | 4020914.83 | 2122.5 | 646.93 | 118.1 | 36.00 | 7784.318 | 2372.660 | " |
| 41 | 487973.32 | 4020912.23 | 2155.3 | 656.93 | 120.0 | 36.58 | 7782.415 | 2372.080 | " |



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| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 42 | 487963.66 | 4020909.64 | 2188.1 | 666.93 | 119.9 | 36.54 | 7782.546 | 2372.120 | " |
| 43 | 487954.01 | 4020907.04 | 2220.9 | 676.93 | 119.8 | 36.53 | 7782.579 | 2372.130 | " |
| 44 | 487944.35 | 4020904.45 | 2253.7 | 686.93 | 119.0 | 36.26 | 7783.465 | 2372.400 | " |
| 45 | 487934.69 | 4020901.85 | 2286.5 | 696.93 | 115.0 | 35.04 | 7787.467 | 2373.620 | " |
| 46 | 487925.03 | 4020899.25 | 2319.3 | 706.93 | 106.6 | 32.49 | 7795.834 | 2376.170 | " |
| 47 | 487915.38 | 4020896.66 | 2352.1 | 716.93 | 95.2 | 29.02 | 7807.218 | 2379.640 | " |
| 48 | 487905.72 | 4020894.06 | 2384.9 | 726.93 | 75.5 | 23.02 | 7826.903 | 2385.640 | " |
| 49 | 487896.06 | 4020891.47 | 2417.7 | 736.93 | 59.0 | 17.98 | 7843.439 | 2390.680 | " |
| 50 | 487886.40 | 4020888.87 | 2450.6 | 746.93 | 43.3 | 13.19 | 7859.154 | 2395.470 | " |
| 51 | 487876.75 | 4020886.27 | 2483.4 | 756.93 | 32.9 | 10.02 | 7869.554 | 2398.640 | " |
| 52 | 487867.09 | 4020883.68 | 2516.2 | 766.93 | 20.9 | 6.38 | 7881.496 | 2402.280 | " |
| 53 | 487857.43 | 4020881.08 | 2549.0 | 776.93 | 8.7 | 2.64 | 7893.767 | 2406.020 | " |
| 54 | 487850.26 | 4020879.15 | 2573.4 | 784.36 | 0.0 | 0.00 | 7902.428 | 2408.660 | Water Edge on Right Bank |
| 55 | 487842.38 | 4020877.04 | 2600.1 | 792.52 | | | 7915.886 | 2412.762 | Slope |
| 56 | 487835.37 | 4020875.15 | 2624.0 | 799.78 | | | 7931.772 | 2417.604 | " |
| 57 | 487831.63 | 4020874.15 | 2636.6 | 803.65 | | | 7944.685 | 2421.540 | " |
| 58 | 487827.86 | 4020873.13 | 2649.4 | 807.55 | | | 7964.698 | 2427.640 | " |
| 59 | 487824.22 | 4020872.16 | 2661.8 | 811.32 | | | 7969.160 | 2429.000 | " |
| 60 | 487820.44 | 4020871.14 | 2674.7 | 815.24 | | | 7981.201 | 2432.670 | T.B.M on Right Bank (Vertical Cut) |



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## Table 1-29 Cross Sectional Coordinates, Cross Section 21

| Sr. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| No. | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 488494.56 | 4021505.89 | 0.0 | 0.00 | | | 5541.578 | 2430.005 | T,B.M on Left Bank |
| 2 | 488484.08 | 4021503.89 | 35.0 | 10.67 | | | 5536.301 | 2427.691 | Slope |
| 3 | 488464.78 | 4021500.21 | 99.5 | 30.32 | | | 5529.405 | 2424.667 | " |
| 4 | 488451.03 | 4021497.59 | 145.4 | 44.32 | | | 5520.328 | 2420.687 | " |
| 5 | 488428.64 | 4021493.32 | 220.2 | 67.11 | | | 5512.805 | 2417.388 | " |
| 6 | 488422.92 | 4021492.23 | 239.3 | 72.93 | | | 5507.501 | 2415.062 | " |
| 7 | 488386.51 | 4021485.28 | 360.9 | 110.00 | 0.0 | 0.00 | 5492.901 | 2408.660 | Water Edge on Left Bank |
| 8 | 488376.69 | 4021483.41 | 393.7 | 120.00 | 7.6 | 2.33 | 5487.587 | 2406.330 | Bed |
| 9 | 488366.86 | 4021481.53 | 426.5 | 130.00 | 9.5 | 2.91 | 5486.265 | 2405.750 | " |
| 10 | 488357.04 | 4021479.66 | 459.3 | 140.00 | 16.3 | 4.96 | 5481.590 | 2403.700 | " |
| 11 | 488347.22 | 4021477.78 | 492.1 | 150.00 | 21.6 | 6.59 | 5477.873 | 2402.070 | " |
| 12 | 488337.40 | 4021475.91 | 524.9 | 160.00 | 29.6 | 9.01 | 5472.354 | 2399.650 | " |
| 13 | 488327.57 | 4021474.04 | 557.7 | 170.00 | 36.0 | 10.98 | 5467.861 | 2397.680 | " |
| 14 | 488317.75 | 4021472.16 | 590.6 | 180.00 | 38.0 | 11.58 | 5466.493 | 2397.080 | " |
| 15 | 488307.93 | 4021470.29 | 623.4 | 190.00 | 44.7 | 13.62 | 5461.841 | 2395.040 | " |
| 16 | 488298.10 | 4021468.41 | 656.2 | 200.00 | 48.9 | 14.90 | 5458.922 | 2393.760 | " |
| 17 | 488288.28 | 4021466.54 | 689.0 | 210.00 | 56.2 | 17.13 | 5453.836 | 2391.530 | " |
| 18 | 488278.46 | 4021464.67 | 721.8 | 220.00 | 61.4 | 18.70 | 5450.256 | 2389.960 | " |
| 19 | 488268.64 | 4021462.79 | 754.6 | 230.00 | 68.2 | 20.80 | 5445.467 | 2387.860 | " |
| 20 | 488258.81 | 4021460.92 | 787.4 | 240.00 | 78.1 | 23.82 | 5438.580 | 2384.840 | " |
| 21 | 488248.99 | 4021459.05 | 820.2 | 250.00 | 90.1 | 27.45 | 5430.302 | 2381.210 | " |
| 22 | 488232.29 | 4021455.86 | 876.0 | 267.00 | 96.6 | 29.43 | 5425.786 | 2379.230 | " |
| 23 | 488229.34 | 4021455.30 | 885.8 | 270.00 | 95.8 | 29.20 | 5426.311 | 2379.460 | " |
| 24 | 488209.70 | 4021451.55 | 951.4 | 290.00 | 97.1 | 29.61 | 5425.376 | 2379.050 | " |
| 25 | 488190.05 | 4021447.80 | 1017.1 | 310.00 | 97.7 | 29.79 | 5424.965 | 2378.870 | " |
| 26 | 488170.41 | 4021444.06 | 1082.7 | 330.00 | 101.3 | 30.87 | 5422.503 | 2377.790 | " |
| 27 | 488150.76 | 4021440.31 | 1148.3 | 350.00 | 104.9 | 31.96 | 5420.017 | 2376.700 | " |
| 28 | 488131.12 | 4021436.56 | 1213.9 | 370.00 | 95.2 | 29.01 | 5426.744 | 2379.650 | " |
| 29 | 488111.47 | 4021432.81 | 1279.5 | 390.00 | 93.8 | 28.60 | 5427.679 | 2380.060 | " |
| 30 | 488091.82 | 4021429.06 | 1345.1 | 410.00 | 93.2 | 28.40 | 5428.135 | 2380.260 | " |
| 31 | 488072.18 | 4021425.32 | 1410.8 | 430.00 | 93.1 | 28.39 | 5428.158 | 2380.270 | " |
| 32 | 488052.53 | 4021421.57 | 1476.4 | 450.00 | 93.7 | 28.56 | 5427.770 | 2380.100 | " |
| 33 | 488032.89 | 4021417.82 | 1542.0 | 470.00 | 94.1 | 28.67 | 5427.520 | 2379.990 | " |
| 34 | 488013.24 | 4021414.07 | 1607.6 | 490.00 | 94.6 | 28.83 | 5427.155 | 2379.830 | " |
| 35 | 487993.60 | 4021410.33 | 1673.2 | 510.00 | 95.9 | 29.23 | 5426.243 | 2379.430 | " |
| 36 | 487973.95 | 4021406.58 | 1738.8 | 530.00 | 97.6 | 29.76 | 5425.034 | 2378.900 | Bed |
| 37 | 487954.30 | 4021402.83 | 1804.5 | 550.00 | 99.0 | 30.16 | 5424.122 | 2378.500 | " |
| 38 | 487934.66 | 4021399.08 | 1870.1 | 570.00 | 104.6 | 31.87 | 5420.222 | 2376.790 | " |
| 39 | 487915.01 | 4021395.34 | 1935.7 | 590.00 | 102.1 | 31.13 | 5421.910 | 2377.530 | " |
| 40 | 487895.37 | 4021391.59 | 2001.3 | 610.00 | 103.4 | 31.52 | 5421.020 | 2377.140 | " |
| 41 | 487875.72 | 4021387.84 | 2066.9 | 630.00 | 103.2 | 31.46 | 5421.157 | 2377.200 | " |



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| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 42 | 487856.08 | 4021384.09 | 2132.5 | 650.00 | 90.7 | 27.65 | 5429.846 | 2381.010 | " |
| 43 | 487846.25 | 4021382.22 | 2165.4 | 660.00 | 68.3 | 20.82 | 5445.421 | 2387.840 | " |
| 44 | 487836.43 | 4021380.35 | 2198.2 | 670.00 | 47.3 | 14.42 | 5460.016 | 2394.240 | " |
| 45 | 487826.61 | 4021378.47 | 2231.0 | 680.00 | 31.9 | 9.72 | 5470.735 | 2398.940 | " |
| 46 | 487816.78 | 4021376.60 | 2263.8 | 690.00 | 21.1 | 6.43 | 5478.237 | 2402.230 | " |
| 47 | 487806.96 | 4021374.72 | 2296.6 | 700.00 | 8.3 | 2.54 | 5487.109 | 2406.120 | " |
| 48 | 487797.14 | 4021372.85 | 2329.4 | 710.00 | 4.6 | 1.40 | 5489.708 | 2407.260 | " |
| 49 | 487791.42 | 4021371.76 | 2348.5 | 715.82 | 0.0 | 0.00 | 5492.901 | 2408.660 | Water Edge on Right Bank |
| 50 | 487781.36 | 4021369.84 | 2382.1 | 726.06 | | | 5506.762 | 2414.738 | Slope |
| 51 | 487767.57 | 4021367.21 | 2428.1 | 740.10 | | | 5523.202 | 2421.947 | " |
| 52 | 487759.68 | 4021365.71 | 2454.5 | 748.13 | | | 5534.725 | 2427.000 | " |
| 53 | 487744.37 | 4021362.78 | 2505.6 | 763.72 | | | 5552.734 | 2434.897 | T.B.M on Right Bank |



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## Table 1-30 Cross Sectional Coordinates, Cross Section 22

| Sr. No. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 488467.85 | 4021949.29 | 0.0 | 0.00 | | | 7977.198 | 2431.450 | T,B.M on Left Bank (House Wall) |
| 2 | 488465.86 | 4021949.18 | 6.6 | 2.00 | | | 7954.879 | 2424.647 | Slope |
| 3 | 488425.46 | 4021946.93 | 139.3 | 42.46 | | | 7944.259 | 2421.410 | " |
| 4 | 488414.03 | 4021946.30 | 176.9 | 53.91 | | | 7939.134 | 2419.848 | " |
| 5 | 488404.65 | 4021945.77 | 207.7 | 63.30 | | | 7927.461 | 2416.290 | " |
| 6 | 488372.83 | 4021944.00 | 312.2 | 95.17 | | | 7927.218 | 2416.216 | " |
| 7 | 488345.90 | 4021942.50 | 400.7 | 122.14 | | | 7916.017 | 2412.802 | " |
| 8 | 488319.68 | 4021941.04 | 486.9 | 148.40 | 0.0 | 0.00 | 7902.559 | 2408.700 | Water Edge on Left Bank |
| 9 | 488309.70 | 4021940.49 | 519.7 | 158.40 | 6.4 | 1.94 | 7896.194 | 2406.760 | Bed |
| 10 | 488299.71 | 4021939.93 | 552.5 | 168.40 | 13.1 | 3.99 | 7889.469 | 2404.710 | " |
| 11 | 488289.73 | 4021939.37 | 585.3 | 178.40 | 21.7 | 6.61 | 7880.873 | 2402.090 | " |
| 12 | 488279.75 | 4021938.82 | 618.1 | 188.40 | 30.4 | 9.27 | 7872.146 | 2399.430 | " |
| 13 | 488269.76 | 4021938.26 | 650.9 | 198.40 | 42.4 | 12.93 | 7860.138 | 2395.770 | " |
| 14 | 488259.78 | 4021937.70 | 683.7 | 208.40 | 59.4 | 18.10 | 7843.176 | 2390.600 | " |
| 15 | 488249.79 | 4021937.15 | 716.5 | 218.40 | 58.5 | 17.84 | 7844.029 | 2390.860 | " |
| 16 | 488239.81 | 4021936.59 | 749.3 | 228.40 | 61.3 | 18.67 | 7841.306 | 2390.030 | " |
| 17 | 488229.82 | 4021936.04 | 782.2 | 238.40 | 62.6 | 19.07 | 7839.994 | 2389.630 | " |
| 18 | 488219.84 | 4021935.48 | 815.0 | 248.40 | 65.5 | 19.95 | 7837.107 | 2388.750 | " |
| 19 | 488199.87 | 4021934.37 | 880.6 | 268.40 | 69.2 | 21.10 | 7833.334 | 2387.600 | " |
| 20 | 488179.90 | 4021933.26 | 946.2 | 288.40 | 69.0 | 21.04 | 7833.530 | 2387.660 | " |
| 21 | 488159.93 | 4021932.14 | 1011.8 | 308.40 | 68.1 | 20.76 | 7834.449 | 2387.940 | " |
| 22 | 488139.96 | 4021931.03 | 1077.4 | 328.40 | 68.0 | 20.73 | 7834.547 | 2387.970 | " |
| 23 | 488119.99 | 4021929.92 | 1143.0 | 348.40 | 66.1 | 20.14 | 7836.483 | 2388.560 | " |
| 24 | 488100.02 | 4021928.81 | 1208.7 | 368.40 | 66.1 | 20.15 | 7836.450 | 2388.550 | " |
| 25 | 488080.06 | 4021927.69 | 1274.3 | 388.40 | 63.0 | 19.19 | 7839.600 | 2389.510 | " |
| 26 | 488060.09 | 4021926.58 | 1339.9 | 408.40 | 60.8 | 18.53 | 7841.765 | 2390.170 | " |
| 27 | 488040.12 | 4021925.47 | 1405.5 | 428.40 | 59.3 | 18.08 | 7843.242 | 2390.620 | " |
| 28 | 488020.15 | 4021924.36 | 1471.1 | 448.40 | 58.0 | 17.67 | 7844.587 | 2391.030 | " |
| 29 | 488000.18 | 4021923.24 | 1536.7 | 468.40 | 56.5 | 17.21 | 7846.096 | 2391.490 | " |
| 30 | 487980.21 | 4021922.13 | 1602.4 | 488.40 | 55.1 | 16.79 | 7847.474 | 2391.910 | " |
| 31 | 487960.24 | 4021921.02 | 1668.0 | 508.40 | 52.9 | 16.12 | 7849.672 | 2392.580 | " |
| 32 | 487940.27 | 4021919.91 | 1733.6 | 528.40 | 47.9 | 14.59 | 7854.692 | 2394.110 | " |
| 33 | 487920.30 | 4021918.80 | 1799.2 | 548.40 | 50.5 | 15.40 | 7852.034 | 2393.300 | " |
| 34 | 487900.33 | 4021917.68 | 1864.8 | 568.40 | 47.7 | 14.55 | 7854.823 | 2394.150 | " |
| 35 | 487880.36 | 4021916.57 | 1930.4 | 588.40 | 44.8 | 13.67 | 7857.710 | 2395.030 | " |
| 36 | 487860.40 | 4021915.46 | 1996.1 | 608.40 | 38.6 | 11.78 | 7863.911 | 2396.920 | Bed |
| 37 | 487840.43 | 4021914.35 | 2061.7 | 628.40 | 33.0 | 10.07 | 7869.521 | 2398.630 | " |
| 38 | 487820.46 | 4021913.23 | 2127.3 | 648.40 | 9.3 | 2.84 | 7893.242 | 2405.860 | " |
| 39 | 487800.49 | 4021912.12 | 2192.9 | 668.40 | 2.6 | 0.80 | 7899.935 | 2407.900 | " |
| 40 | 487780.52 | 4021911.01 | 2258.5 | 688.40 | 2.6 | 0.80 | 7899.935 | 2407.900 | " |



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| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 41 | 487760.55 | 4021909.90 | 2324.1 | 708.40 | 2.6 | 0.80 | 7899.935 | 2407.900 | " |
| 42 | 487740.58 | 4021908.79 | 2389.8 | 728.40 | 2.6 | 0.80 | 7899.935 | 2407.900 | " |
| 43 | 487720.61 | 4021907.67 | 2455.4 | 748.40 | 2.3 | 0.70 | 7900.263 | 2408.000 | " |
| 44 | 487700.64 | 4021906.56 | 2521.0 | 768.40 | 3.9 | 1.20 | 7898.622 | 2407.500 | " |
| 45 | 487680.67 | 4021905.45 | 2586.6 | 788.40 | 4.3 | 1.30 | 7898.294 | 2407.400 | " |
| 46 | 487670.69 | 4021904.89 | 2619.4 | 798.40 | 4.9 | 1.50 | 7897.638 | 2407.200 | " |
| 47 | 487660.71 | 4021904.34 | 2652.2 | 808.40 | 5.2 | 1.60 | 7897.310 | 2407.100 | " |
| 48 | 487650.72 | 4021903.78 | 2685.0 | 818.40 | 2.6 | 0.80 | 7899.935 | 2407.900 | " |
| 49 | 487639.76 | 4021903.17 | 2721.1 | 829.38 | 0.0 | 0.00 | 7902.559 | 2408.700 | Water Edge on Right Bank |
| 50 | 487618.89 | 4021902.01 | 2789.6 | 850.28 | | | 7919.105 | 2413.743 | Slope |
| 51 | 487598.18 | 4021900.85 | 2857.7 | 871.02 | | | 7933.517 | 2418.136 | " |
| 52 | 487580.55 | 4021899.87 | 2915.6 | 888.68 | | | 7944.702 | 2421.545 | " |
| 53 | 487566.64 | 4021899.10 | 2961.3 | 902.61 | | | 7966.119 | 2428.073 | " |
| 54 | 487562.56 | 4021898.87 | 2974.7 | 906.70 | | | 7973.147 | 2430.215 | T.B.M on Right Bank |



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## Table 1-31 Cross Sectional Coordinates, Cross Section 23

| Sr. No. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 488590.20 | 4022513.29 | 0.0 | 0.00 | | | 7979.964 | 2432.293 | T,B.M on Left Bank (Road Wall) |
| 2 | 488572.75 | 4022510.33 | 58.1 | 17.70 | | | 7948.763 | 2422.783 | Slope |
| 3 | 488565.17 | 4022509.05 | 83.3 | 25.38 | | | 7935.095 | 2418.617 | " |
| 4 | 488556.03 | 4022507.50 | 113.7 | 34.65 | | | 7918.258 | 2413.485 | " |
| 5 | 488531.69 | 4022503.37 | 194.7 | 59.34 | | | 7912.937 | 2411.863 | " |
| 6 | 488530.41 | 4022503.15 | 199.0 | 60.64 | 0.0 | 0.00 | 7902.559 | 2408.700 | Water Edge on Left Bank Creek-I |
| 7 | 488520.55 | 4022501.48 | 231.8 | 70.64 | 4.9 | 1.48 | 7902.559 | 2408.700 | Bed |
| 8 | 488510.69 | 4022499.81 | 264.6 | 80.64 | 7.7 | 2.35 | 7902.559 | 2408.700 | " |
| 9 | 488500.83 | 4022498.14 | 297.4 | 90.64 | 8.7 | 2.65 | 7902.559 | 2408.700 | " |
| 10 | 488490.97 | 4022496.47 | 330.2 | 100.64 | 9.1 | 2.76 | 7902.559 | 2408.700 | " |
| 11 | 488481.11 | 4022494.79 | 363.0 | 110.64 | 9.8 | 2.98 | 7902.559 | 2408.700 | " |
| 12 | 488471.25 | 4022493.12 | 395.8 | 120.64 | 9.9 | 3.02 | 7902.559 | 2408.700 | " |
| 13 | 488461.40 | 4022491.45 | 428.6 | 130.64 | 10.1 | 3.07 | 7902.559 | 2408.700 | " |
| 14 | 488451.54 | 4022489.78 | 461.4 | 140.64 | 10.2 | 3.12 | 7902.559 | 2408.700 | " |
| 15 | 488441.68 | 4022488.10 | 494.2 | 150.64 | 10.5 | 3.20 | 7902.559 | 2408.700 | " |
| 16 | 488431.82 | 4022486.43 | 527.0 | 160.64 | 10.6 | 3.24 | 7902.559 | 2408.700 | " |
| 17 | 488421.96 | 4022484.76 | 559.8 | 170.64 | 10.6 | 3.24 | 7902.559 | 2408.700 | " |
| 18 | 488412.10 | 4022483.09 | 592.7 | 180.64 | 10.9 | 3.32 | 7902.559 | 2408.700 | " |
| 19 | 488402.24 | 4022481.42 | 625.5 | 190.64 | 11.1 | 3.37 | 7902.559 | 2408.700 | " |
| 20 | 488392.38 | 4022479.74 | 658.3 | 200.64 | 10.9 | 3.33 | 7902.559 | 2408.700 | " |
| 21 | 488382.52 | 4022478.07 | 691.1 | 210.64 | 11.1 | 3.37 | 7902.559 | 2408.700 | " |
| 22 | 488372.66 | 4022476.40 | 723.9 | 220.64 | 11.1 | 3.39 | 7902.559 | 2408.700 | " |
| 23 | 488362.80 | 4022474.73 | 756.7 | 230.64 | 11.1 | 3.37 | 7902.559 | 2408.700 | " |
| 24 | 488352.94 | 4022473.06 | 789.5 | 240.64 | 11.0 | 3.34 | 7902.559 | 2408.700 | " |
| 25 | 488343.08 | 4022471.38 | 822.3 | 250.64 | 11.0 | 3.34 | 7902.559 | 2408.700 | " |
| 26 | 488333.23 | 4022469.71 | 855.1 | 260.64 | 11.0 | 3.36 | 7902.559 | 2408.700 | " |
| 27 | 488323.37 | 4022468.04 | 887.9 | 270.64 | 9.6 | 2.93 | 7902.559 | 2408.700 | " |
| 28 | 488313.51 | 4022466.37 | 920.7 | 280.64 | 6.8 | 2.08 | 7902.559 | 2408.700 | " |
| 29 | 488303.65 | 4022464.70 | 953.5 | 290.64 | 3.5 | 1.08 | 7902.559 | 2408.700 | " |
| 30 | 488293.79 | 4022463.02 | 986.4 | 300.64 | 2.9 | 0.88 | 7902.559 | 2408.700 | " |
| 31 | 488283.93 | 4022461.35 | 1019.2 | 310.64 | 2.0 | 0.62 | 7902.559 | 2408.700 | " |
| 32 | 488274.07 | 4022459.68 | 1052.0 | 320.64 | 3.0 | 0.91 | 7902.559 | 2408.700 | " |
| 33 | 488264.51 | 4022458.06 | 1083.8 | 330.34 | 2.3 | 0.70 | 7902.559 | 2408.700 | " |
| 34 | 488254.35 | 4022456.33 | 1117.6 | 340.64 | 1.3 | 0.40 | 7902.559 | 2408.700 | " |
| 35 | 488234.63 | 4022452.99 | 1183.2 | 360.64 | 1.6 | 0.50 | 7902.559 | 2408.700 | " |
| 36 | 488214.92 | 4022449.65 | 1248.8 | 380.64 | 1.3 | 0.40 | 7902.559 | 2408.700 | Bed |
| 37 | 488195.20 | 4022446.30 | 1314.4 | 400.64 | 1.6 | 0.50 | 7902.559 | 2408.700 | " |
| 38 | 488175.48 | 4022442.96 | 1380.1 | 420.64 | 1.3 | 0.40 | 7902.559 | 2408.700 | " |
| 39 | 488155.76 | 4022439.61 | 1445.7 | 440.64 | 1.0 | 0.30 | 7902.559 | 2408.700 | " |



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| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 40 | 488145.90 | 4022437.94 | 1478.5 | 450.64 | 0.7 | 0.20 | 7902.559 | 2408.700 | " |
| 41 | 488136.98 | 4022436.43 | 1508.2 | 459.69 | 0.0 | 0.00 | 7902.559 | 2408.700 | Water Edge on Right Bank Creek-I |
| 42 | 488062.58 | 4022423.81 | 1755.7 | 535.15 | | | 7907.474 | 2410.198 | Slope |
| 43 | 487973.07 | 4022408.63 | 2053.6 | 625.94 | | | 7907.454 | 2410.192 | " |
| 44 | 487902.34 | 4022396.63 | 2289.0 | 697.68 | | | 7907.235 | 2410.125 | " |
| 45 | 487835.53 | 4022385.30 | 2511.3 | 765.44 | | | 7907.307 | 2410.147 | " |
| 46 | 487801.02 | 4022379.45 | 2626.1 | 800.45 | 0.0 | 0.00 | 7902.559 | 2408.700 | Water Edge on Left Bank Creek-II |
| 47 | 487781.30 | 4022376.10 | 2691.8 | 820.45 | 2.3 | 0.70 | 7900.263 | 2408.000 | Bed |
| 48 | 487761.58 | 4022372.76 | 2757.4 | 840.45 | 2.0 | 0.60 | 7900.591 | 2408.100 | " |
| 49 | 487741.86 | 4022369.42 | 2823.0 | 860.45 | 2.0 | 0.60 | 7900.591 | 2408.100 | " |
| 50 | 487722.14 | 4022366.07 | 2888.6 | 880.45 | 2.0 | 0.60 | 7900.591 | 2408.100 | " |
| 51 | 487702.42 | 4022362.73 | 2954.2 | 900.45 | 2.3 | 0.70 | 7900.263 | 2408.000 | " |
| 52 | 487682.71 | 4022359.38 | 3019.8 | 920.45 | 2.6 | 0.80 | 7899.935 | 2407.900 | " |
| 53 | 487662.99 | 4022356.04 | 3085.5 | 940.45 | 3.0 | 0.90 | 7899.607 | 2407.800 | " |
| 54 | 487643.27 | 4022352.69 | 3151.1 | 960.45 | 3.9 | 1.20 | 7898.622 | 2407.500 | " |
| 55 | 487623.55 | 4022349.35 | 3216.7 | 980.45 | 4.6 | 1.40 | 7897.966 | 2407.300 | " |
| 56 | 487603.83 | 4022346.01 | 3282.3 | 1000.45 | 4.9 | 1.50 | 7897.638 | 2407.200 | " |
| 57 | 487593.97 | 4022344.33 | 3315.1 | 1010.45 | 3.0 | 0.90 | 7899.607 | 2407.800 | " |
| 58 | 487581.84 | 4022342.27 | 3355.5 | 1022.76 | 0.0 | 0.00 | 7902.559 | 2408.700 | Water Edge on Right Bank Creek-II |
| 59 | 487554.62 | 4022337.66 | 3446.1 | 1050.36 | | | 7907.622 | 2410.243 | Slope |
| 60 | 487449.71 | 4022319.87 | 3795.2 | 1156.77 | | | 7912.225 | 2411.646 | " |
| 61 | 487354.23 | 4022303.67 | 4112.9 | 1253.62 | | | 7908.776 | 2410.595 | " |
| 62 | 487352.91 | 4022303.45 | 4117.3 | 1254.95 | | | 7914.488 | 2412.336 | " |
| 63 | 487346.09 | 4022302.29 | 4140.0 | 1261.87 | | | 7923.760 | 2415.162 | " |
| 64 | 487338.57 | 4022301.02 | 4165.0 | 1269.50 | | | 7938.488 | 2419.651 | " |
| 65 | 487334.64 | 4022300.35 | 4178.1 | 1273.49 | | | 7947.038 | 2422.257 | " |
| 66 | 487325.54 | 4022298.81 | 4208.4 | 1282.72 | | | 7964.899 | 2427.701 | " |
| 67 | 487319.32 | 4022297.75 | 4229.1 | 1289.02 | | | 7978.904 | 2431.970 | T.B.M on Right Bank |



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## Table 1-32 Cross Sectional Coordinates, Cross Section 23 A

| Sr. No. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 487596.42 | 4022920.71 | 0.0 | 0.00 | | | 7980.840 | 2432.560 | T,B.M on Left Bank (House Wall) |
| 2 | 487595.03 | 4022919.27 | 6.6 | 2.00 | | | 7962.152 | 2426.864 | Slope |
| 3 | 487588.78 | 4022912.79 | 36.1 | 11.00 | | | 7955.679 | 2424.891 | " |
| 4 | 487581.98 | 4022905.75 | 68.2 | 20.79 | | | 7951.877 | 2423.732 | " |
| 5 | 487565.90 | 4022889.08 | 144.2 | 43.95 | | | 7932.704 | 2417.888 | " |
| 6 | 487559.39 | 4022882.34 | 174.9 | 53.32 | | | 7917.904 | 2413.377 | " |
| 7 | 487556.40 | 4022879.25 | 189.0 | 57.62 | 0.0 | 0.00 | 7906.824 | 2410.000 | Water Edge on Left Bank |
| 8 | 487552.93 | 4022875.65 | 205.4 | 62.62 | 3.0 | 0.90 | 7903.872 | 2409.100 | Bed |
| 9 | 487545.98 | 4022868.45 | 238.3 | 72.62 | 3.9 | 1.20 | 7902.887 | 2408.800 | " |
| 10 | 487539.04 | 4022861.26 | 271.1 | 82.62 | 4.6 | 1.40 | 7902.231 | 2408.600 | " |
| 11 | 487532.09 | 4022854.06 | 303.9 | 92.62 | 4.9 | 1.50 | 7901.903 | 2408.500 | " |
| 12 | 487525.15 | 4022846.87 | 336.7 | 102.62 | 6.6 | 2.00 | 7900.263 | 2408.000 | " |
| 13 | 487518.21 | 4022839.67 | 369.5 | 112.62 | 5.6 | 1.70 | 7901.247 | 2408.300 | " |
| 14 | 487511.26 | 4022832.48 | 402.3 | 122.62 | 3.9 | 1.20 | 7902.887 | 2408.800 | " |
| 15 | 487504.32 | 4022825.28 | 435.1 | 132.62 | 3.3 | 1.00 | 7903.544 | 2409.000 | " |
| 16 | 487497.37 | 4022818.09 | 467.9 | 142.62 | 2.3 | 0.70 | 7904.528 | 2409.300 | " |
| 17 | 487490.43 | 4022810.89 | 500.7 | 152.62 | 2.0 | 0.60 | 7904.856 | 2409.400 | " |
| 18 | 487483.48 | 4022803.70 | 533.5 | 162.62 | 1.3 | 0.40 | 7905.512 | 2409.600 | " |
| 19 | 487476.54 | 4022796.50 | 566.3 | 172.62 | 1.0 | 0.30 | 7905.840 | 2409.700 | " |
| 20 | 487469.59 | 4022789.31 | 599.1 | 182.62 | 1.0 | 0.30 | 7905.840 | 2409.700 | " |
| 21 | 487467.10 | 4022786.73 | 610.9 | 186.21 | 0.0 | 0.00 | 7906.824 | 2410.000 | Water Edge on Right Bank |
| 22 | 487461.40 | 4022780.82 | 637.9 | 194.42 | | | 7912.832 | 2411.831 | Slope |
| 23 | 487450.44 | 4022769.46 | 689.6 | 210.20 | | | 7913.058 | 2411.900 | " |
| 24 | 487439.85 | 4022758.50 | 739.6 | 225.44 | | | 7913.091 | 2411.910 | " |
| 25 | 487429.47 | 4022747.74 | 788.7 | 240.39 | | | 7913.386 | 2412.000 | " |
| 26 | 487419.25 | 4022737.15 | 837.0 | 255.11 | | | 7913.714 | 2412.100 | " |
| 27 | 487411.76 | 4022729.39 | 872.3 | 265.89 | | | 7914.042 | 2412.200 | " |
| 28 | 487401.91 | 4022719.19 | 918.9 | 280.07 | | | 7914.403 | 2412.310 | " |
| 29 | 487388.07 | 4022704.85 | 984.3 | 300.00 | | | 7914.042 | 2412.200 | " |
| 30 | 487374.10 | 4022690.38 | 1050.3 | 320.12 | | | 7912.730 | 2411.800 | " |
| 31 | 487359.91 | 4022675.68 | 1117.3 | 340.55 | | | 7911.582 | 2411.450 | " |
| 32 | 487345.79 | 4022661.05 | 1184.0 | 360.88 | | | 7910.433 | 2411.100 | " |
| 33 | 487335.99 | 4022650.89 | 1230.3 | 375.00 | | | 7909.777 | 2410.900 | " |
| 34 | 487329.10 | 4022643.75 | 1262.9 | 384.92 | | | 7909.423 | 2410.792 | " |
| 35 | 487311.51 | 4022625.53 | 1346.0 | 410.25 | | | 7912.336 | 2411.680 | " |
| 36 | 487304.30 | 4022618.06 | 1380.0 | 420.63 | | | 7921.034 | 2414.331 | Slope |
| 37 | 487295.52 | 4022608.96 | 1421.5 | 433.27 | | | 7929.236 | 2416.831 | " |
| 38 | 487286.21 | 4022599.32 | 1465.5 | 446.67 | | | 7941.536 | 2420.580 | " |
| 39 | 487279.09 | 4022591.94 | 1499.1 | 456.93 | | | 7954.134 | 2424.420 | " |
| 40 | 487268.11 | 4022580.57 | 1551.0 | 472.73 | | | 7975.486 | 2430.928 | T.B.M on Right Bank |



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## Table 1-33 Cross Sectional Coordinates, Cross Section 24

| Sr. No. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 487576.39 | 4022979.94 | 0.0 | 0.00 | | | 7975.791 | 2431.021 | T,B.M on Left Bank |
| 2 | 487557.18 | 4022977.43 | 63.5 | 19.37 | | | 7963.173 | 2427.175 | Slope |
| 3 | 487543.67 | 4022975.67 | 108.2 | 32.99 | | | 7957.310 | 2425.388 | " |
| 4 | 487530.94 | 4022974.01 | 150.4 | 45.83 | | | 7953.934 | 2424.359 | " |
| 5 | 487528.73 | 4022973.72 | 157.7 | 48.06 | | | 7952.218 | 2423.836 | " |
| 6 | 487518.67 | 4022972.41 | 191.0 | 58.21 | | | 7929.200 | 2416.820 | " |
| 7 | 487512.40 | 4022971.59 | 211.7 | 64.53 | | | 7919.190 | 2413.769 | " |
| 8 | 487505.42 | 4022970.68 | 234.8 | 71.57 | | | 7914.128 | 2412.226 | " |
| 9 | 487502.48 | 4022970.30 | 244.5 | 74.53 | | | 7909.974 | 2410.960 | " |
| 10 | 487500.80 | 4022970.08 | 250.1 | 76.23 | 0.0 | 0.00 | 7907.015 | 2410.058 | Water Edge on Left Bank |
| 11 | 487490.88 | 4022968.78 | 282.9 | 86.23 | 3.3 | 1.00 | 7903.734 | 2409.058 | Bed |
| 12 | 487480.96 | 4022967.49 | 315.7 | 96.23 | 2.6 | 0.80 | 7904.390 | 2409.258 | " |
| 13 | 487471.05 | 4022966.19 | 348.5 | 106.23 | 2.6 | 0.80 | 7904.390 | 2409.258 | " |
| 14 | 487461.13 | 4022964.90 | 381.3 | 116.23 | 2.3 | 0.70 | 7904.718 | 2409.358 | " |
| 15 | 487451.22 | 4022963.61 | 414.1 | 126.23 | 1.0 | 0.30 | 7906.030 | 2409.758 | " |
| 16 | 487441.30 | 4022962.31 | 446.9 | 136.23 | 0.7 | 0.20 | 7906.359 | 2409.858 | " |
| 17 | 487431.39 | 4022961.02 | 479.8 | 146.23 | 0.7 | 0.20 | 7906.359 | 2409.858 | " |
| 18 | 487421.47 | 4022959.72 | 512.6 | 156.23 | 0.7 | 0.20 | 7906.359 | 2409.858 | " |
| 19 | 487415.35 | 4022958.93 | 532.8 | 162.40 | 0.0 | 0.00 | 7907.015 | 2410.058 | Water Edge on Right Bank |
| 20 | 487395.56 | 4022956.34 | 598.3 | 182.36 | | | 7906.988 | 2410.050 | Slope |
| 21 | 487375.55 | 4022953.73 | 664.5 | 202.54 | | | 7907.481 | 2410.200 | " |
| 22 | 487356.13 | 4022951.20 | 728.7 | 222.12 | | | 7907.743 | 2410.280 | " |
| 23 | 487345.54 | 4022949.82 | 763.8 | 232.80 | | | 7908.137 | 2410.400 | " |
| 24 | 487330.46 | 4022947.85 | 813.7 | 248.01 | | | 7908.711 | 2410.575 | " |
| 25 | 487300.18 | 4022943.90 | 913.9 | 278.55 | | | 7908.793 | 2410.600 | " |
| 26 | 487278.50 | 4022941.07 | 985.6 | 300.41 | | | 7909.121 | 2410.700 | " |
| 27 | 487248.62 | 4022937.17 | 1084.4 | 330.54 | | | 7909.187 | 2410.720 | " |
| 28 | 487219.12 | 4022933.32 | 1182.1 | 360.29 | | | 7909.449 | 2410.800 | " |
| 29 | 487189.66 | 4022929.48 | 1279.5 | 390.00 | | | 7909.941 | 2410.950 | " |
| 30 | 487159.32 | 4022925.52 | 1379.9 | 420.60 | | | 7910.433 | 2411.100 | " |
| 31 | 487132.50 | 4022922.02 | 1468.7 | 447.65 | | | 7910.597 | 2411.150 | " |
| 32 | 487124.72 | 4022921.01 | 1494.4 | 455.49 | | | 7930.168 | 2417.115 | " |
| 33 | 487116.97 | 4022919.99 | 1520.0 | 463.31 | | | 7959.456 | 2426.042 | " |
| 34 | 487107.85 | 4022918.80 | 1550.2 | 472.51 | | | 7974.055 | 2430.492 | T.B.M on Right Bank |



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## Table 1-34 Cross Sectional Coordinates, Cross Section 25

| Sr. No. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 487416.27 | 4023345.22 | 0.0 | 0.00 | | | 7979.954 | 2432.290 | T,B.M on Left Bank |
| 2 | 487414.30 | 4023344.87 | 6.6 | 2.00 | | | 7971.910 | 2429.838 | Slope |
| 3 | 487407.16 | 4023343.60 | 30.3 | 9.25 | | | 7963.550 | 2427.290 | " |
| 4 | 487385.13 | 4023339.69 | 103.7 | 31.62 | | | 7914.334 | 2412.289 | " |
| 5 | 487368.71 | 4023336.77 | 158.5 | 48.30 | 0.0 | 0.00 | 7908.993 | 2410.661 | Water Edge on Left Bank |
| 6 | 487358.87 | 4023335.02 | 191.3 | 58.30 | 0.7 | 0.20 | 7908.337 | 2410.461 | Bed |
| 7 | 487349.02 | 4023333.27 | 224.1 | 68.30 | 0.7 | 0.20 | 7908.337 | 2410.461 | " |
| 8 | 487329.33 | 4023329.77 | 289.7 | 88.30 | 1.0 | 0.30 | 7908.009 | 2410.361 | " |
| 9 | 487309.64 | 4023326.27 | 355.3 | 108.30 | 1.6 | 0.50 | 7907.353 | 2410.161 | " |
| 10 | 487289.95 | 4023322.77 | 420.9 | 128.30 | 2.0 | 0.60 | 7907.025 | 2410.061 | " |
| 11 | 487270.25 | 4023319.27 | 486.5 | 148.30 | 2.0 | 0.60 | 7907.025 | 2410.061 | " |
| 12 | 487250.56 | 4023315.77 | 552.2 | 168.30 | 2.0 | 0.60 | 7907.025 | 2410.061 | " |
| 13 | 487230.87 | 4023312.27 | 617.8 | 188.30 | 2.0 | 0.60 | 7907.025 | 2410.061 | " |
| 14 | 487211.18 | 4023308.77 | 683.4 | 208.30 | 1.3 | 0.40 | 7907.681 | 2410.261 | " |
| 15 | 487201.33 | 4023307.02 | 716.2 | 218.30 | 1.0 | 0.30 | 7908.009 | 2410.361 | " |
| 16 | 487191.49 | 4023305.27 | 749.0 | 228.30 | 0.7 | 0.20 | 7908.337 | 2410.461 | " |
| 17 | 487183.65 | 4023303.88 | 775.1 | 236.26 | 0.0 | 0.00 | 7908.993 | 2410.661 | Water Edge on Right Bank |
| 18 | 487182.33 | 4023303.64 | 779.5 | 237.60 | | | 7917.940 | 2413.388 | Slope |
| 19 | 487167.86 | 4023301.07 | 827.8 | 252.30 | | | 7917.651 | 2413.300 | " |
| 20 | 487149.99 | 4023297.89 | 887.3 | 270.45 | | | 7917.454 | 2413.240 | " |
| 21 | 487122.72 | 4023293.05 | 978.2 | 298.15 | | | 7917.159 | 2413.150 | " |
| 22 | 487105.98 | 4023290.07 | 1034.0 | 315.15 | | | 7916.651 | 2412.995 | " |
| 23 | 487090.91 | 4023287.39 | 1084.2 | 330.45 | | | 7916.011 | 2412.800 | " |
| 24 | 487070.79 | 4023283.82 | 1151.2 | 350.89 | | | 7915.256 | 2412.570 | " |
| 25 | 487052.49 | 4023280.56 | 1212.2 | 369.48 | | | 7913.780 | 2412.120 | " |
| 26 | 487036.92 | 4023277.80 | 1264.1 | 385.29 | | | 7911.880 | 2411.541 | " |
| 27 | 487022.05 | 4023275.15 | 1313.6 | 400.39 | | | 7912.730 | 2411.800 | " |
| 28 | 487007.49 | 4023272.57 | 1362.1 | 415.18 | | | 7915.683 | 2412.700 | " |
| 29 | 486992.90 | 4023269.97 | 1410.8 | 430.00 | | | 7918.307 | 2413.500 | " |
| 30 | 486975.62 | 4023266.90 | 1468.3 | 447.55 | | | 7920.604 | 2414.200 | " |
| 31 | 486956.41 | 4023263.49 | 1532.3 | 467.06 | | | 7923.163 | 2414.980 | " |
| 32 | 486952.88 | 4023262.86 | 1544.1 | 470.65 | | | 7947.244 | 2422.320 | " |
| 33 | 486949.29 | 4023262.22 | 1556.1 | 474.29 | | | 7960.335 | 2426.310 | " |
| 34 | 486946.31 | 4023261.69 | 1566.0 | 477.32 | | | 7972.080 | 2429.890 | " |
| 35 | 486943.43 | 4023261.18 | 1575.6 | 480.25 | | | 7981.103 | 2432.640 | T.B.M on Right Bank |



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## Table 1-35 Cross Sectional Coordinates, Cross Section 26

| Sr. No. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 487410.67 | 4024225.10 | 0.0 | 0.00 | | | 7975.010 | 2430.783 | T,B.M on Left Bank |
| 2 | 487407.95 | 4024226.21 | 9.6 | 2.94 | | | 7967.317 | 2428.438 | Slope |
| 3 | 487401.21 | 4024228.96 | 33.5 | 10.22 | | | 7955.975 | 2424.981 | " |
| 4 | 487395.88 | 4024231.13 | 52.4 | 15.97 | | | 7945.007 | 2421.638 | " |
| 5 | 487390.82 | 4024233.19 | 70.3 | 21.44 | | | 7935.673 | 2418.793 | " |
| 6 | 487358.85 | 4024246.22 | 183.6 | 55.96 | | | 7933.055 | 2417.995 | " |
| 7 | 487313.00 | 4024264.91 | 346.0 | 105.47 | | | 7923.845 | 2415.188 | " |
| 8 | 487292.98 | 4024273.07 | 417.0 | 127.09 | | | 7920.171 | 2414.068 | " |
| 9 | 487279.47 | 4024278.58 | 464.8 | 141.68 | | | 7916.119 | 2412.833 | " |
| 10 | 487277.23 | 4024279.49 | 472.8 | 144.10 | 0.0 | 0.00 | 7911.673 | 2411.478 | Water Edge on Left Bank |
| 11 | 487267.97 | 4024283.26 | 505.6 | 154.10 | 3.3 | 1.00 | 7908.393 | 2410.478 | Bed |
| 12 | 487258.71 | 4024287.04 | 538.4 | 164.10 | 3.0 | 0.90 | 7908.721 | 2410.578 | " |
| 13 | 487249.45 | 4024290.81 | 571.2 | 174.10 | 3.6 | 1.10 | 7908.065 | 2410.378 | " |
| 14 | 487240.19 | 4024294.59 | 604.0 | 184.10 | 3.9 | 1.20 | 7907.736 | 2410.278 | " |
| 15 | 487230.93 | 4024298.36 | 636.8 | 194.10 | 2.6 | 0.80 | 7909.049 | 2410.678 | " |
| 16 | 487221.67 | 4024302.14 | 669.6 | 204.10 | 1.3 | 0.40 | 7910.361 | 2411.078 | " |
| 17 | 487216.88 | 4024304.09 | 686.6 | 209.27 | 0.0 | 0.00 | 7911.673 | 2411.478 | Water Edge on Right Bank |
| 18 | 487211.20 | 4024306.40 | 706.7 | 215.40 | | | 7922.549 | 2414.793 | Slope |
| 19 | 487206.74 | 4024308.22 | 722.5 | 220.22 | | | 7925.066 | 2415.560 | " |
| 20 | 487201.26 | 4024310.45 | 741.9 | 226.14 | | | 7926.260 | 2415.924 | " |
| 21 | 487193.32 | 4024313.69 | 770.0 | 234.71 | | | 7932.887 | 2417.944 | " |
| 22 | 487190.79 | 4024314.72 | 779.0 | 237.44 | | | 7945.381 | 2421.752 | " |
| 23 | 487186.35 | 4024316.53 | 794.8 | 242.24 | | | 7966.834 | 2428.291 | " |
| 24 | 487183.36 | 4024317.75 | 805.3 | 245.47 | | | 7975.889 | 2431.051 | T.B.M on Right Bank |



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## Table 1-36 Cross Sectional Coordinates, Cross Section 27

| Sr. No. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 487531.82 | 4024628.97 | 0.0 | 0.00 | | | 7980.046 | 2432.318 | T,B.M on Left Bank |
| 2 | 487514.61 | 4024637.37 | 62.8 | 19.15 | | | 7953.606 | 2424.259 | Slope |
| 3 | 487505.89 | 4024641.64 | 94.7 | 28.86 | | | 7938.658 | 2419.703 | " |
| 4 | 487502.80 | 4024643.15 | 106.0 | 32.30 | | | 7914.698 | 2412.400 | " |
| 5 | 487483.14 | 4024652.75 | 177.8 | 54.18 | | | 7915.889 | 2412.763 | " |
| 6 | 487429.83 | 4024678.80 | 372.4 | 113.51 | | | 7918.606 | 2413.591 | " |
| 7 | 487406.16 | 4024690.37 | 458.9 | 139.86 | | | 7915.525 | 2412.652 | " |
| 8 | 487377.58 | 4024704.34 | 563.2 | 171.67 | 0.0 | 0.00 | 7912.684 | 2411.786 | Water Edge on Left Bank |
| 9 | 487369.49 | 4024708.29 | 592.7 | 180.67 | 3.9 | 1.20 | 7908.747 | 2410.586 | Bed |
| 10 | 487360.51 | 4024712.68 | 625.6 | 190.67 | 4.3 | 1.30 | 7908.419 | 2410.486 | " |
| 11 | 487351.53 | 4024717.07 | 658.4 | 200.67 | 3.3 | 1.00 | 7909.403 | 2410.786 | " |
| 12 | 487342.54 | 4024721.46 | 691.2 | 210.67 | 3.3 | 1.00 | 7909.403 | 2410.786 | " |
| 13 | 487333.56 | 4024725.86 | 724.0 | 220.67 | 3.3 | 1.00 | 7909.403 | 2410.786 | " |
| 14 | 487324.57 | 4024730.25 | 756.8 | 230.67 | 2.6 | 0.80 | 7910.059 | 2410.986 | " |
| 15 | 487315.59 | 4024734.64 | 789.6 | 240.67 | 2.3 | 0.70 | 7910.387 | 2411.086 | " |
| 16 | 487306.60 | 4024739.03 | 822.4 | 250.67 | 2.0 | 0.60 | 7910.715 | 2411.186 | " |
| 17 | 487297.62 | 4024743.42 | 855.2 | 260.67 | 1.3 | 0.40 | 7911.372 | 2411.386 | " |
| 18 | 487291.57 | 4024746.37 | 877.3 | 267.40 | 0.0 | 0.00 | 7912.684 | 2411.786 | Water Edge on Right Bank |
| 19 | 487286.05 | 4024749.07 | 897.5 | 273.55 | | | 7982.523 | 2433.073 | Slope |
| 20 | 487276.13 | 4024753.92 | 933.7 | 284.59 | | | 8002.569 | 2439.183 | T.B.M on Right Bank (Vertical Cut) |



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## Table 1-37 Cross Sectional Coordinates, Cross Section 28

| Sr. No. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 487724.07 | 4024983.99 | 0.0 | 0.00 | | | 7980.378 | 2432.419 | T,B.M on Left Bank (Vertical Cut) |
| 2 | 487722.30 | 4024986.90 | 11.2 | 3.40 | | | 7957.126 | 2425.332 | Slope |
| 3 | 487714.63 | 4024999.57 | 59.7 | 18.21 | | | 7951.270 | 2423.547 | " |
| 4 | 487707.27 | 4025011.73 | 106.4 | 32.43 | | | 7918.225 | 2413.475 | " |
| 5 | 487701.16 | 4025021.82 | 145.1 | 44.22 | 0.0 | 0.00 | 7914.534 | 2412.350 | Water Edge on Left Bank |
| 6 | 487698.05 | 4025026.95 | 164.8 | 50.22 | 0.7 | 0.20 | 7913.878 | 2412.150 | Bed |
| 7 | 487692.87 | 4025035.50 | 197.6 | 60.22 | 1.0 | 0.30 | 7913.550 | 2412.050 | " |
| 8 | 487687.69 | 4025044.06 | 230.4 | 70.22 | 2.0 | 0.60 | 7912.566 | 2411.750 | " |
| 9 | 487682.52 | 4025052.61 | 263.2 | 80.22 | 2.6 | 0.80 | 7911.910 | 2411.550 | " |
| 10 | 487677.34 | 4025061.16 | 296.0 | 90.22 | 2.3 | 0.70 | 7912.238 | 2411.650 | " |
| 11 | 487672.16 | 4025069.72 | 328.8 | 100.22 | 2.6 | 0.80 | 7911.910 | 2411.550 | " |
| 12 | 487666.98 | 4025078.27 | 361.6 | 110.22 | 2.0 | 0.60 | 7912.566 | 2411.750 | " |
| 13 | 487661.80 | 4025086.83 | 394.4 | 120.22 | 1.6 | 0.50 | 7912.894 | 2411.850 | " |
| 14 | 487656.62 | 4025095.38 | 427.2 | 130.22 | 1.0 | 0.30 | 7913.550 | 2412.050 | " |
| 15 | 487651.44 | 4025103.93 | 460.0 | 140.22 | 0.7 | 0.20 | 7913.878 | 2412.150 | " |
| 16 | 487646.26 | 4025112.49 | 492.8 | 150.22 | 0.7 | 0.20 | 7913.878 | 2412.150 | " |
| 17 | 487644.61 | 4025115.21 | 503.3 | 153.40 | 0.0 | 0.00 | 7914.534 | 2412.350 | Water Edge on Right Bank |
| 18 | 487616.93 | 4025160.92 | 678.6 | 206.84 | | | 7919.679 | 2413.918 | Slope |
| 19 | 487580.19 | 4025221.60 | 911.3 | 277.77 | | | 7920.699 | 2414.229 | " |
| 20 | 487542.87 | 4025283.24 | 1147.7 | 349.83 | | | 7923.110 | 2414.964 | " |
| 21 | 487515.20 | 4025328.94 | 1323.0 | 403.26 | | | 7924.370 | 2415.348 | " |
| 22 | 487487.73 | 4025374.31 | 1497.0 | 456.30 | | | 7926.109 | 2415.878 | " |
| 23 | 487482.91 | 4025382.26 | 1527.5 | 465.59 | | | 7941.447 | 2420.553 | " |
| 24 | 487477.98 | 4025390.40 | 1558.8 | 475.11 | | | 7959.439 | 2426.037 | " |
| 25 | 487472.39 | 4025399.63 | 1594.2 | 485.90 | | | 7978.475 | 2431.839 | T.B.M on Right Bank |



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## Table 1-38 Cross Sectional Coordinates, Cross Section 29

| Sr. No. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 487932.17 | 4025036.73 | 0.0 | 0.00 | | | 7979.794 | 2432.241 | T,B.M on Left Bank (Vertical Cut) |
| 2 | 487932.35 | 4025040.01 | 10.8 | 3.28 | | | 7941.614 | 2420.604 | Slope |
| 3 | 487932.44 | 4025041.61 | 16.0 | 4.89 | | | 7922.113 | 2414.660 | " |
| 4 | 487933.00 | 4025051.84 | 49.6 | 15.13 | | | 7923.672 | 2415.135 | Water Edge on Left Bank |
| 5 | 487933.00 | 4025051.84 | 49.6 | 15.13 | 0.0 | 0.00 | 7915.118 | 2412.528 | Bed |
| 6 | 487933.27 | 4025056.83 | 66.0 | 20.13 | 3.9 | 1.20 | 7911.181 | 2411.328 | " |
| 7 | 487933.82 | 4025066.82 | 98.9 | 30.13 | 3.6 | 1.10 | 7911.509 | 2411.428 | " |
| 8 | 487934.36 | 4025076.80 | 131.7 | 40.13 | 3.3 | 1.00 | 7911.838 | 2411.528 | " |
| 9 | 487934.91 | 4025086.79 | 164.5 | 50.13 | 2.6 | 0.80 | 7912.494 | 2411.728 | " |
| 10 | 487935.46 | 4025096.77 | 197.3 | 60.13 | 2.6 | 0.80 | 7912.494 | 2411.728 | " |
| 11 | 487936.00 | 4025106.76 | 230.1 | 70.13 | 2.3 | 0.70 | 7912.822 | 2411.828 | " |
| 12 | 487936.55 | 4025116.74 | 262.9 | 80.13 | 2.0 | 0.60 | 7913.150 | 2411.928 | " |
| 13 | 487937.10 | 4025126.73 | 295.7 | 90.13 | 1.6 | 0.50 | 7913.478 | 2412.028 | " |
| 14 | 487937.64 | 4025136.71 | 328.5 | 100.13 | 1.3 | 0.40 | 7913.806 | 2412.128 | " |
| 15 | 487938.19 | 4025146.70 | 361.3 | 110.13 | 1.3 | 0.40 | 7913.806 | 2412.128 | " |
| 16 | 487938.74 | 4025156.68 | 394.1 | 120.13 | 0.7 | 0.20 | 7914.462 | 2412.328 | " |
| 17 | 487939.03 | 4025162.03 | 411.7 | 125.49 | 0.0 | 0.00 | 7915.118 | 2412.528 | Water Edge on Right Bank |
| 18 | 487944.39 | 4025259.90 | 733.3 | 223.50 | | | 7918.284 | 2413.493 | Slope |
| 19 | 487949.73 | 4025357.46 | 1053.8 | 321.21 | | | 7921.746 | 2414.548 | " |
| 20 | 487953.05 | 4025418.13 | 1253.2 | 381.97 | | | 7920.145 | 2414.060 | " |
| 21 | 487955.11 | 4025455.72 | 1376.7 | 419.62 | | | 7927.527 | 2416.310 | " |
| 22 | 487956.44 | 4025480.03 | 1456.6 | 443.96 | | | 7967.458 | 2428.481 | " |
| 23 | 487956.61 | 4025483.02 | 1466.4 | 446.96 | | | 7969.731 | 2429.174 | " |
| 24 | 487957.08 | 4025491.77 | 1495.1 | 455.72 | | | 7982.815 | 2433.162 | T.B.M on Right Bank |



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## Table 1-39 Cross Sectional Coordinates, Cross Section 30

| Sr. No. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 488323.66 | 4025166.81 | 0.0 | 0.00 | | | 7976.975 | 2431.382 | T,B.M on Left Bank |
| 2 | 488318.20 | 4025172.70 | 26.3 | 8.03 | | | 7965.601 | 2427.915 | Slope |
| 3 | 488311.56 | 4025179.87 | 58.4 | 17.80 | | | 7940.437 | 2420.245 | " |
| 4 | 488308.13 | 4025183.57 | 75.0 | 22.85 | | | 7927.592 | 2416.330 | " |
| 5 | 488299.23 | 4025193.17 | 117.9 | 35.94 | | | 7919.118 | 2413.747 | " |
| 6 | 488270.39 | 4025224.30 | 257.1 | 78.37 | | | 7919.541 | 2413.876 | " |
| 7 | 488239.28 | 4025257.87 | 407.3 | 124.14 | 0.0 | 0.00 | 7916.030 | 2412.806 | Water Edge on Left Bank |
| 8 | 488235.21 | 4025262.27 | 427.0 | 130.14 | 0.7 | 0.20 | 7915.374 | 2412.606 | Bed |
| 9 | 488228.41 | 4025269.61 | 459.8 | 140.14 | 0.7 | 0.20 | 7915.374 | 2412.606 | " |
| 10 | 488214.82 | 4025284.28 | 525.4 | 160.14 | 1.0 | 0.30 | 7915.046 | 2412.506 | " |
| 11 | 488201.22 | 4025298.95 | 591.0 | 180.14 | 1.6 | 0.50 | 7914.390 | 2412.306 | " |
| 12 | 488187.63 | 4025313.62 | 656.6 | 200.14 | 2.0 | 0.60 | 7914.062 | 2412.206 | " |
| 13 | 488174.04 | 4025328.29 | 722.2 | 220.14 | 2.3 | 0.70 | 7913.734 | 2412.106 | " |
| 14 | 488160.43 | 4025342.98 | 787.9 | 240.16 | 2.3 | 0.70 | 7913.734 | 2412.106 | " |
| 15 | 488146.85 | 4025357.63 | 853.5 | 260.14 | 2.6 | 0.80 | 7913.406 | 2412.006 | " |
| 16 | 488133.26 | 4025372.30 | 919.1 | 280.14 | 2.0 | 0.60 | 7914.062 | 2412.206 | " |
| 17 | 488119.66 | 4025386.97 | 984.7 | 300.14 | 1.3 | 0.40 | 7914.718 | 2412.406 | " |
| 18 | 488106.07 | 4025401.64 | 1050.3 | 320.14 | 0.7 | 0.20 | 7915.374 | 2412.606 | " |
| 19 | 488092.48 | 4025416.31 | 1115.9 | 340.14 | 0.7 | 0.20 | 7915.374 | 2412.606 | " |
| 20 | 488078.89 | 4025430.99 | 1181.6 | 360.14 | 0.7 | 0.20 | 7915.374 | 2412.606 | " |
| 21 | 488065.29 | 4025445.66 | 1247.2 | 380.14 | 0.3 | 0.10 | 7915.702 | 2412.706 | " |
| 22 | 488058.35 | 4025453.15 | 1280.7 | 390.36 | 0.0 | 0.00 | 7916.030 | 2412.806 | Water Edge on Right Bank |
| 23 | 488040.37 | 4025472.55 | 1367.5 | 416.81 | | | 7919.433 | 2413.843 | Slope |
| 24 | 488033.43 | 4025480.04 | 1401.0 | 427.02 | | | 7923.488 | 2415.079 | " |
| 25 | 488028.93 | 4025484.90 | 1422.7 | 433.64 | | | 7923.829 | 2415.183 | " |
| 26 | 488024.48 | 4025489.70 | 1444.2 | 440.19 | | | 7934.006 | 2418.285 | " |
| 27 | 488014.71 | 4025500.25 | 1491.3 | 454.56 | | | 7968.370 | 2428.759 | " |
| 28 | 488012.91 | 4025502.19 | 1500.0 | 457.21 | | | 7976.283 | 2431.171 | " |
| 29 | 488012.00 | 4025503.17 | 1504.4 | 458.55 | | | 7976.224 | 2431.153 | T.B.M on Right Bank |



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## Table 1-40 Cross Sectional Coordinates, Cross Section 31

| Sr. No. | Coordinates (m) | | Distance | | Depth | | Reduced Level (SPD) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | (ft) | (m) | (ft) | (m) | (ft) | (m) | |
| 1 | 488472.23 | 4025558.16 | 0.0 | 0.00 | | | 7976.841 | 2431.341 | T,B.M on Left Bank |
| 2 | 488461.94 | 4025557.69 | 33.8 | 10.30 | | | 7960.696 | 2426.420 | Slope |
| 3 | 488451.15 | 4025557.20 | 69.2 | 21.10 | | | 7940.699 | 2420.325 | " |
| 4 | 488447.00 | 4025557.02 | 82.8 | 25.25 | | | 7924.623 | 2415.425 | " |
| 5 | 488431.87 | 4025556.33 | 132.5 | 40.40 | | | 7921.867 | 2414.585 | " |
| 6 | 488398.90 | 4025554.83 | 240.8 | 73.40 | | | 7918.947 | 2413.695 | " |
| 7 | 488349.18 | 4025552.58 | 404.1 | 123.18 | | | 7919.800 | 2413.955 | " |
| 8 | 488277.93 | 4025549.35 | 638.1 | 194.50 | | | 7921.332 | 2414.422 | " |
| 9 | 488201.94 | 4025545.90 | 887.7 | 270.57 | | | 7922.228 | 2414.695 | " |
| 10 | 488167.82 | 4025544.36 | 999.7 | 304.72 | | | 7919.032 | 2413.721 | " |
| 11 | 488128.50 | 4025542.58 | 1128.9 | 344.08 | 0.0 | 0.00 | 7916.798 | 2413.040 | Water Edge on Left Bank |
| 12 | 488122.51 | 4025542.30 | 1148.6 | 350.08 | 3.3 | 1.00 | 7913.517 | 2412.040 | Bed |
| 13 | 488112.52 | 4025541.85 | 1181.4 | 360.08 | 3.0 | 0.90 | 7913.845 | 2412.140 | " |
| 14 | 488102.53 | 4025541.40 | 1214.2 | 370.08 | 2.6 | 0.80 | 7914.173 | 2412.240 | " |
| 15 | 488092.54 | 4025540.95 | 1247.0 | 380.08 | 3.3 | 1.00 | 7913.517 | 2412.040 | " |
| 16 | 488082.55 | 4025540.49 | 1279.8 | 390.08 | 3.9 | 1.20 | 7912.861 | 2411.840 | " |
| 17 | 488072.56 | 4025540.04 | 1312.6 | 400.08 | 2.6 | 0.80 | 7914.173 | 2412.240 | " |
| 18 | 488061.95 | 4025539.56 | 1347.4 | 410.70 | 0.0 | 0.00 | 7916.798 | 2413.040 | Water Edge on Right Bank |
| 19 | 488057.55 | 4025539.36 | 1361.9 | 415.10 | | | 7925.719 | 2415.759 | " |
| 20 | 488049.56 | 4025539.00 | 1388.1 | 423.10 | | | 7927.904 | 2416.425 | " |
| 21 | 488035.73 | 4025538.37 | 1433.6 | 436.95 | | | 7959.784 | 2426.142 | " |
| 22 | 488027.19 | 4025537.98 | 1461.6 | 445.50 | | | 7975.046 | 2430.794 | T.B.M on Right Bank (Vertical Cut) |



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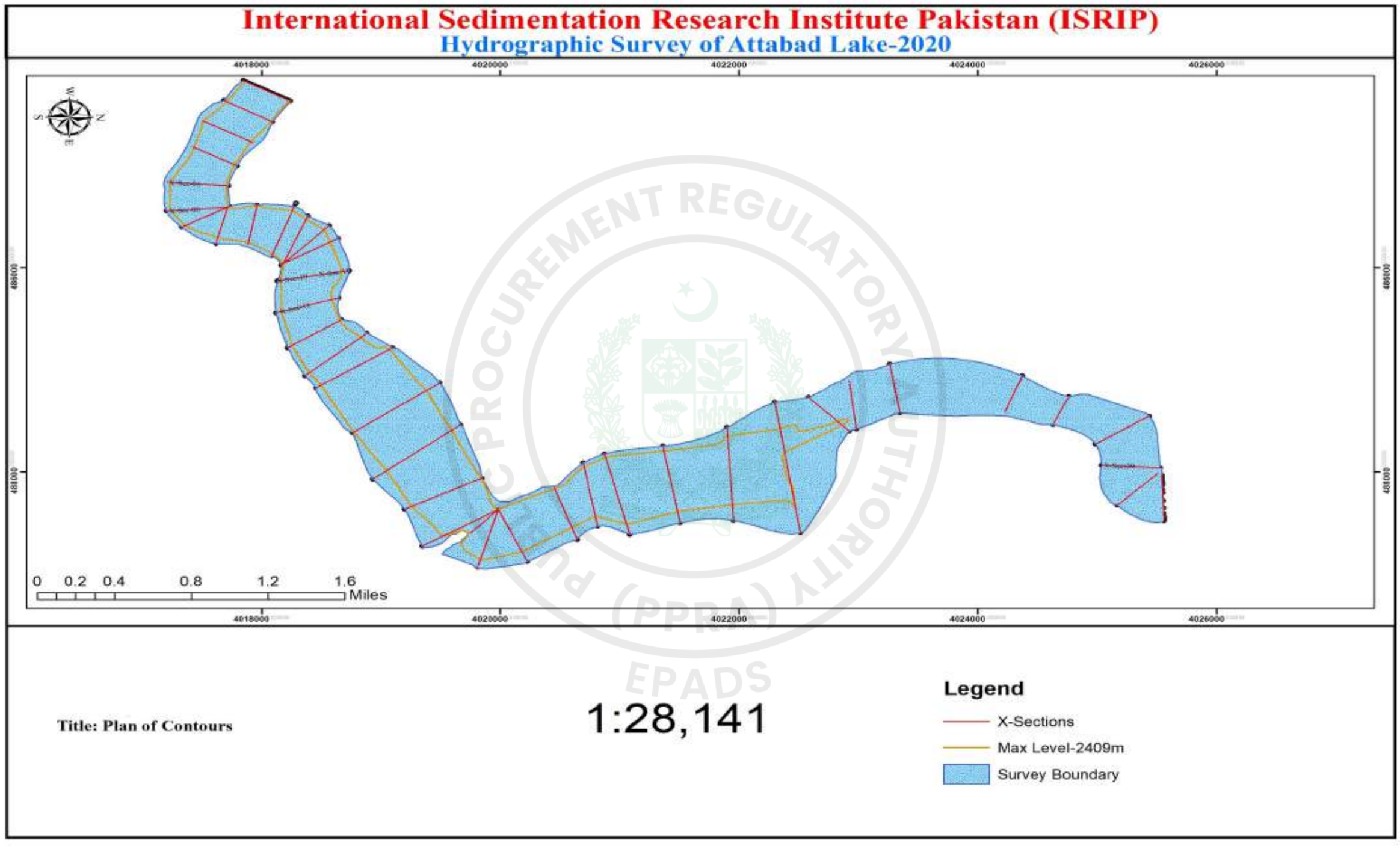


**Figure 1-1 The Plan of Contours**



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# APPENDIX – I(B):

# AREA AND CAPACITY DATA OF HYDROGRAPHIC SURVEY OF ATTABAD LAKE



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## 1.2 APPENDIX – I(B): AREA AND CAPACITY DATA OF HYDROGRAPHIC SURVEY OF ATTABAD LAKE

**Table 1-41 Area and Capacity Data**

| Sr. No. | Reservoir Elevation SPD (m) | Water Surface Area (Acres) | Water Surface Area $Km^2$ | Storage Capacity (Acre Feet) | Storage Capacity $Mm^3$ |
|---|---|---|---|---|---|
| 1 | 2366.0 | 0.0 | 0.00 | 0 | 0.00 |
| 2 | 2366.5 | 0.0 | 0.00 | 0 | 0.00 |
| 3 | 2367.0 | 1.7 | 0.01 | 0 | 0.00 |
| 4 | 2367.5 | 94.5 | 0.38 | 87 | 0.11 |
| 5 | 2368.0 | 167.7 | 0.68 | 294 | 0.36 |
| 6 | 2368.5 | 231.0 | 0.93 | 624 | 0.77 |
| 7 | 2369.0 | 309.4 | 1.25 | 1065 | 1.31 |
| 8 | 2369.5 | 371.2 | 1.50 | 1626 | 2.01 |
| 9 | 2370.0 | 399.7 | 1.62 | 2261 | 2.79 |
| 10 | 2370.5 | 419.0 | 1.70 | 2933 | 3.62 |
| 11 | 2371.0 | 431.9 | 1.75 | 3631 | 4.48 |
| 12 | 2371.5 | 447.0 | 1.81 | 4351 | 5.37 |
| 13 | 2372.0 | 472.6 | 1.91 | 5103 | 6.30 |
| 14 | 2372.5 | 495.0 | 2.00 | 5898 | 7.28 |
| 15 | 2373.0 | 512.1 | 2.07 | 6725 | 8.30 |
| 16 | 2373.5 | 524.8 | 2.12 | 7576 | 9.34 |
| 17 | 2374.0 | 535.7 | 2.17 | 8446 | 10.42 |
| 18 | 2374.5 | 545.1 | 2.21 | 9332 | 11.51 |
| 19 | 2375.0 | 554.2 | 2.24 | 10234 | 12.62 |
| 20 | 2375.5 | 563.3 | 2.28 | 11151 | 13.75 |
| 21 | 2376.0 | 571.9 | 2.31 | 12082 | 14.90 |
| 22 | 2376.5 | 580.4 | 2.35 | 13027 | 16.07 |
| 23 | 2377.0 | 588.8 | 2.38 | 13986 | 17.25 |
| 24 | 2377.5 | 596.8 | 2.42 | 14959 | 18.45 |
| 25 | 2378.0 | 604.3 | 2.45 | 15944 | 19.67 |
| 26 | 2378.5 | 611.5 | 2.47 | 16941 | 20.90 |
| 27 | 2379.0 | 618.6 | 2.50 | 17950 | 22.14 |
| 28 | 2379.5 | 625.8 | 2.53 | 18971 | 23.40 |
| 29 | 2380.0 | 632.7 | 2.56 | 20003 | 24.67 |
| 30 | 2380.5 | 639.2 | 2.59 | 21046 | 25.96 |
| 31 | 2381.0 | 645.5 | 2.61 | 22100 | 27.26 |
| 32 | 2381.5 | 651.7 | 2.64 | 23164 | 28.57 |
| 33 | 2382.0 | 657.9 | 2.66 | 24238 | 29.90 |
| 34 | 2382.5 | 664.2 | 2.69 | 25323 | 31.23 |
| 35 | 2383.0 | 670.4 | 2.71 | 26417 | 32.59 |
| 36 | 2383.5 | 676.6 | 2.74 | 27522 | 33.95 |
| 37 | 2384.0 | 682.8 | 2.76 | 28637 | 35.32 |
| 38 | 2384.5 | 689.0 | 2.79 | 29762 | 36.71 |



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| | | | | | |
|---|---|---|---|---|---|
| 39 | 2385.0 | 695.4 | 2.81 | 30898 | 38.11 |
| 40 | 2385.5 | 701.9 | 2.84 | 32044 | 39.53 |
| 41 | 2386.0 | 708.5 | 2.87 | 33200 | 40.95 |
| 42 | 2386.5 | 715.2 | 2.89 | 34368 | 42.39 |
| 43 | 2387.0 | 722.0 | 2.92 | 35547 | 43.85 |
| 44 | 2387.5 | 729.0 | 2.95 | 36737 | 45.31 |
| 45 | 2388.0 | 736.6 | 2.98 | 37939 | 46.80 |
| 46 | 2388.5 | 744.5 | 3.01 | 39154 | 48.30 |
| 47 | 2389.0 | 752.0 | 3.04 | 40382 | 49.81 |
| 48 | 2389.5 | 759.1 | 3.07 | 41621 | 51.34 |
| 49 | 2390.0 | 766.3 | 3.10 | 42872 | 52.88 |
| 50 | 2390.5 | 773.4 | 3.13 | 44135 | 54.44 |
| 51 | 2391.0 | 780.3 | 3.16 | 45409 | 56.01 |
| 52 | 2391.5 | 787.2 | 3.19 | 46695 | 57.60 |
| 53 | 2392.0 | 793.9 | 3.21 | 47992 | 59.20 |
| 54 | 2392.5 | 800.6 | 3.24 | 49300 | 60.81 |
| 55 | 2393.0 | 807.4 | 3.27 | 50619 | 62.44 |
| 56 | 2393.5 | 814.5 | 3.30 | 51949 | 64.08 |
| 57 | 2394.0 | 821.2 | 3.32 | 53291 | 65.73 |
| 58 | 2394.5 | 827.9 | 3.35 | 54643 | 67.40 |
| 59 | 2395.0 | 834.6 | 3.38 | 56007 | 69.08 |
| 60 | 2395.5 | 841.4 | 3.41 | 57382 | 70.78 |
| 61 | 2396.0 | 848.3 | 3.43 | 58767 | 72.49 |
| 62 | 2396.5 | 855.3 | 3.46 | 60165 | 74.21 |
| 63 | 2397.0 | 862.5 | 3.49 | 61574 | 75.95 |
| 64 | 2397.5 | 869.8 | 3.52 | 62995 | 77.70 |
| 65 | 2398.0 | 877.1 | 3.55 | 64427 | 79.47 |
| 66 | 2398.5 | 884.4 | 3.58 | 65872 | 81.25 |
| 67 | 2399.0 | 891.7 | 3.61 | 67329 | 83.05 |
| 68 | 2399.5 | 899.1 | 3.64 | 68798 | 84.86 |
| 69 | 2400.0 | 906.7 | 3.67 | 70279 | 86.69 |
| 70 | 2400.5 | 914.4 | 3.70 | 71773 | 88.53 |
| 71 | 2401.0 | 922.3 | 3.73 | 73279 | 90.39 |
| 72 | 2401.5 | 930.3 | 3.76 | 74799 | 92.26 |
| 73 | 2402.0 | 938.3 | 3.80 | 76331 | 94.15 |
| 74 | 2402.5 | 945.8 | 3.83 | 77877 | 96.06 |
| 75 | 2403.0 | 953.3 | 3.86 | 79435 | 97.98 |
| 76 | 2403.5 | 960.8 | 3.89 | 81005 | 99.92 |
| 77 | 2404.0 | 968.3 | 3.92 | 82587 | 101.87 |
| 78 | 2404.5 | 976.0 | 3.95 | 84181 | 103.84 |
| 79 | 2405.0 | 984.3 | 3.98 | 85789 | 105.82 |
| 80 | 2405.5 | 992.3 | 4.02 | 87410 | 107.82 |
| 81 | 2406.0 | 1000.4 | 4.05 | 89045 | 109.84 |
| 82 | 2406.5 | 1008.3 | 4.08 | 90693 | 111.87 |
| 83 | 2407.0 | 1016.6 | 4.11 | 92353 | 113.92 |
| 84 | 2407.5 | 1030.4 | 4.17 | 94031 | 115.99 |



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| | | | | | |
|---|---|---|---|---|---|
| 85 | 2408.0 | 1051.4 | 4.25 | 95734 | 118.09 |
| 86 | 2408.5 | 1071.1 | 4.33 | 97478 | 120.24 |
| 87 | 2409.0 | 1088.7 | 4.41 | 99249 | 122.42 |
| 88 | 2409.5 | 1104.3 | 4.47 | 101048 | 124.64 |
| 89 | 2410.0 | 1120.1 | 4.53 | 102872 | 126.89 |
| 90 | 2410.5 | 1149.9 | 4.65 | 104733 | 129.19 |
| 91 | 2411.0 | 1182.0 | 4.78 | 106644 | 131.54 |
| 92 | 2411.5 | 1216.3 | 4.92 | 108612 | 133.97 |
| 93 | 2412.0 | 1251.6 | 5.07 | 110635 | 136.47 |
| 94 | 2412.5 | 1285.5 | 5.20 | 112716 | 139.03 |
| 95 | 2413.0 | 1323.4 | 5.36 | 114856 | 141.67 |
| 96 | 2413.5 | 1355.8 | 5.49 | 117055 | 144.39 |
| 97 | 2414.0 | 1383.6 | 5.60 | 119302 | 147.16 |
| 98 | 2414.5 | 1409.4 | 5.70 | 121593 | 149.98 |
| 99 | 2415.0 | 1430.8 | 5.79 | 123924 | 152.86 |
| 100 | 2415.5 | 1446.4 | 5.85 | 126284 | 155.77 |
| 101 | 2416.0 | 1462.3 | 5.92 | 128670 | 158.71 |
| 102 | 2416.5 | 1475.9 | 5.97 | 131080 | 161.68 |
| 103 | 2417.0 | 1488.5 | 6.02 | 133511 | 164.68 |
| 104 | 2417.5 | 1500.9 | 6.07 | 135963 | 167.71 |
| 105 | 2418.0 | 1513.0 | 6.12 | 138435 | 170.76 |
| 106 | 2418.5 | 1524.6 | 6.17 | 140927 | 173.83 |
| 107 | 2419.0 | 1535.7 | 6.21 | 143437 | 176.93 |
| 108 | 2419.5 | 1546.4 | 6.26 | 145965 | 180.05 |
| 109 | 2420.0 | 1556.8 | 6.30 | 148511 | 183.18 |
| 110 | 2420.5 | 1566.9 | 6.34 | 151073 | 186.35 |
| 111 | 2421.0 | 1576.9 | 6.38 | 153651 | 189.53 |
| 112 | 2421.5 | 1586.8 | 6.42 | 156246 | 192.73 |
| 113 | 2422.0 | 1596.7 | 6.46 | 158857 | 195.95 |
| 114 | 2422.5 | 1606.6 | 6.50 | 161485 | 199.19 |
| 115 | 2423.0 | 1616.4 | 6.54 | 164128 | 202.45 |
| 116 | 2423.5 | 1626.1 | 6.58 | 166788 | 205.73 |
| 117 | 2424.0 | 1635.7 | 6.62 | 169463 | 209.03 |
| 118 | 2424.5 | 1645.1 | 6.66 | 172154 | 212.35 |
| 119 | 2425.0 | 1654.3 | 6.69 | 174860 | 215.69 |
| 120 | 2425.5 | 1663.3 | 6.73 | 177581 | 219.04 |
| 121 | 2426.0 | 1672.0 | 6.77 | 180317 | 222.42 |
| 122 | 2426.5 | 1680.6 | 6.80 | 183067 | 225.81 |
| 123 | 2427.0 | 1689.0 | 6.84 | 185831 | 229.22 |
| 124 | 2427.5 | 1697.2 | 6.87 | 188608 | 232.64 |
| 125 | 2428.0 | 1705.3 | 6.90 | 191399 | 236.09 |
| 126 | 2428.5 | 1713.2 | 6.93 | 194203 | 239.55 |
| 127 | 2429.0 | 1720.9 | 6.96 | 197019 | 243.02 |
| 128 | 2429.5 | 1728.4 | 6.99 | 199849 | 246.51 |
| 129 | 2430.0 | 1735.7 | 7.02 | 202690 | 250.01 |



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# APPENDIX – I(C):

# LONGITUDINAL BED PROFILE OF ATTABAD LAKE



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## 1.3 APPENDIX – I(C): LONGITUDINAL BED PROFILE OF ATTABAD LAKE

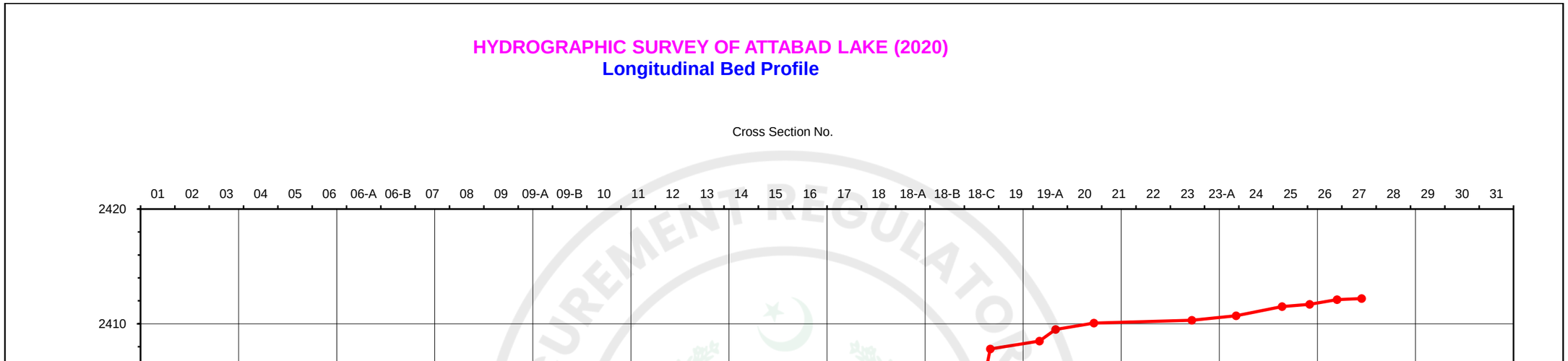


**Figure 1-2 Longitudinal Profile Bed**



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# APPENDIX – I(D):

# THALWEG PROFILE OF ATTABAD LAKE



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## 1.4 APPENDIX – I(D): THALWEG PROFILE OF ATTABAD LAKE

**Table 1-42: Thalweg Profile of Attabad Lake**

| Sr. No. | Cross Section No. | Distance from Natural Outlet (m) | Reduced Level (m) |
|---|---|---|---|
| 01 | 01 | 350.0 | 2368.100 |
| 02 | 02 | 600.0 | 2367.663 |
| 03 | 03 | 850.0 | 2367.106 |
| 04 | 04 | 1100.0 | 2367.030 |
| 05 | 05 | 1400.0 | 2366.950 |
| 06 | 06 | 1630.0 | 2367.051 |
| 07 | 06-A | 1705.0 | 2367.110 |
| 08 | 06-B | 1855.0 | 2367.054 |
| 09 | 07 | 2105.0 | 2367.050 |
| 10 | 08 | 2365.0 | 2367.412 |
| 11 | 09 | 2485.0 | 2367.592 |
| 12 | 09-A | 2605.0 | 2367.632 |
| 13 | 09-B | 2685.0 | 2367.752 |
| 14 | 10 | 2935.0 | 2367.732 |
| 15 | 11 | 3210.0 | 2367.842 |
| 16 | 12 | 3490.0 | 2368.162 |
| 17 | 13 | 3760.0 | 2368.410 |
| 18 | 14 | 3990.0 | 2368.350 |
| 19 | 15 | 4520.0 | 2368.700 |
| 20 | 16 | 4980.0 | 2368.965 |
| 21 | 17 | 5460.0 | 2369.255 |
| 22 | 18 | 5820.0 | 2369.820 |
| 23 | 18-A | 5880.0 | 2370.260 |
| 24 | 18-B | 5985.0 | 2370.220 |
| 25 | 18-C | 6215.0 | 2370.100 |
| 26 | 19 | 6715.0 | 2371.560 |
| 27 | 19-A | 6985.0 | 2371.700 |
| 28 | 20 | 7200.0 | 2371.900 |
| 29 | 21 | 7680.0 | 2376.700 |
| 30 | 22 | 8175.0 | 2387.600 |
| 31 | 23 | 8665 | 2407.200 |
| 32 | 23-A | 9165 | 2408.000 |
| 33 | 24 | 9330 | 2409.058 |
| 34 | 25 | 9720 | 2410.061 |
| 35 | 26 | 10720 | 2410.278 |
| 36 | 27 | 11170 | 2410.486 |
| 37 | 28 | 11640 | 2411.550 |
| 38 | 29 | 11920 | 2411.328 |
| 39 | 30 | 12200 | 2412.006 |



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| | | | |
|---|---|---|---|
| 40 | 31 | 12450 | 2411.840 |

# APPENDIX – I(E):

# DISCHARGE MEASUREMENT AT GANISH BRIDGE



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## 1.5 APPENDIX – I(E): DISCHARGE MEASUREMENT AT GANISH BRIDGE

INTERNATIONAL
SEDIMENTATION RESEARCH INSTITUTE, PAKISTAN (ISRIP)

WAPDA

DISCHARGE MEASUREMENT NOTES

Meas. No. 4
Comp. by Dam
Checked. by

Hunza River at Gum Ganish Bridge

Date 15-10-2019 Party Ram Nawaz Khan

Width 900 Area 827.50 Vel. 4.40 G. H. _____ Disch. 3071.57

Method 6 No. secs 19 G. H. change _____ in _____ hrs. Susp. 400

Method coef. _____ Hor. angle coef. _____ Susp. coef. _____ Meter No. S-14

| GAGE READINGS | | | |
|---|---|---|---|
| Time | Recorder | Inside | Outside |
| 09:20 | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| 10:50 | | | |
| Weighted M.G.N. | | | |
| G. H. correction | | | |
| Correct M.G.H. | | | |

Date rated 13-06-2019 Used rating
for rod _____ susp. Meter 1.2 ft.
above bottom of wt. Tags checked
Spin before meas. 100 after 04
Meas plots _____ % diff. from _____ rating
Wading, cable, ice, boat, upstr, downstr, side
bridge _____ feet, mile, above, below
gage, and _____
Check-bar, chain found _____
changed to _____ at _____
Correct _____
Levels obtained Yes

Measurement rated excellent (2%), good (5%), fair (8%), poor (over 8%), based on following conditions: Cross section Gravel bed
Flow Steady Weather Clear
Other _____ Air _____ °F @ _____
Gage _____ Water _____ °F @ _____
_____ Record removed _____ Intake flushed U L
Observer _____
Control _____
Remarks _____
G. H. of zero flow _____ ft.

972.58 / melee



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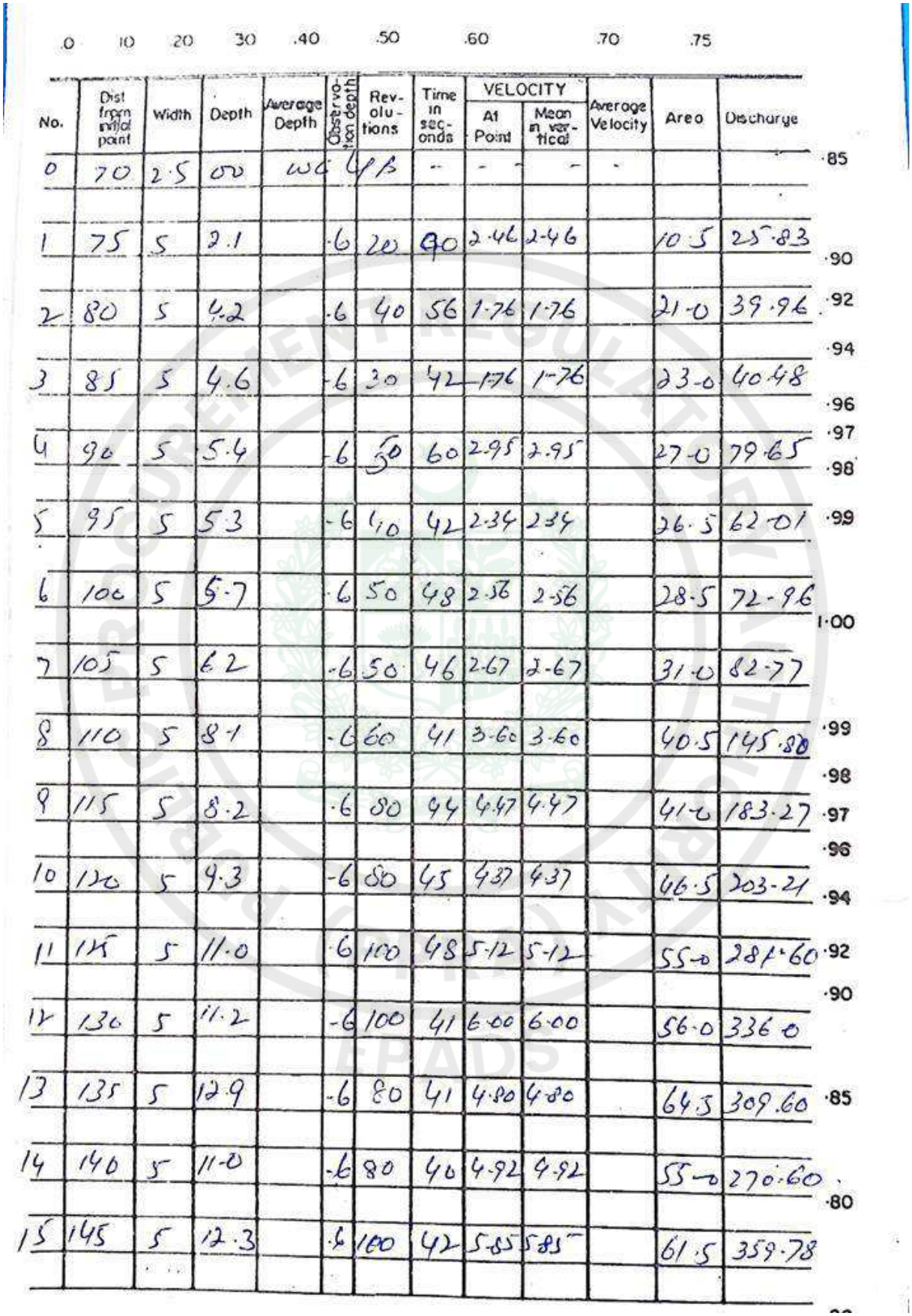

.0 .10 .20 .30 .40 .50 .60 .70 .75

| No. | Dist from initial point | Width | Depth | Average Depth | Observation depth | Revolutions | Time in seconds | VELOCITY At Point | VELOCITY Mean in vertical | Average Velocity | Area | Discharge | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 70 | 2.5 | 00 | WC | 6/8 | -- | - - | - | - | | | | .85 |
| 1 | 75 | 5 | 2.1 | | .6 | 20 | 90 | 2.46 | 2.46 | | 10.5 | 25.83 | .90 |
| 2 | 80 | 5 | 4.2 | | .6 | 40 | 56 | 1.76 | 1.76 | | 21.0 | 39.96 | .92 |
| 3 | 85 | 5 | 4.6 | | .6 | 30 | 42 | 1.76 | 1.76 | | 23.0 | 40.48 | .94 .96 |
| 4 | 90 | 5 | 5.4 | | .6 | 50 | 60 | 2.95 | 2.95 | | 27.0 | 79.65 | .97 .98 |
| 5 | 95 | 5 | 5.3 | | .6 | 40 | 42 | 2.34 | 2.34 | | 26.5 | 62.01 | .99 |
| 6 | 100 | 5 | 5.7 | | .6 | 50 | 48 | 2.56 | 2.56 | | 28.5 | 72.96 | 1.00 |
| 7 | 105 | 5 | 6.2 | | .6 | 50 | 46 | 2.67 | 2.67 | | 31.0 | 82.77 | |
| 8 | 110 | 5 | 8.1 | | .6 | 60 | 41 | 3.60 | 3.60 | | 40.5 | 145.80 | .99 .98 |
| 9 | 115 | 5 | 8.2 | | .6 | 80 | 44 | 4.47 | 4.47 | | 41.0 | 183.27 | .97 .96 |
| 10 | 120 | 5 | 9.3 | | .6 | 80 | 45 | 4.37 | 4.37 | | 46.5 | 203.21 | .94 |
| 11 | 125 | 5 | 11.0 | | .6 | 100 | 48 | 5.12 | 5.12 | | 55.0 | 281.60 | .92 .90 |
| 12 | 130 | 5 | 11.2 | | .6 | 100 | 41 | 6.00 | 6.00 | | 56.0 | 336.0 | |
| 13 | 135 | 5 | 12.9 | | .6 | 80 | 41 | 4.80 | 4.80 | | 64.5 | 309.60 | .85 |
| 14 | 140 | 5 | 11.0 | | .6 | 80 | 40 | 4.92 | 4.92 | | 55.0 | 270.60 | .80 |
| 15 | 145 | 5 | 12.3 | | .6 | 100 | 42 | 5.85 | 5.85 | | 61.5 | 359.78 | |



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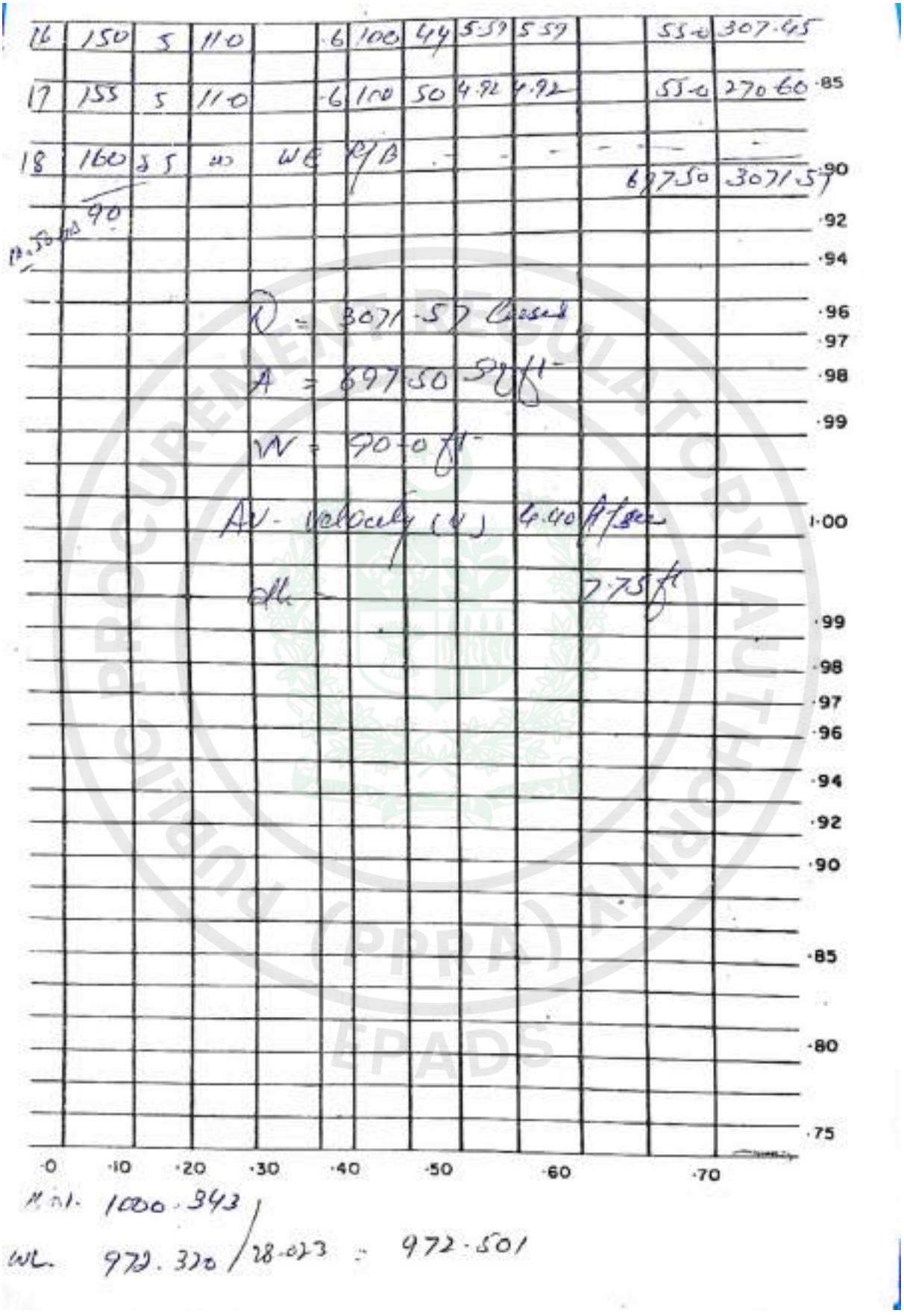




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INTERNATIONAL
SEDIMENTATION RESEARCH INSTITUTE, PAKISTAN (ISRIP)

WAPDA

DISCHARGE MEASUREMENT NOTES

Meas. No. 1
Comp. by
Checked. by

Ganish Bridge on Hunza River

Date 23-10-2012, 19... Party M. Ilyas Nawaz Disch. 2621.72
Width 86.0 Area 661.28 Vel. 3.96 G. H. Disch.
Method 6 No. secs 17 G. H. change in hrs. Susp. S-100
Method coef. Hor. angle coef. Susp. coef. Meter. No. S-14
Date rated 13-06-2012 Used rating
for rod susp. Meter 1.20 ft.
above bottom of wt. Tags checked
Spin before meas. ok after d
Meas plots % diff. from rating
Wading, cable, ice, boat, upstr, downstr, side
bridge feet, mile, above, below
gage, and
Check-bar, chain found
changed to at
Correct
Levels obtained 9

| GAGE READINGS | | | |
|---|---|---|---|
| Time | Recorder | Inside | Outside |
| 14:30 | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| 15:58 | | | |
| Weighted M.G.N. | | | |
| G.H. correction | | | |
| Correct M.G.H. | | | |

Measurement rated excellent (2%), good (5%), fair (8%), poor (over 8%), based on following conditions: Cross section Good Bed
Flow Weather P. Cloudy
Other Air °F@
Gage Water °F@
Record removed Intake flushed U L
Observer
Control
Remarks
G. H. of zero flow ft

100467 nm
972.428 msl
28.039



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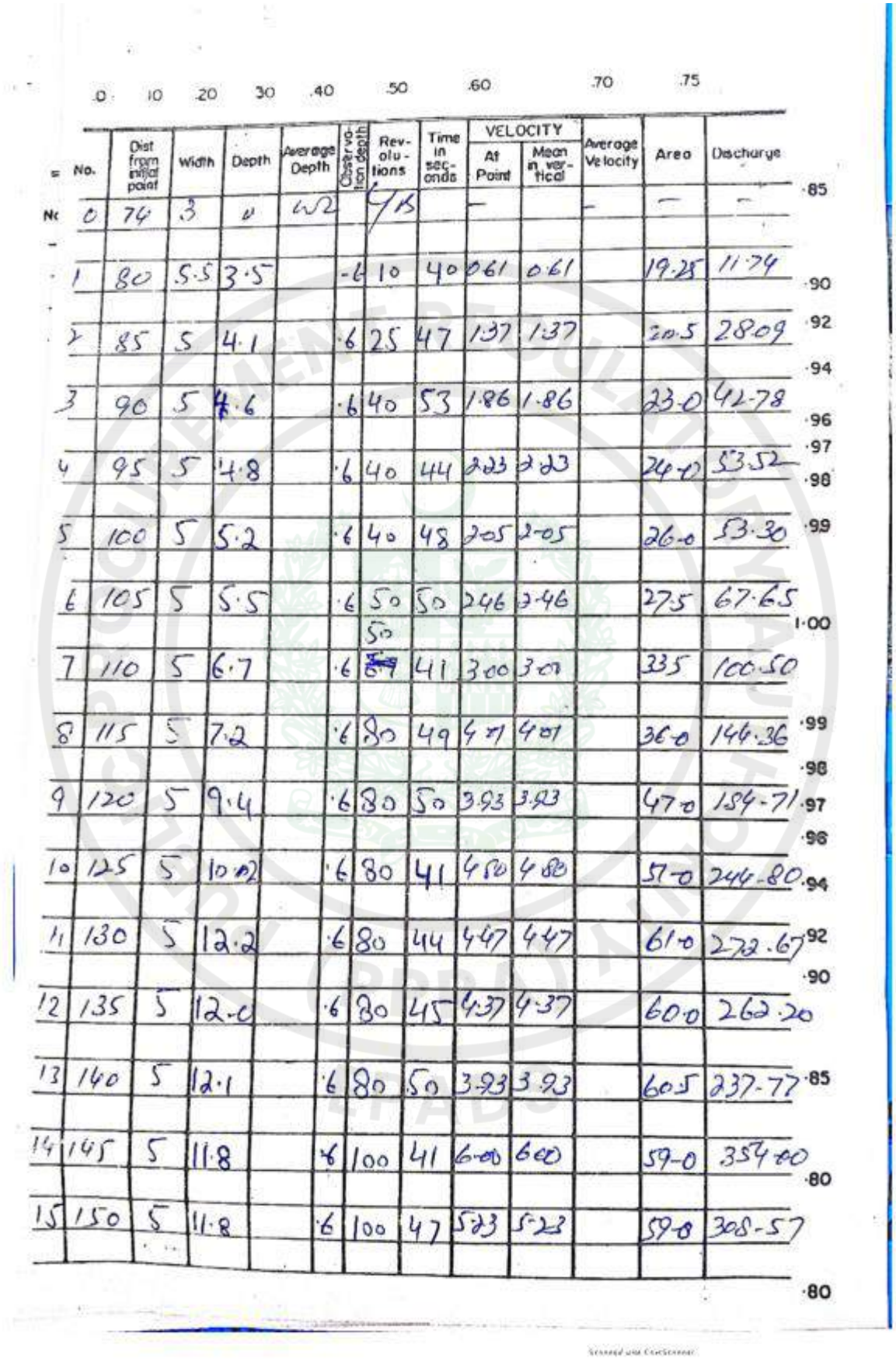

.0 .10 .20 .30 .40 .50 .60 .70 .75

| No. | Dist from initial point | Width | Depth | Average Depth | Observation depth | Revolutions | Time in seconds | VELOCITY At Point | VELOCITY Mean in vertical | Average Velocity | Area | Discharge | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 74 | 3 | 0 | W2 | | 4/15 | | — | | — | — | — | .85 |
| 1 | 80 | 5.5 | 3.5 | | .6 | 10 | 40 | 0.61 | 0.61 | | 19.25 | 11.74 | .90 |
| 2 | 85 | 5 | 4.1 | | .6 | 25 | 47 | 1.37 | 1.37 | | 20.5 | 28.09 | .92 |
| 3 | 90 | 5 | 4.6 | | .6 | 40 | 53 | 1.86 | 1.86 | | 23.0 | 42.78 | .94 |
| 4 | 95 | 5 | 4.8 | | .6 | 40 | 44 | 2.23 | 2.23 | | 24.0 | 53.52 | .96 .97 .98 |
| 5 | 100 | 5 | 5.2 | | .6 | 40 | 48 | 2.05 | 2.05 | | 26.0 | 53.30 | .99 |
| 6 | 105 | 5 | 5.5 | | .6 | 50 | 50 | 2.46 | 2.46 | | 27.5 | 67.65 | 1.00 |
| 7 | 110 | 5 | 6.7 | | .6 | 50 | 41 | 3.00 | 3.00 | | 33.5 | 100.50 | |
| 8 | 115 | 5 | 7.2 | | .6 | 80 | 49 | 4.01 | 4.01 | | 36.0 | 146.36 | .99 .98 |
| 9 | 120 | 5 | 9.4 | | .6 | 80 | 50 | 3.93 | 3.93 | | 47.0 | 184.71 | .97 .96 |
| 10 | 125 | 5 | 10.2 | | .6 | 80 | 41 | 4.80 | 4.80 | | 51.0 | 244.80 | .94 |
| 11 | 130 | 5 | 12.2 | | .6 | 80 | 44 | 4.47 | 4.47 | | 61.0 | 272.67 | .92 .90 |
| 12 | 135 | 5 | 12.0 | | .6 | 80 | 45 | 4.37 | 4.37 | | 60.0 | 262.20 | |
| 13 | 140 | 5 | 12.1 | | .6 | 80 | 50 | 3.93 | 3.93 | | 60.5 | 237.77 | .85 |
| 14 | 145 | 5 | 11.8 | | .6 | 100 | 41 | 6.00 | 6.00 | | 59.0 | 354.00 | .80 |
| 15 | 150 | 5 | 11.8 | | .6 | 100 | 47 | 5.23 | 5.23 | | 59.0 | 308.57 | |
| | | | | | | | | | | | | | .80 |



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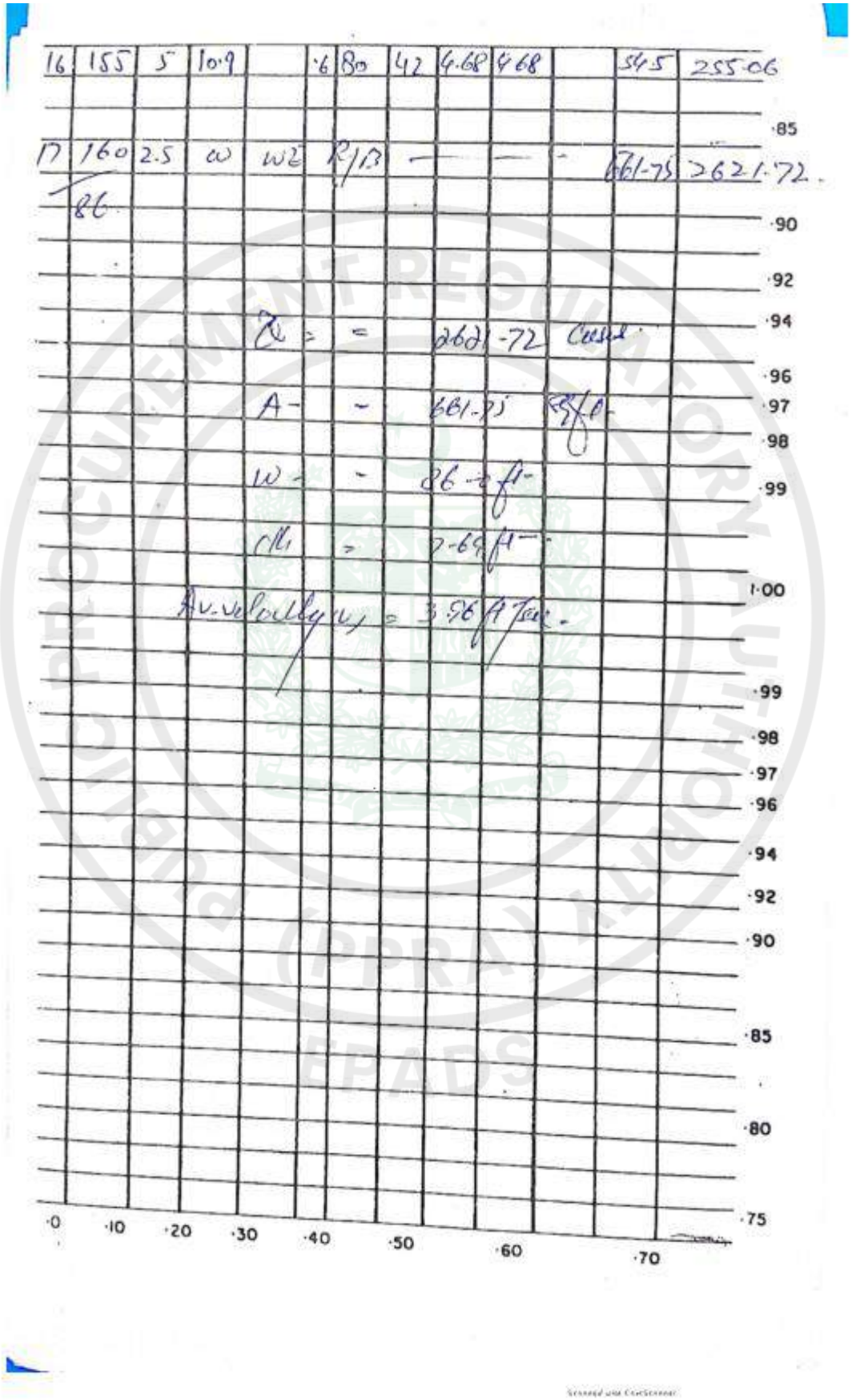




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INTERNATIONAL
SEDIMENTATION RESEARCH INSTITUTE, PAKISTAN (ISRIP)

WAPDA

DISCHARGE MEASUREMENT NOTES

Meas. No.
Comp. by Nau
Checked. by

Hunza River at Ganish Bridge

Date 26-09-2019 Party [illegible] NW
Width 100 Area 914 Vel 8.43 G. H. Disch 7707.24
Method L No. secs 20 G. H. change in hrs. Susp. 0.700
Method coef. Hor. angle coef. Susp. coef. Meter. No. S-16

| GAGE READINGS | | | |
|---|---|---|---|
| Time | Recorder | Inside | Outside |
| 8:09:50 | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| 8:11:58 | | | |
| Weighted M.G.N. | | | |
| G. H. correction | | | |
| Correct M.G.H. | | | |

Date rated 13-06-2019 Used rating
for rod susp. Meter 1.7 ft.
above bottom of wt. Tags checked
Spin before meas. 17 after 9
Meas plots % diff. from rating
Wading, cable, ice, boat, upstr, downstr, side bridge feet, mile, above, below gage, and
Check-bar, chain found
changed to at
Correct
Levels obtained Tes

Measurement rated excellent (2%), good (5%), fair (8%), poor (over 8%), based on following conditions: Cross section Irregular Covered Bad
Flow Weather Cloudy
Other Air °F@
Gage Water °F@
Record removed Intake flushed U L
Observer
Control
Remarks
G. H. of zero flow ft

WSL 973.029 from dwr



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Start from GS at 09:50 hrs.

0 10 20 30 40 50 60 70 75

| No. | Dist from initial point | Width | Depth | Average Depth | Observation depth | Revolutions | Time in seconds | VELOCITY At Point | VELOCITY Mean in vertical | Average Velocity | Area | Discharge | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 60 | 2.5 | 00 | WE | | 4 B | | — | | | — | | .85 |
| 1 | 65 | 5 | 0.4 | — | | No. velocity | | | | | 2.0 30 | — — | .90 |
| 2 | 70 | 5 | 2.0 | | .6 | 30 60 | 60 | 1.84 | 1.84 | | 10.0 | 18.40 | .92 .94 |
| 3 | 75 | 5 | 4.7 | | .6 | 50 | 41 | 3.00 | 3.00 | | 23.5 | 70.50 | .96 .97 |
| 4 | 80 | 5 | 5.2 | | .6 | 50 | 45 | 2.73 | 2.73 | | 26.0 | 70.98 | .98 .99 |
| 5 | 85 | 5 | 6.1 | | .6 | 80 | 47 | 4.18 | 4.18 | | 30.5 | 127.49 | 1.00 |
| 6 | 90 | 5 | 7.5 | | .6 | 80 | 41 | 4.82 | 4.80 | | 37.5 | 180.00 | |
| 7 | 95 | 5 | 7.3 | | .6 | 80 | 57 | 3.45 | 3.45 | | 36.5 | 125.93 | .99 .98 |
| 8 | 100 | 5 | 7.1 | | .6 | 80 | 44 | 4.47 | 4.47 | | 35.5 | 158.69 | .97 .96 |
| 9 | 105 | 5 | 8.2 | | .6 | 150 | 54 | 6.83 | 6.83 | | 41.0 | 280.03 | .94 |
| 10 | 110 | 5 | 10.2 | | .6 | 100 | 42 | 5.35 | 5.35 | | 51.0 | 272.85 | .92 .90 |
| 11 | 115 | 5 | 12.5 | | .6 | 150 | 42 | 8.78 | 8.78 | | 62.5 | 548.75 | |
| 12 | 120 | 5 | 13.3 | | .6 | 200 | 47 | 10.46 | 10.46 | | 66.5 | 695.59 | .85 |
| 13 | 125 | 5 | 15.5 | | .6 | 200 | 50 | 9.83 | 9.83 | | 77.5 | 761.83 | .80 |
| 14 | 130 | 5 | 15.2 | | .6 | 200 | 48 | 10.24 | 10.24 | | 76.0 | 778.24 | |
| 15 | 135 | 5 | 15.1 | | .6 | 200 | 46 | 10.69 | 10.69 | | 75.5 | 807.10 | .80 |
| | | | | | | | | | | | 657.5 | 4896.38 | |



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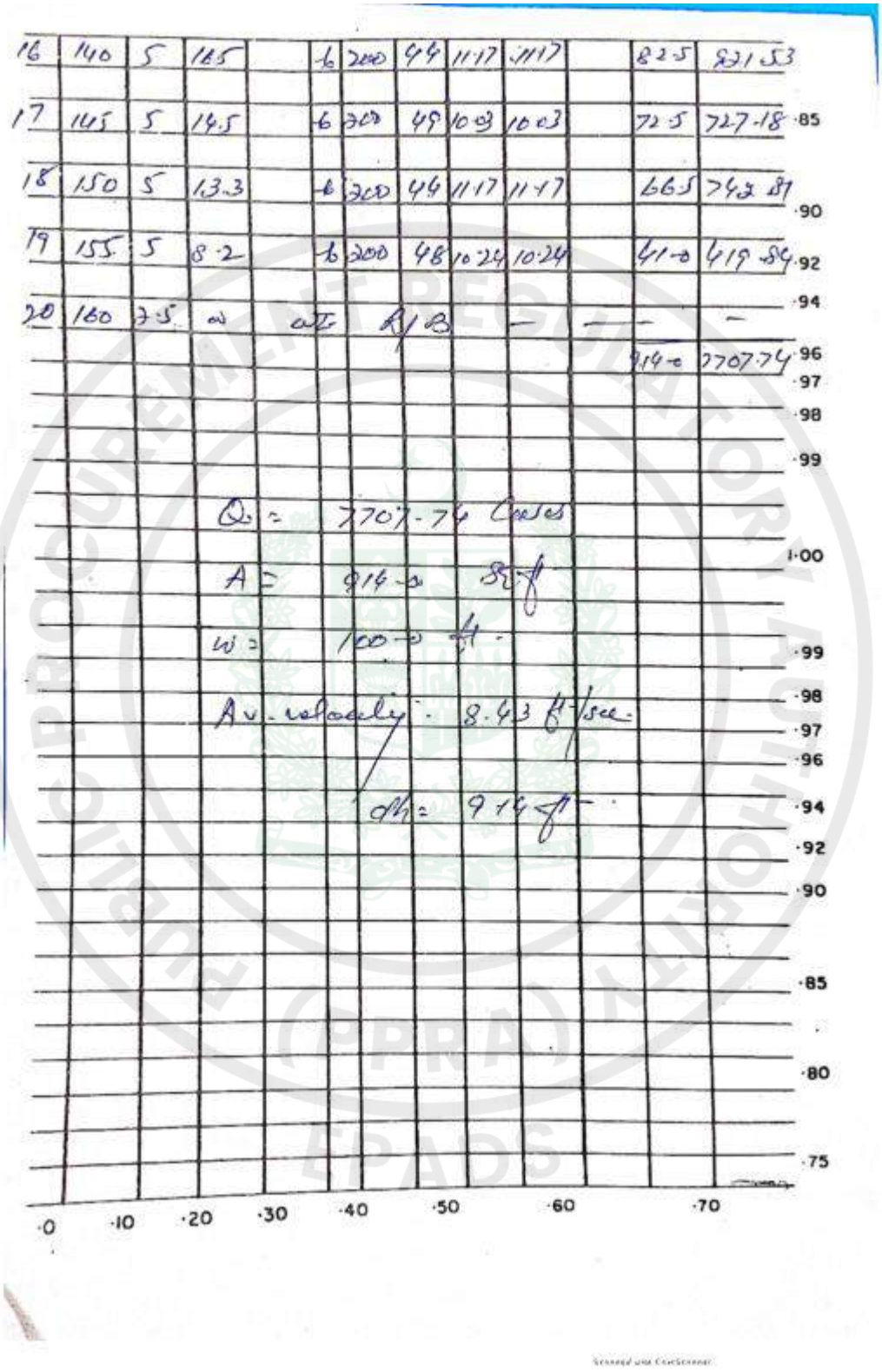

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16 | 140 | 5 | 16.5 | | 6 | 300 | 44 | 11.17 | 11.17 | | 82.5 | 921.53 |
| 17 | 145 | 5 | 14.5 | | 6 | 300 | 49 | 10.03 | 10.03 | | 72.5 | 727.18 |
| 18 | 150 | 5 | 13.3 | | 6 | 300 | 44 | 11.17 | 11.17 | | 66.5 | 743.87 |
| 19 | 155 | 5 | 8.2 | | 6 | 300 | 48 | 10.24 | 10.24 | | 41.0 | 419.84 |
| 20 | 160 | 7.5 | ω | ωΣ | | A/B | | — | — | | — | — |
| | | | | | | | | | | | 914.0 | 7707.74 |

$Q_2$ = 7707.74 Cusecs

A = 914.0 Sq.ft

W = 100.0 ft.

Av. velocity = 8.43 ft/sec.

dh = 9.14 ft.



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**Table 1-43 Cross Section at Ganish Bridge**

| Sr. No. | Distance (ft) | Depth (ft) | Remarks |
|---|---|---|---|
| 1 | 0.0 | 0.0 | Water Edge.at Left Bank |
| 2 | 5.0 | 0.4 | Bed |
| 3 | 10.0 | 2.0 | " |
| 4 | 15.0 | 4.7 | " |
| 5 | 20.0 | 5.2 | " |
| 6 | 25.0 | 6.1 | " |
| 7 | 30.0 | 7.5 | " |
| 8 | 35.0 | 7.3 | " |
| 9 | 40.0 | 7.1 | " |
| 10 | 45.0 | 8.2 | " |
| 11 | 50.0 | 10.2 | " |
| 12 | 55.0 | 12.5 | " |
| 13 | 60.0 | 13.3 | " |
| 14 | 65.0 | 15.5 | " |
| 15 | 70.0 | 15.2 | " |
| 16 | 75.0 | 15.1 | " |
| 17 | 80.0 | 16.5 | " |
| 18 | 85.0 | 14.5 | " |
| 19 | 90.0 | 13.3 | " |
| 20 | 95.0 | 8.2 | " |
| 21 | 100.0 | 0.0 | Water Edge at Right Bank |

**Table 1-44 Discharge Measurements Readings**

| Location | Date | Discharge (cusecs) | Area $(ft)^2$ | Avg. Velocity (ft)/Sec | dh (ft) |
|---|---|---|---|---|---|
| Ganish Bridge | 26-09-2020 | 7707.74 | 914.00 | 8.43 | 9.14 |
| Ganish Bridge | 15-10-2020 | 3071.57 | 697.50 | 4.40 | 7.75 |
| Ganish Bridge | 23-10-2020 | 2621.00 | 661.75 | 3.96 | 7.69 |



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# APPENDIX – I(F):

# HYDROGRAPHIC SURVEY FIGURES

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS



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## 1.6 APPENDIX – I(F): HYDROGRAPHIC SURVEY FIGURES

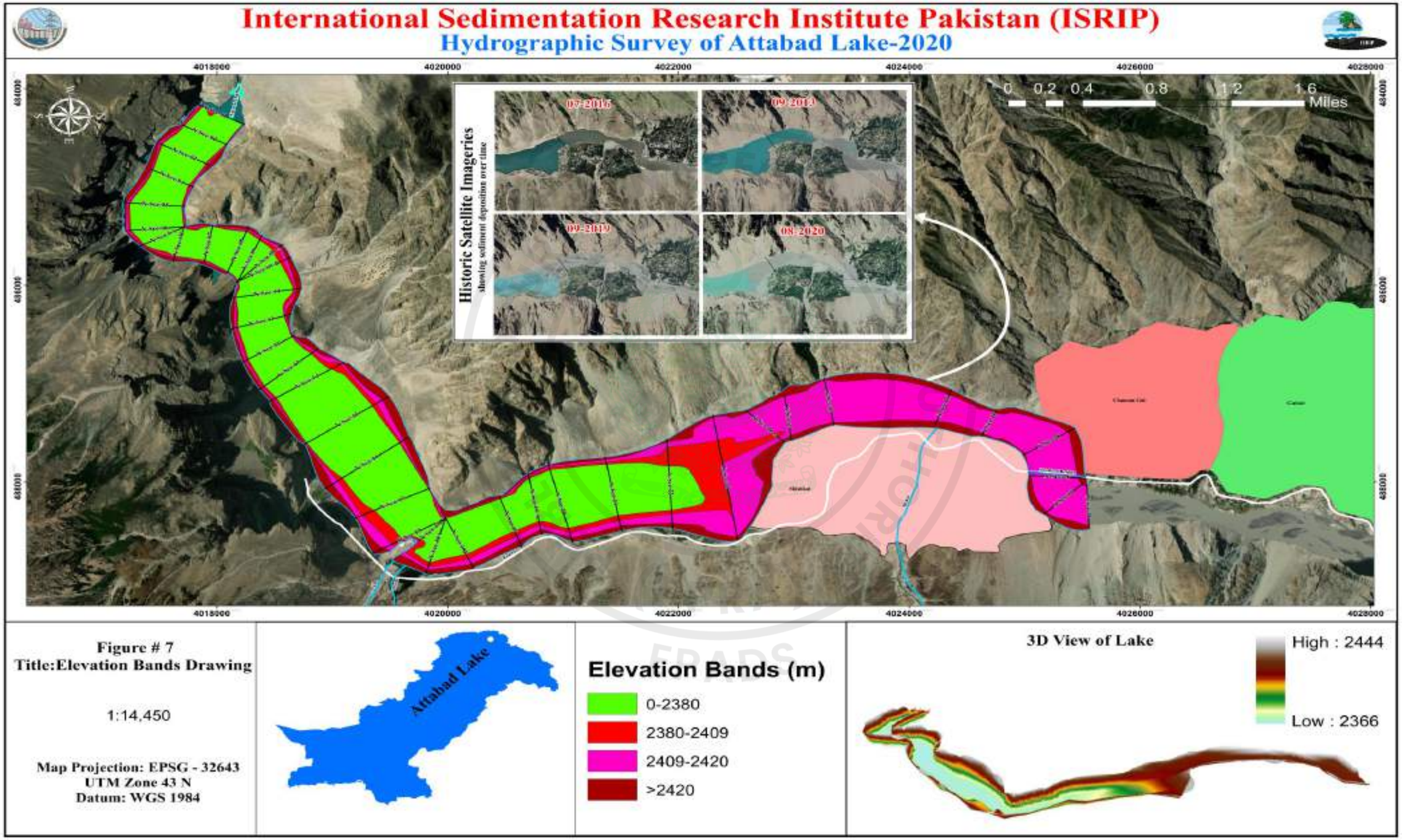


**Figure 1-3 Elevation Band Drawing**



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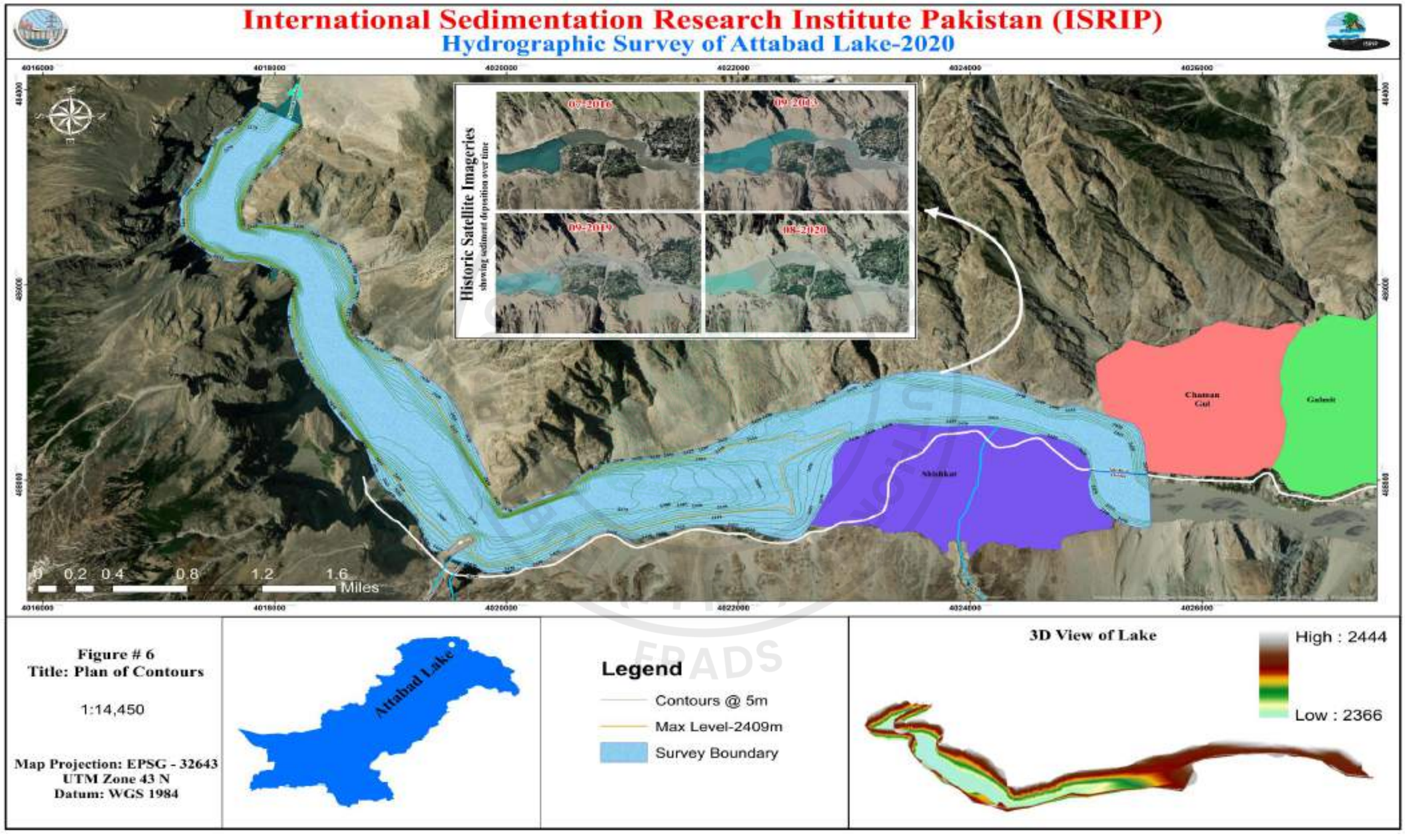


**Figure 1-4 Plan of Contours**



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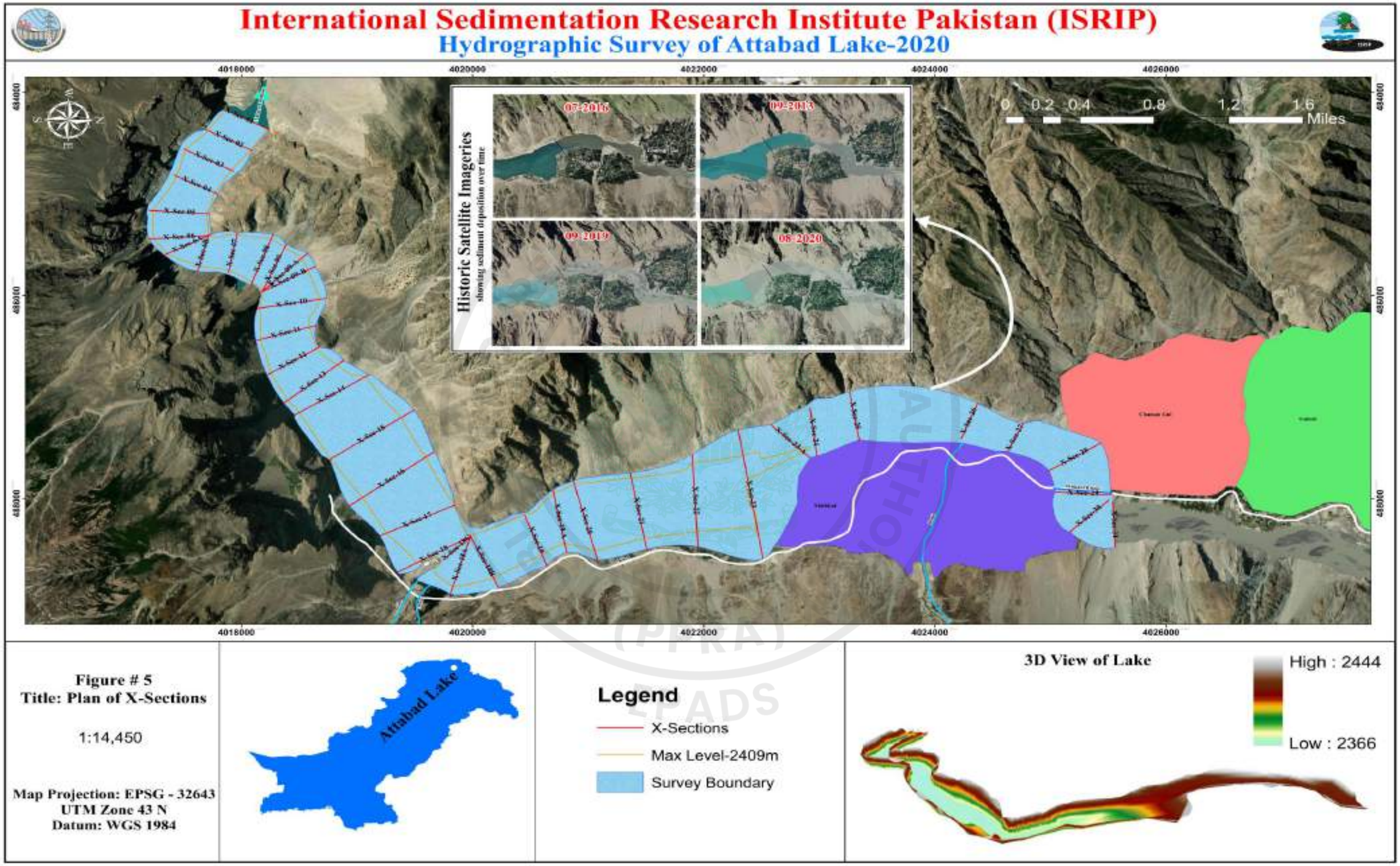


**Figure 1-5 Plan of X-Section**



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# APPENDIX – II:

# 2 GEOTECHNICAL ANALYSIS



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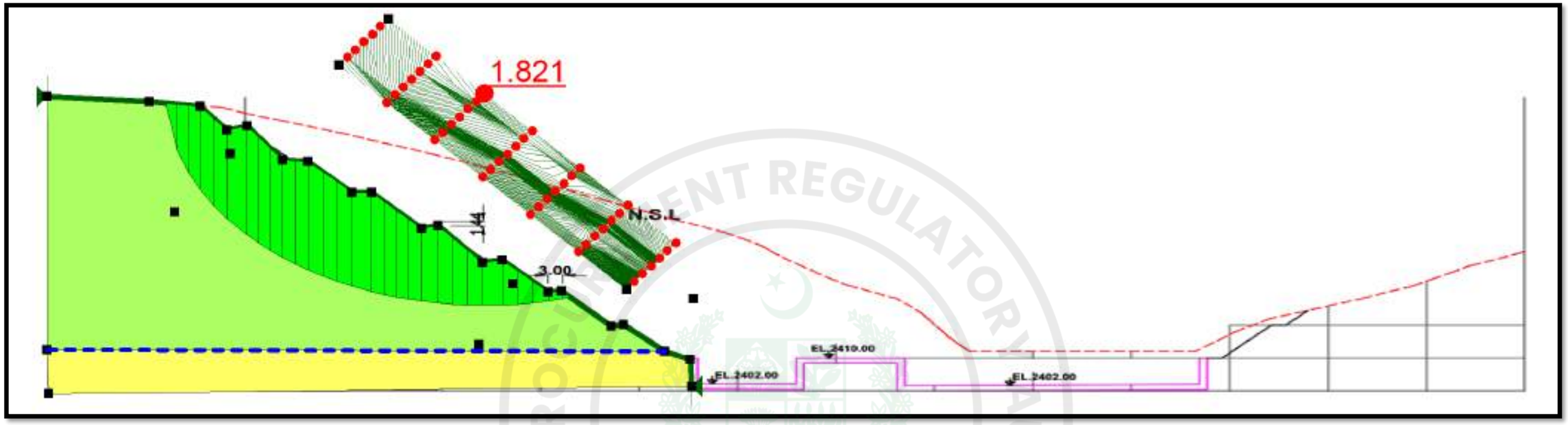
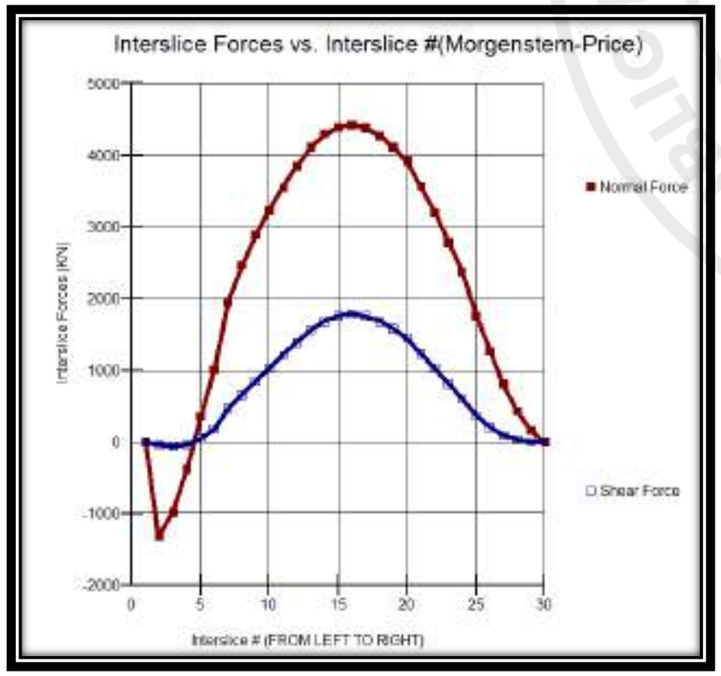
**Figure 2-1 :Factor of Safety of Critical Slope –Cross Section at Chainage 0+50**

**(Morgenstern-Price Method, Grid and Radius Arrangement for Slip Surfaces)**



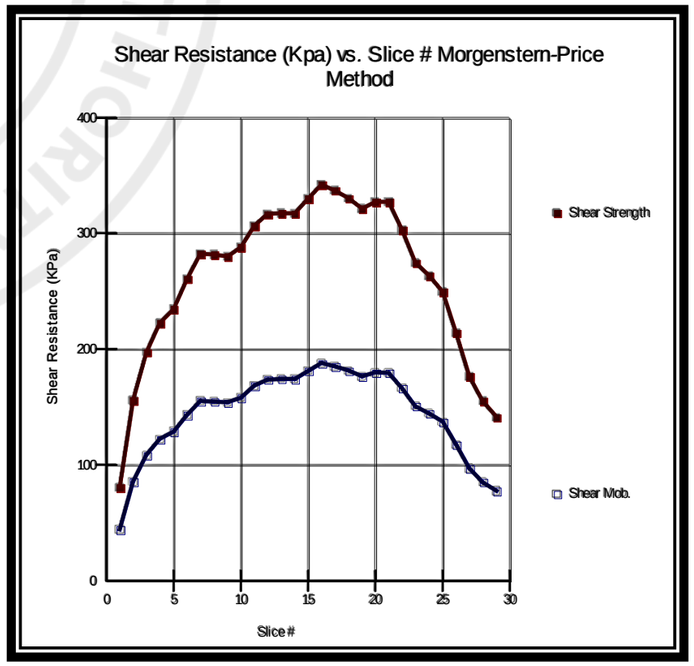






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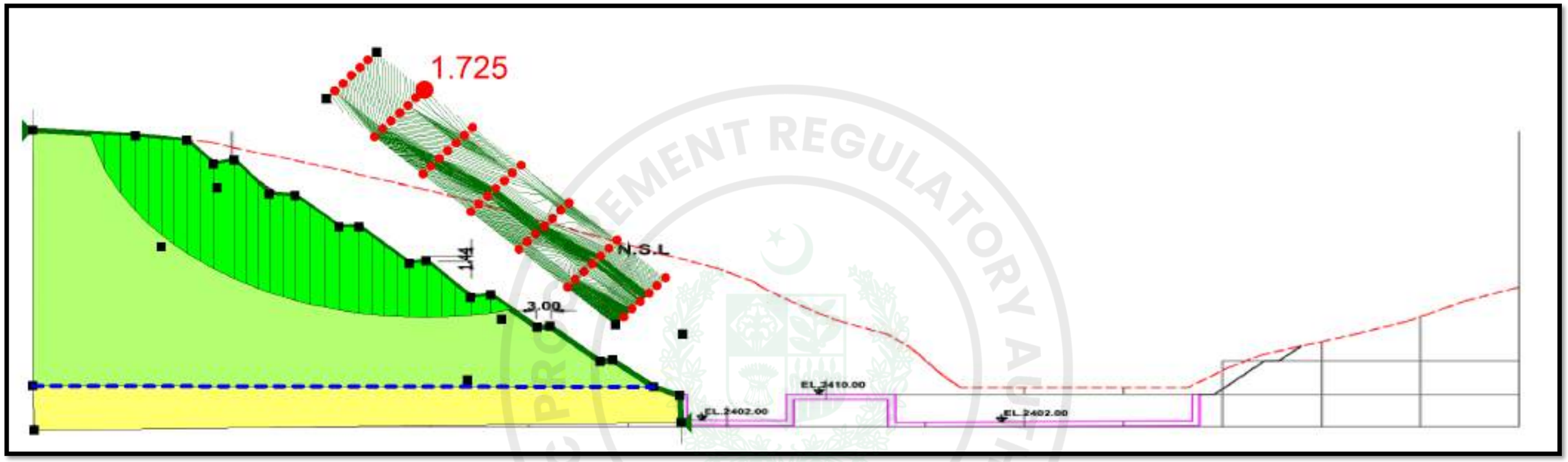
**Figure 2-2 Factor of Safety of Critical Slope–Cross Section at Chainage 0+50**

**(Janbu Method, Grid and Radius Arrangement for Slip Surfaces**



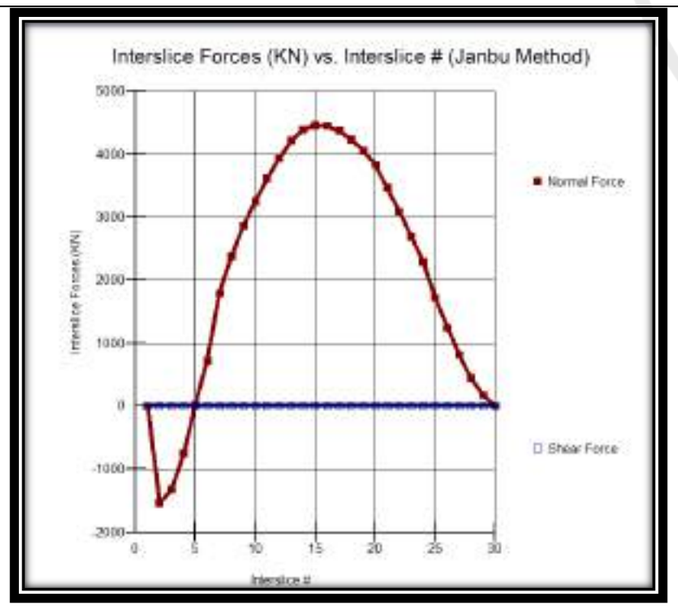



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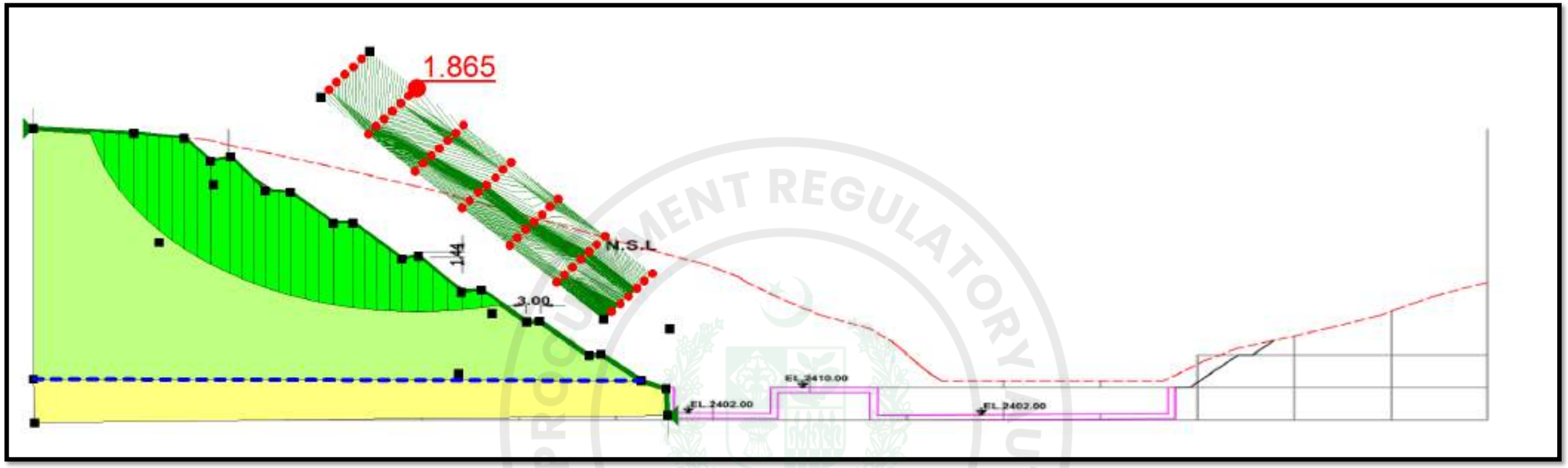
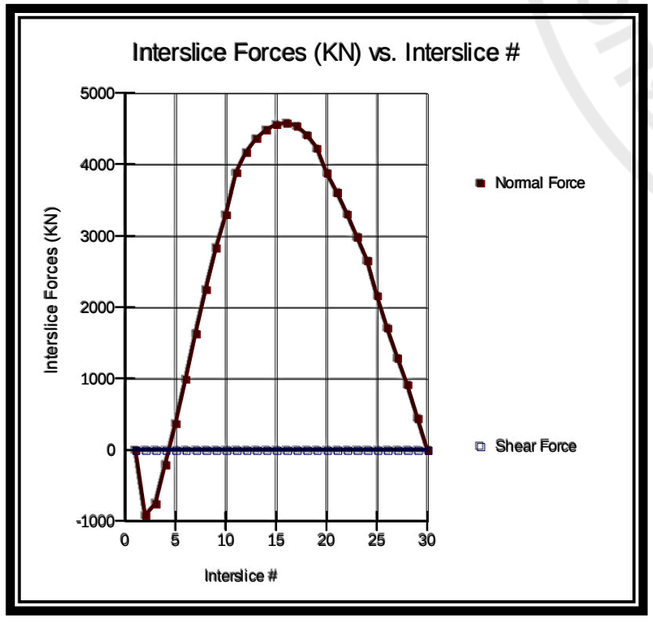
**Figure 2-3 Factor of Safety of Critical Slope –Cross Section at Chainage 0+50**
**(Bishop Method, Grid and Radius Arrangement for Slip Surfaces)**



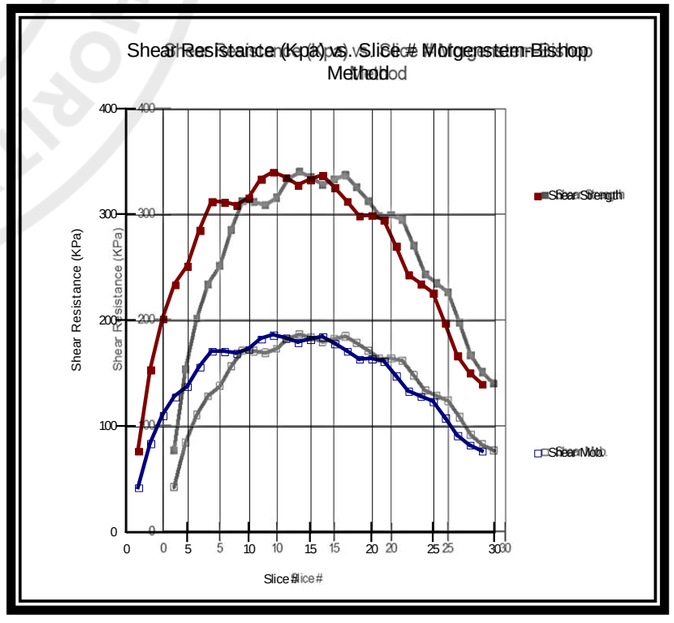






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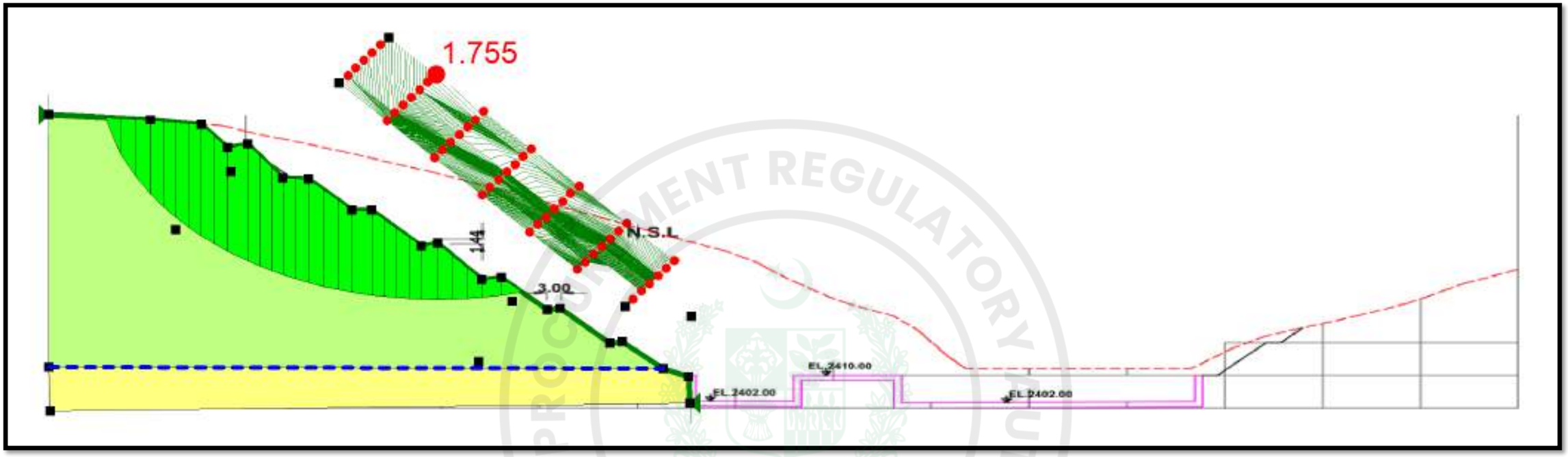
**Figure 2-4:Factor of Safety of Critical Slope –Cross Section at Chainage 0+50**

**(Ordinary Method, Grid and Radius Arrangement for Slip Surfaces)**



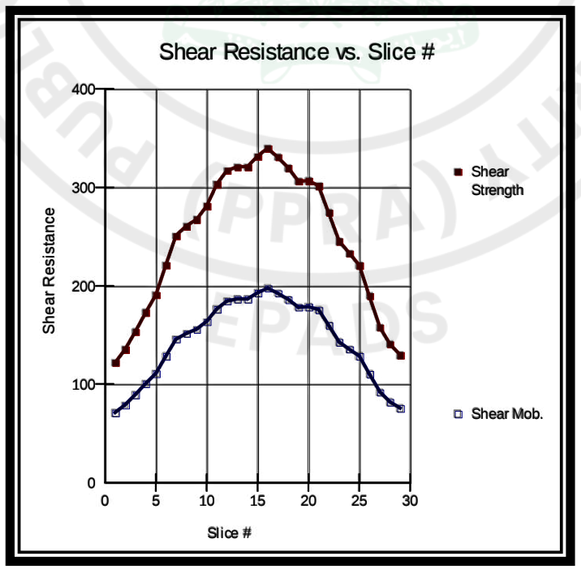






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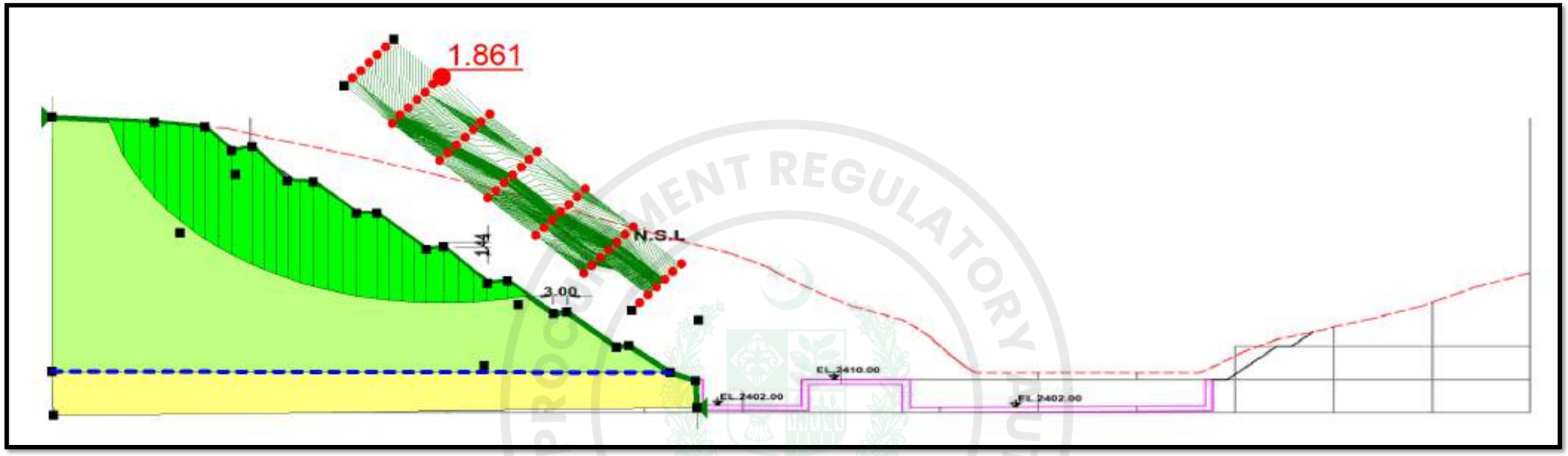
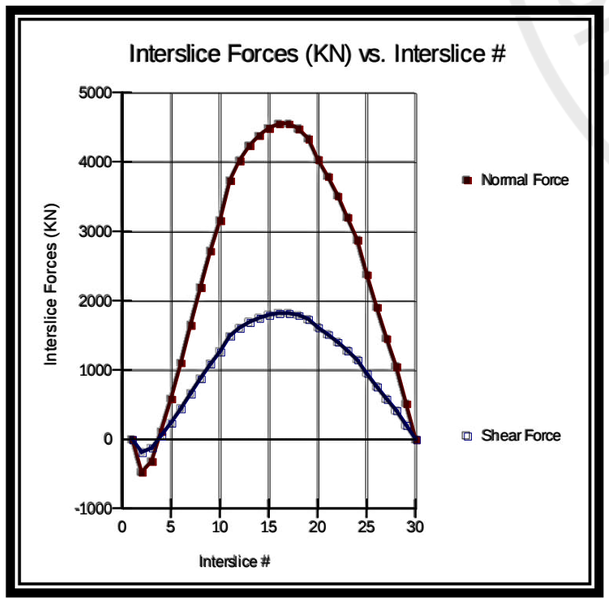
**Figure 2-5 Factor of Safety of Critical Slope –Cross Section at Chainage 0+50**

**(Spencer Method, Grid and Radius Arrangement for Slip Surfaces)**



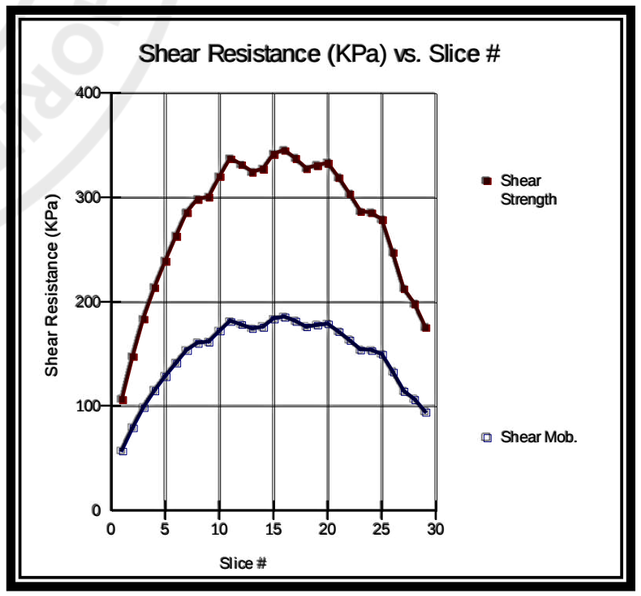






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**Figure 2-6 Factor of Safety of Critical Slope –Cross Section at Chainage 0+50**

**(Morgenstern-Price Method, Exit and Entry Arrangement for Slip Surfaces)**

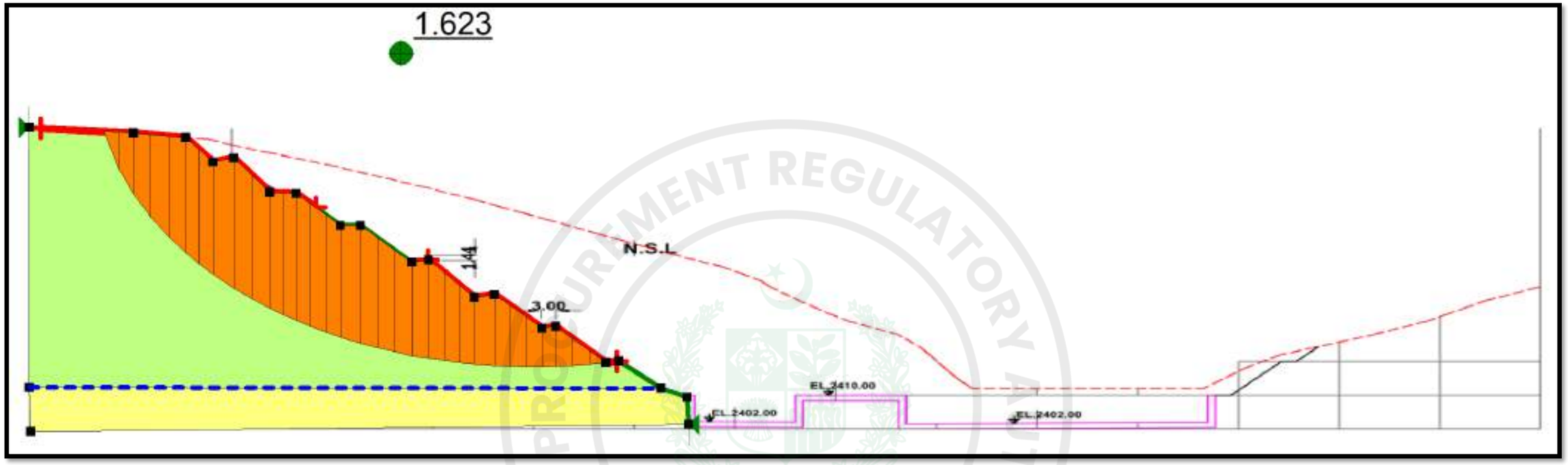




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**Figure 2-7 Factor of Safety of Critical Slope –Cross Section at Chainage 0+50**

**(Janbu Method, Exit and Entry Arrangement for Slip Surfaces)**

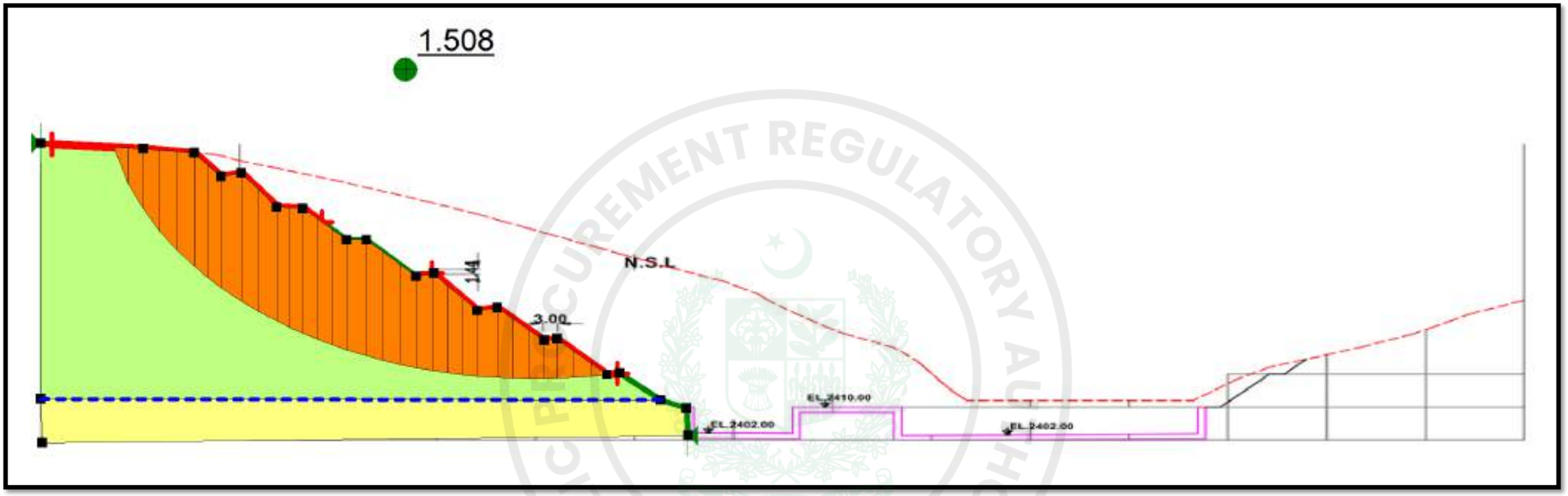




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**Figure 2-8 Factor of Safety of Critical Slope –Cross Section at Chainage 0+50**

**(Biship Method, Exit and Entry Arrangement for Slip Surfaces)**

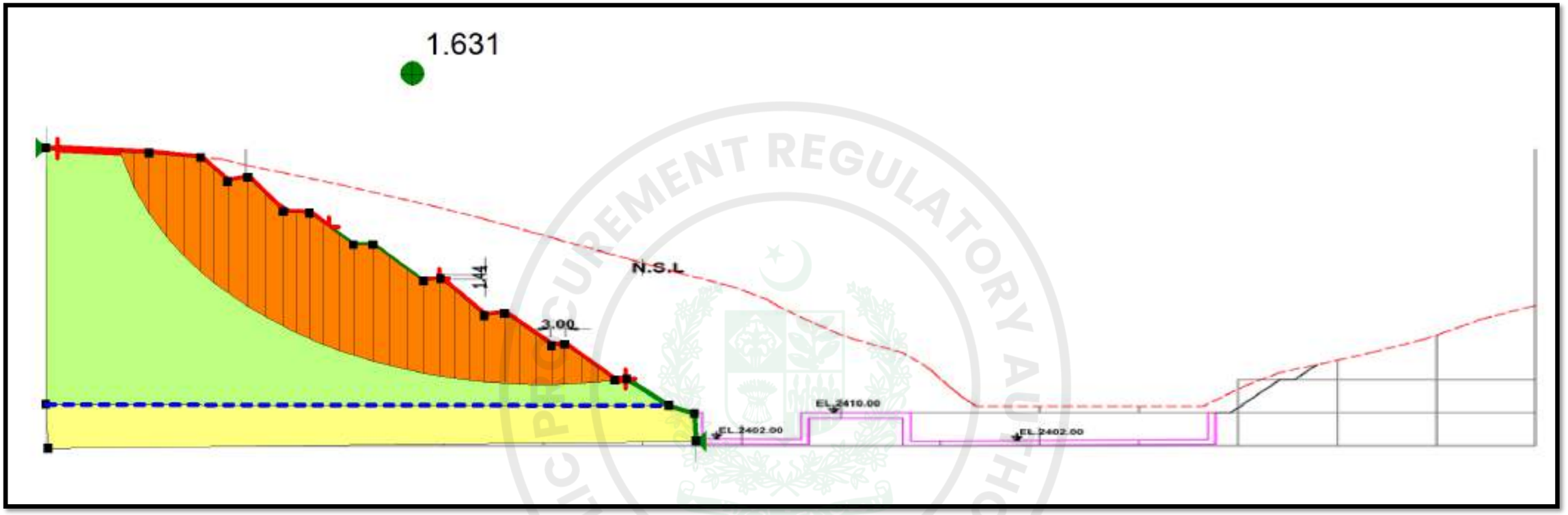




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**Figure 2-9 Factor of Safety of Critical Slope –Cross Section at Chainage 0+50**

**(Ordinary Method, Exit and Entry Arrangement for Slip Surfaces)**

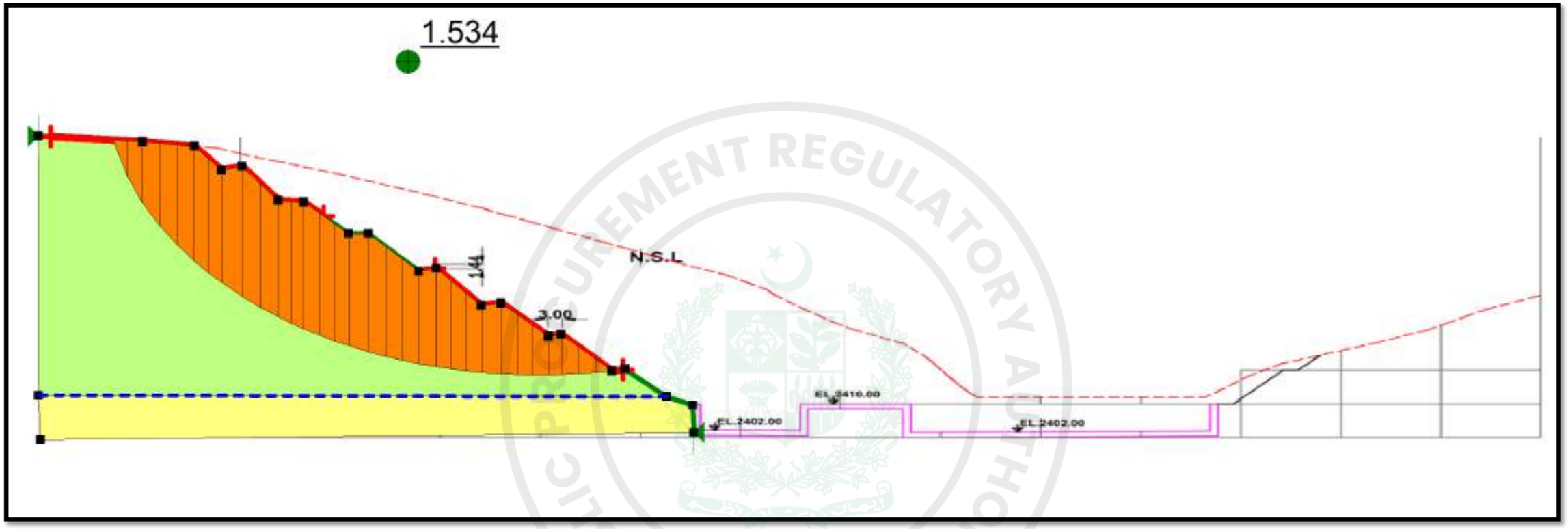




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**Figure 2-10 Factor of Safety of Critical Slope –Cross Section at Chainage 0+50**

**(Spencer Method, Exit and Entry Arrangement for Slip Surfaces)**

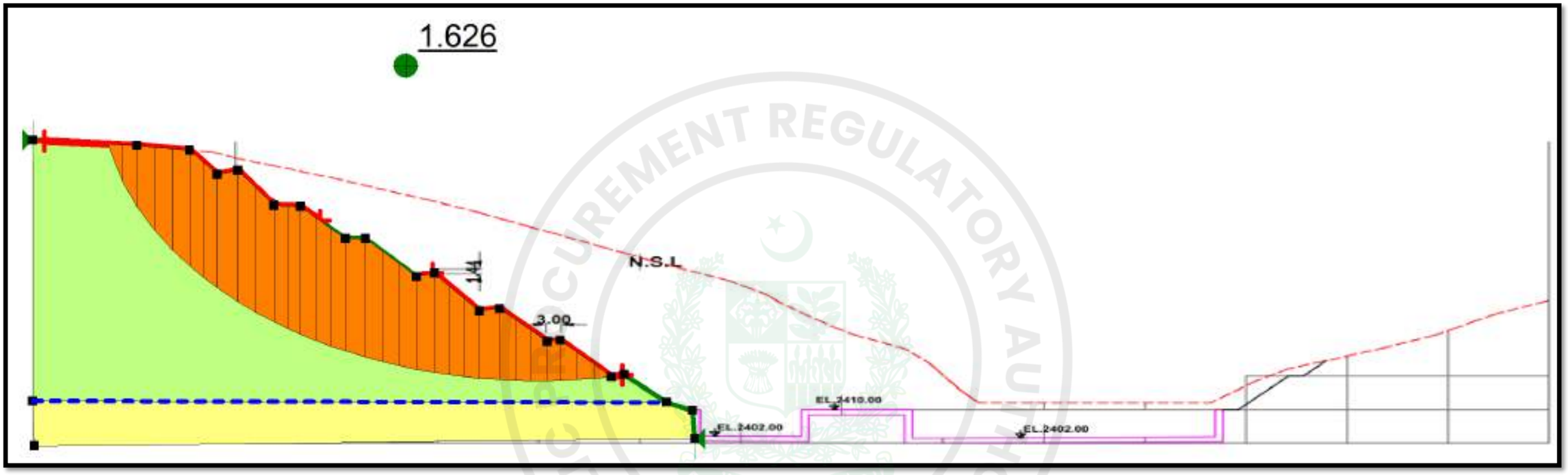




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**Figure 2-11 Finalized Weir Cross Section with All Seepage Line of Defenses**

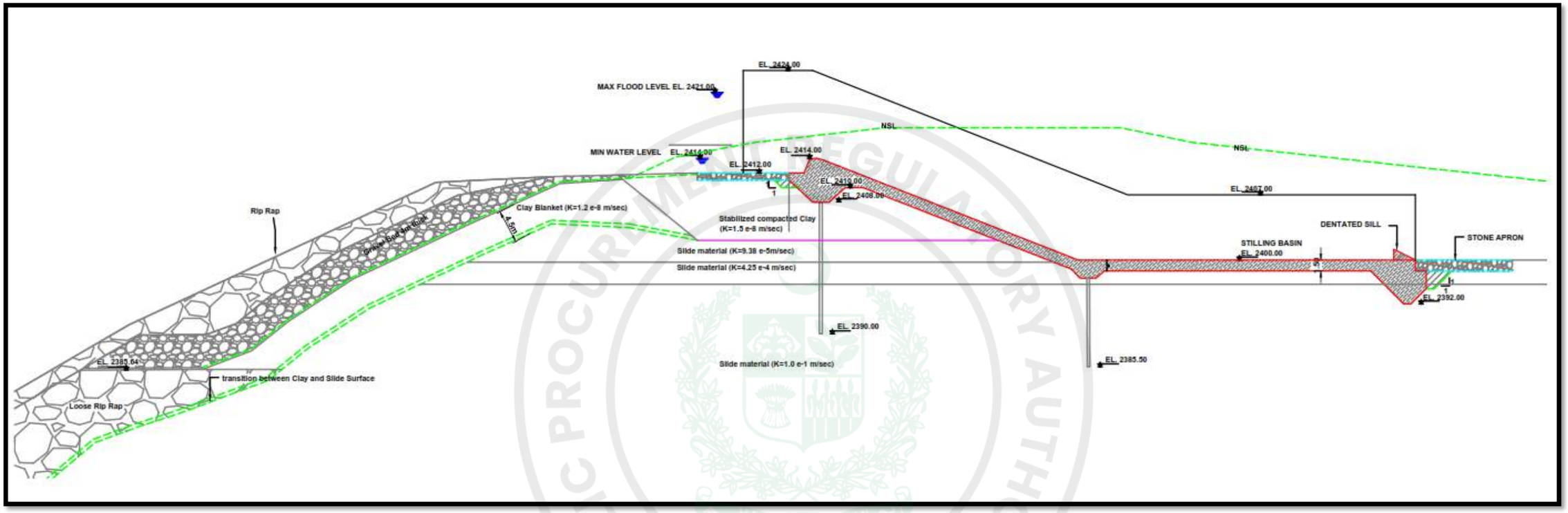




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**Figure 2-12 Finite Element Model of Weir Cross Section**

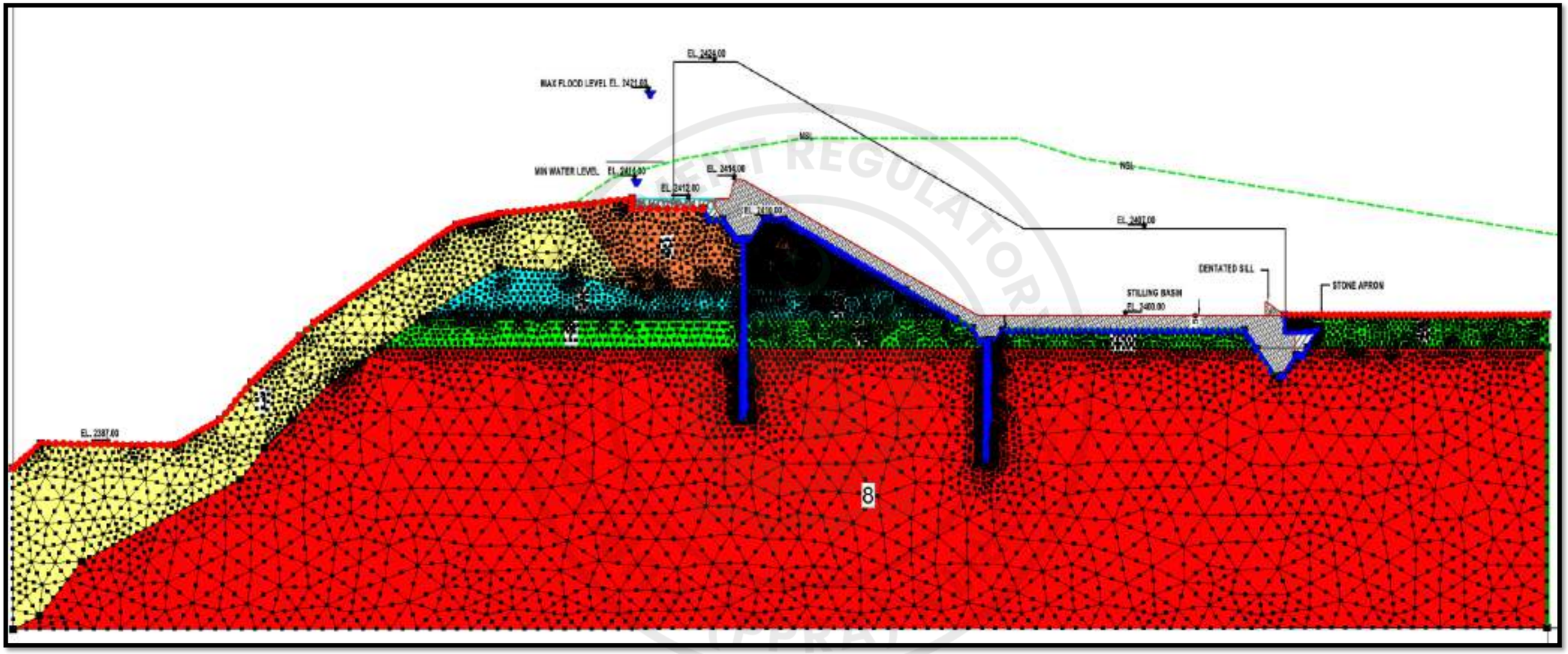




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**Figure 2-13 Pressure Head Profile –Weir Section at Minimum Water El: 2412 m upstream**

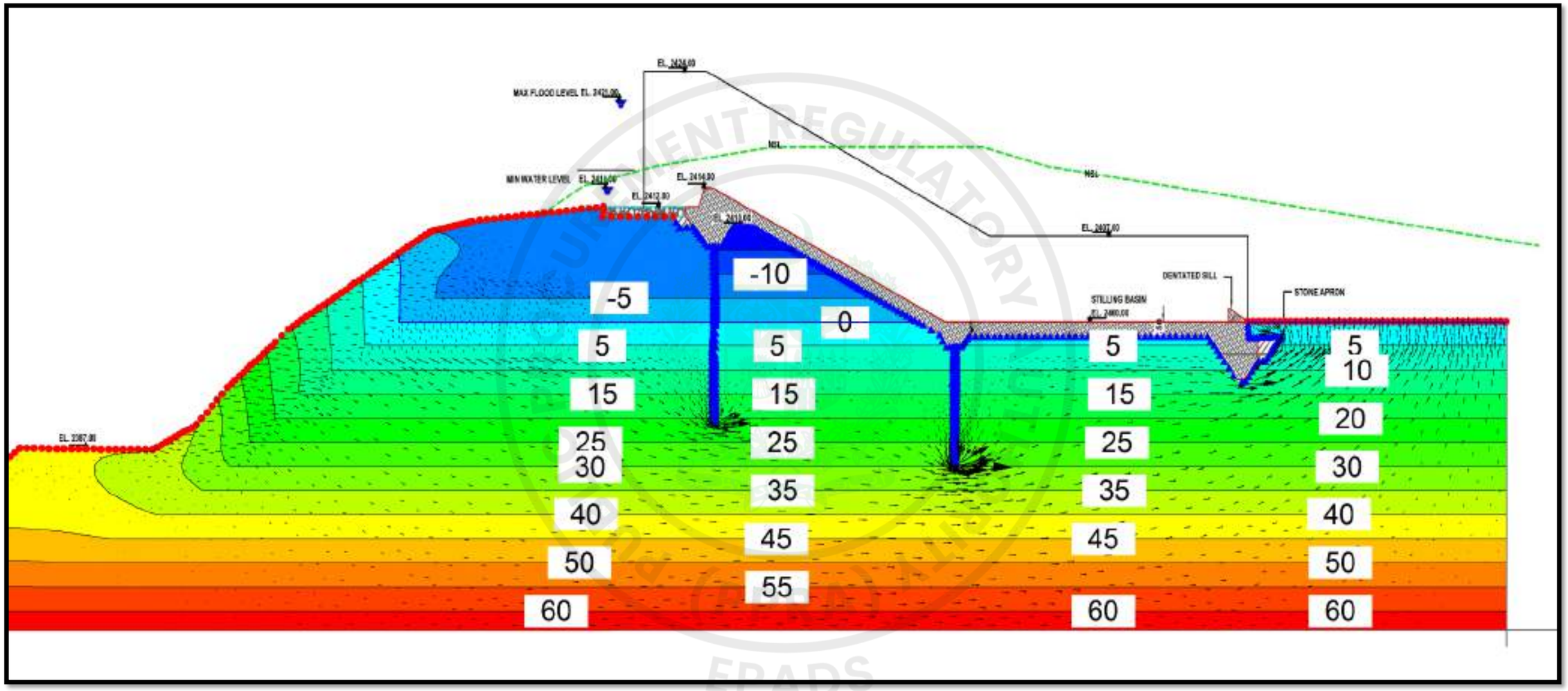




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**Figure 2-14 Critical Hydraulic Gradient Profile –Weir Section at Minimum Water El: 2412 m upstream**

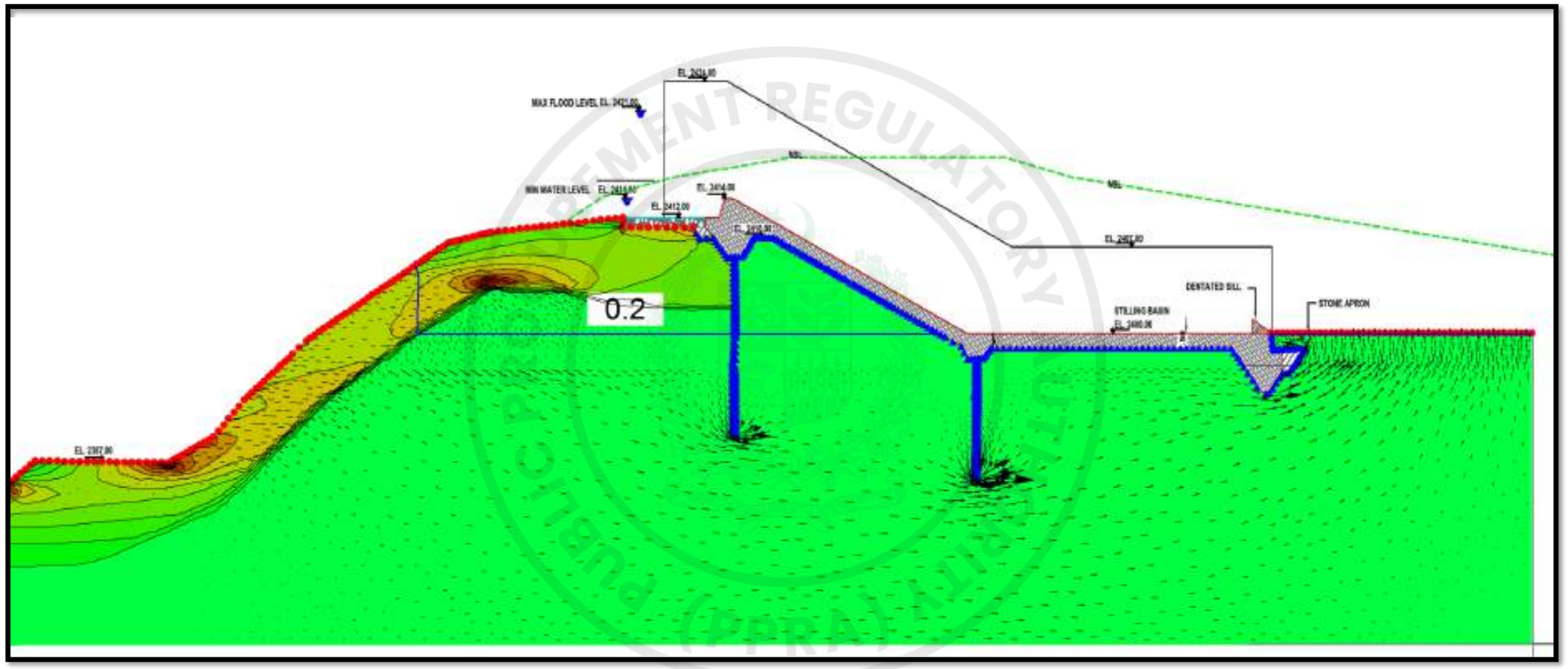




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**Figure 2-15 Critical Hydraulic Gradient Profile –Weir Section at Minimum Water El: 2424 m upstream**

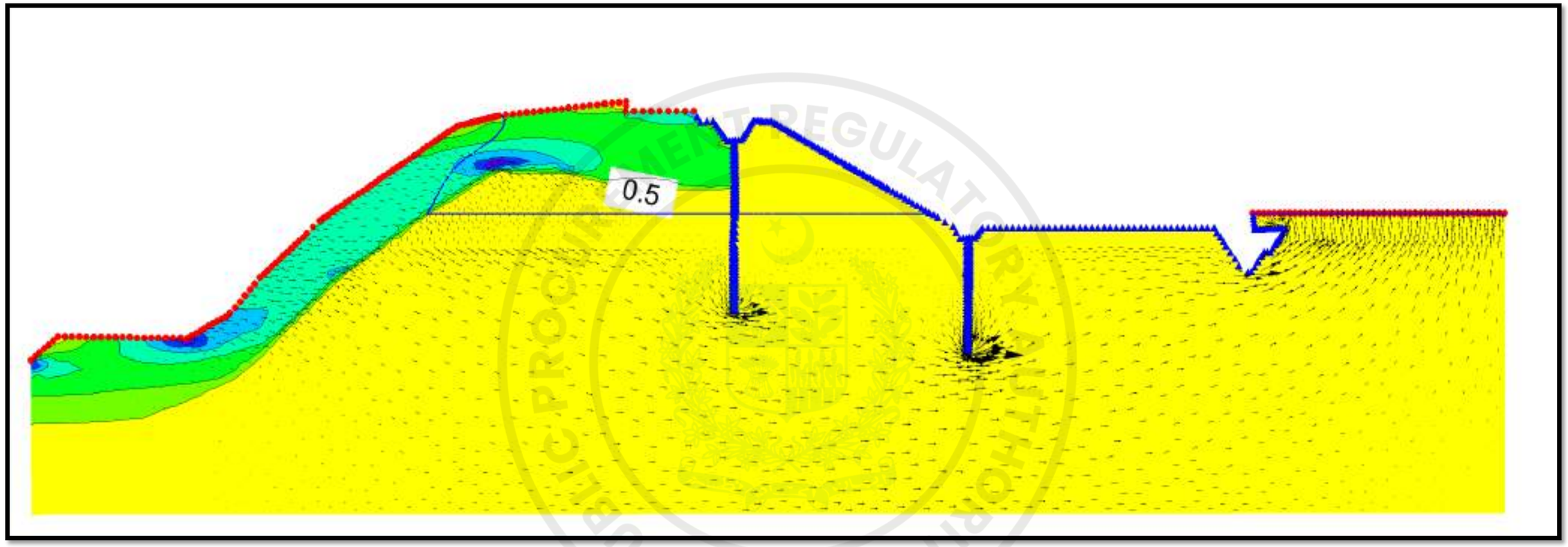




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**Figure 2-16 Critical Hydraulic Gradient Profile –Weir Section at Minimum Water El: 2424 m upstream without clay Blanket**

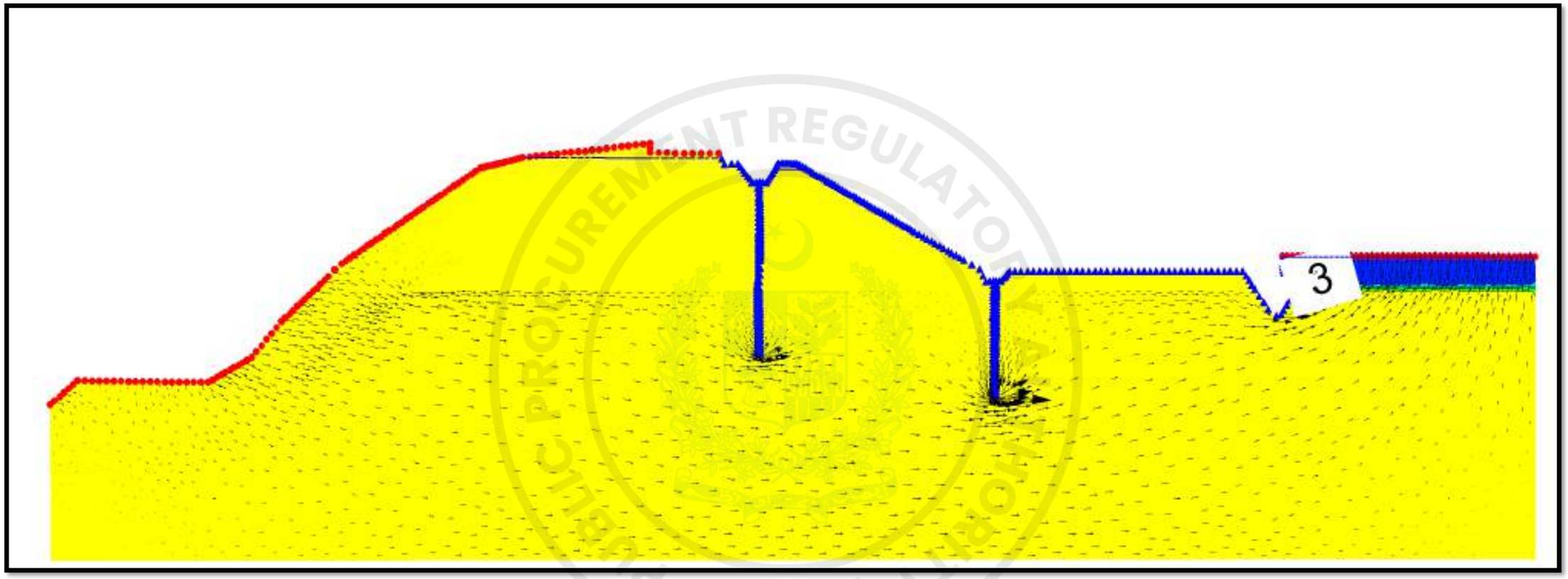




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**Figure 2-17 Cross section Under sluice/ Sediment Flushing Section**

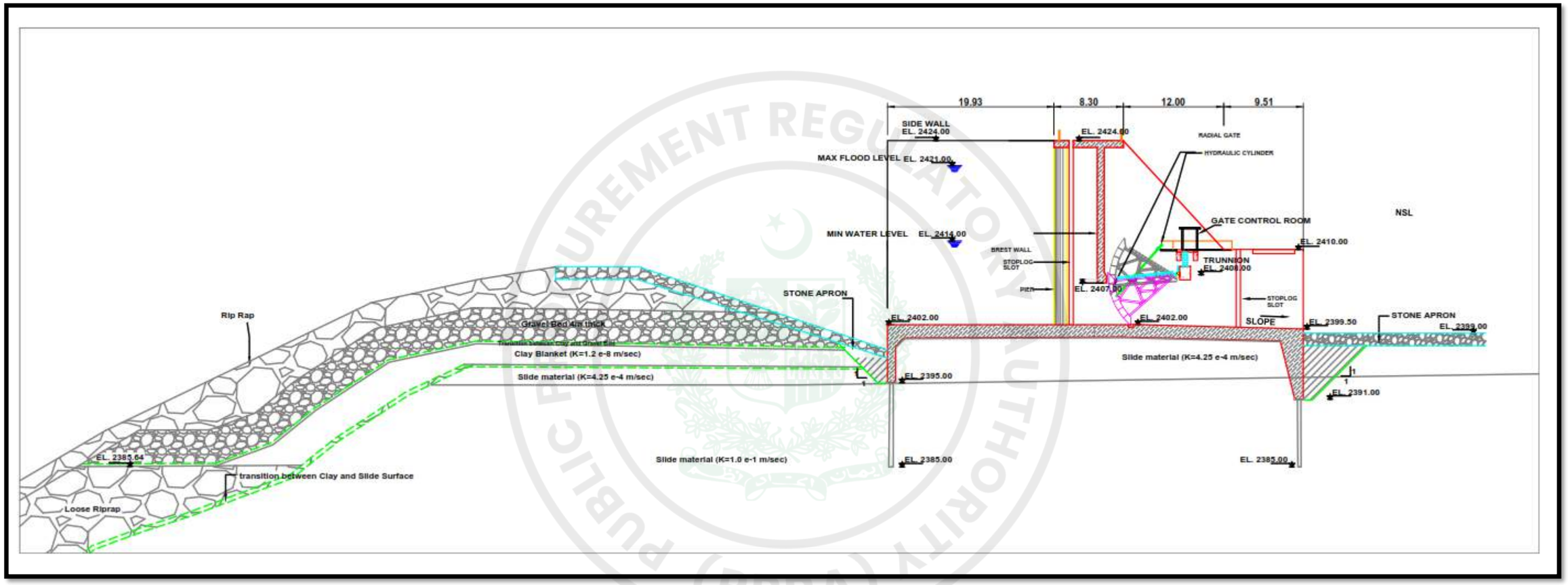




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**Figure 2-18 Finite Element Model –Under sluice Section at Maximum Water El: 2424 m upstream**

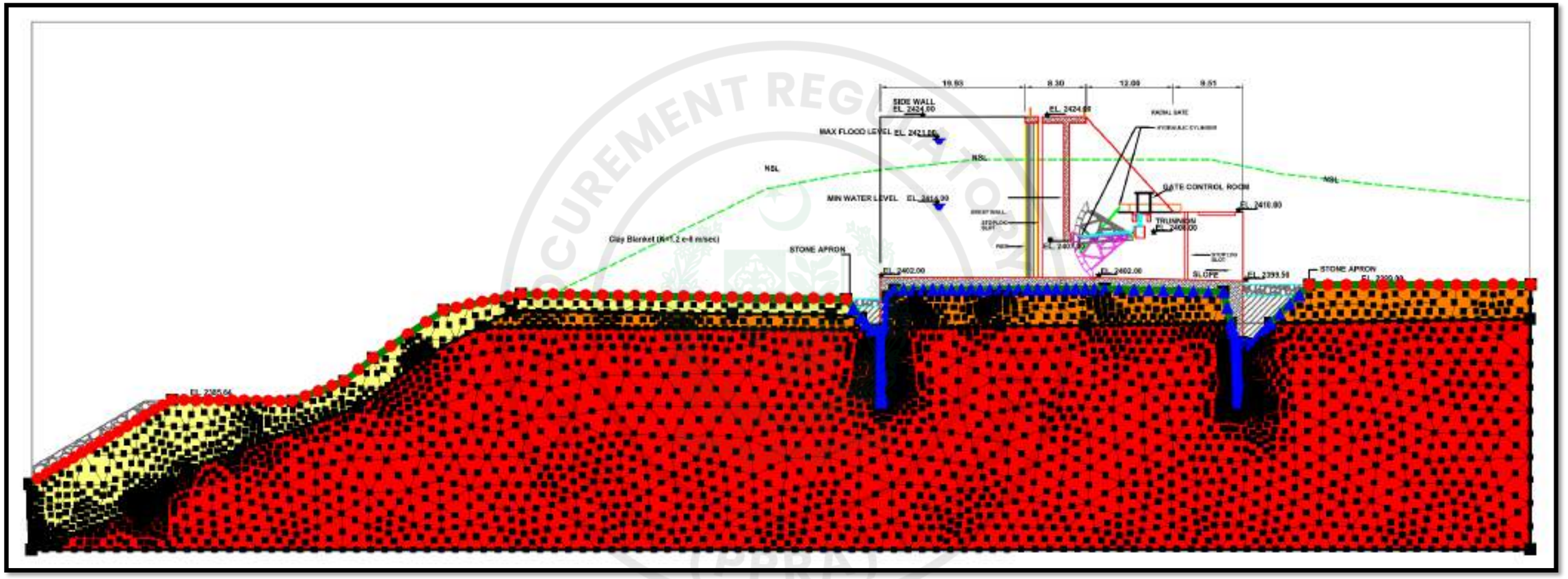




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**Figure 2-19 Pressure Head Profile –Under sluice Section at Maximum Water El: 2424 m upstream**

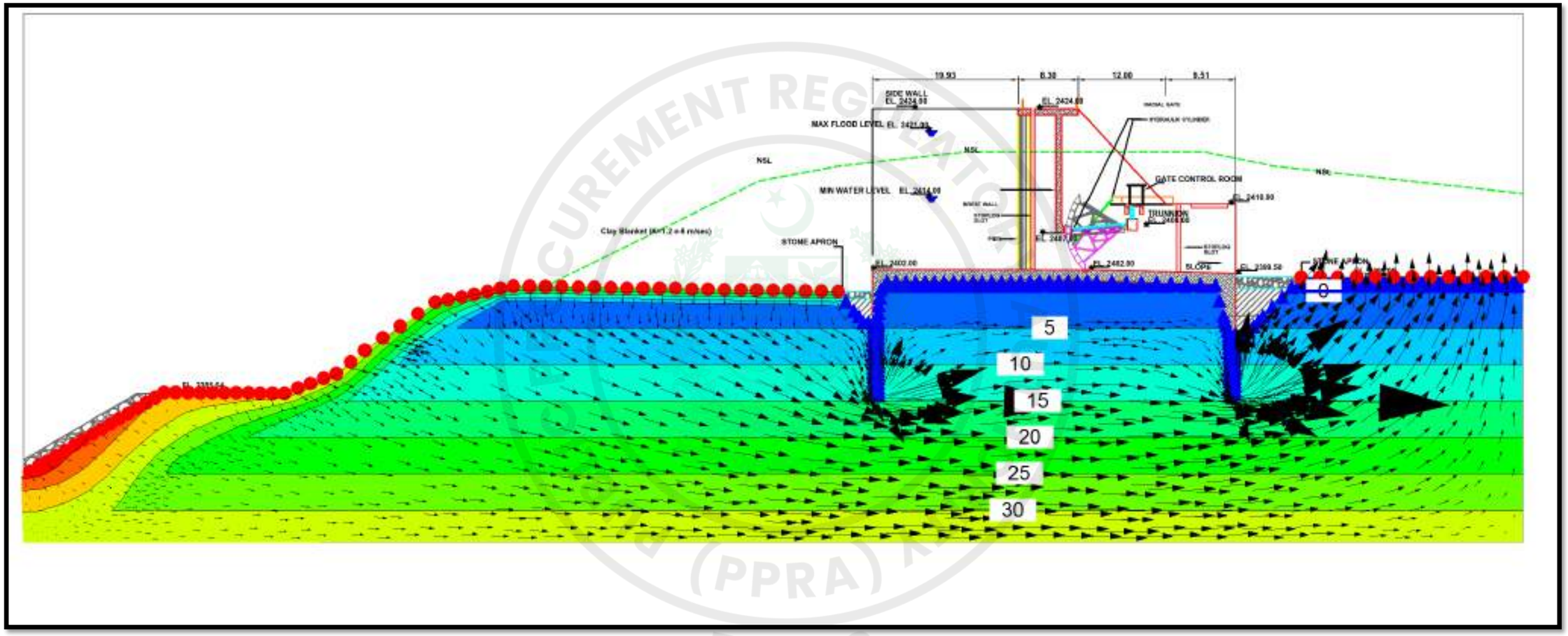




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**Figure2-20 Critical Hydraulic Gradient Profile –Under sluice Section at Maximum Water El: 2424 m upstream**

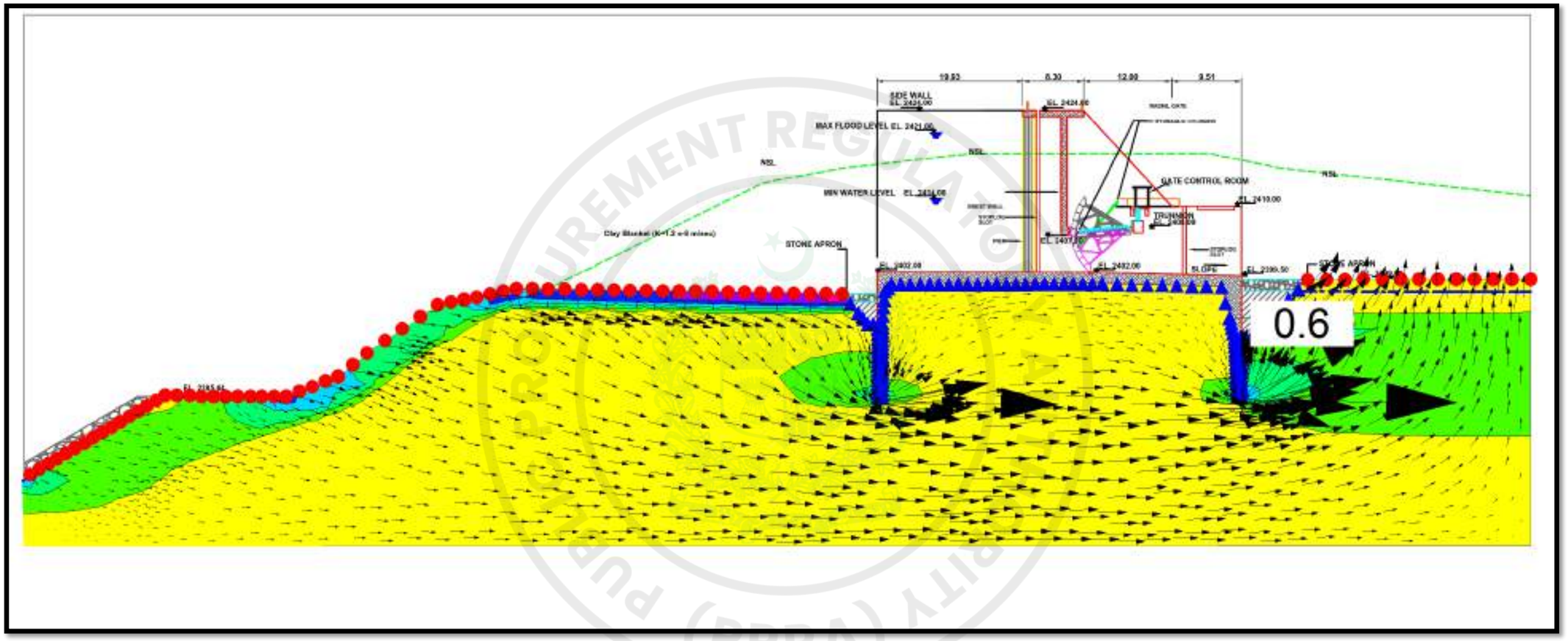




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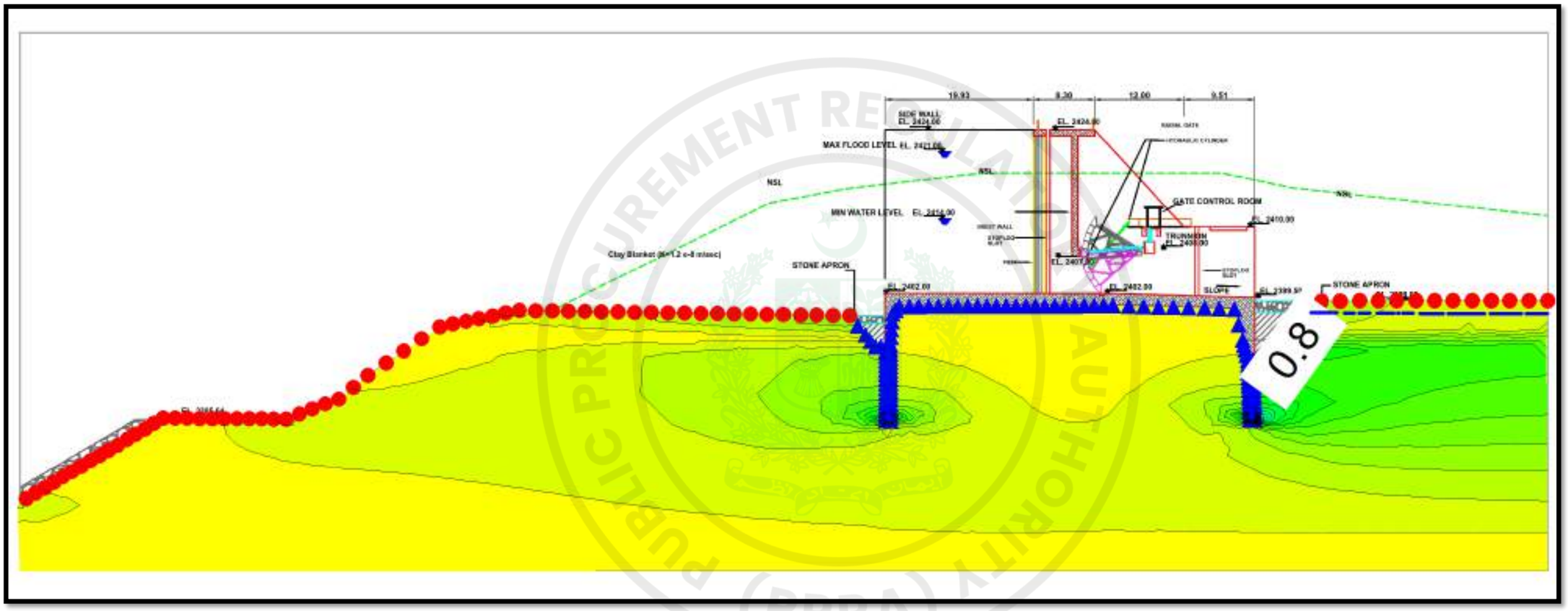
**Figure 2-21 Critical Hydraulic Gradient Profile –Under sluice Section at Maximum Water El: 2424 m upstream without clay Blanket**



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# APPENDIX – III:

# 3 HYDROLOGICAL FLOW DATA

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS



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| 1966 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 38.12 | 33.72 | 30.08 | 22.03 | 34.10 | 93.10 | 1126.43 | 1055.55 | 741.37 | 197.32 | 64.94 | 43.10 |
| 38.12 | 33.14 | 28.54 | 22.80 | 33.72 | 100.38 | 1132.18 | 1026.81 | 693.48 | 195.40 | 60.92 | 43.10 |
| 38.12 | 33.14 | 28.54 | 22.80 | 37.16 | 104.60 | 745.21 | 1061.30 | 768.19 | 195.40 | 59.96 | 43.10 |
| 38.51 | 32.76 | 27.59 | 24.14 | 43.68 | 114.94 | 563.21 | 1136.01 | 772.03 | 190.61 | 56.70 | 42.34 |
| 37.93 | 32.76 | 26.82 | 25.67 | 53.26 | 120.31 | 475.09 | 1139.84 | 706.89 | 181.03 | 55.56 | 42.34 |
| 38.12 | 32.57 | 26.82 | 25.48 | 63.60 | 109.19 | 396.55 | 1147.50 | 639.84 | 181.99 | 56.13 | 41.57 |
| 37.93 | 32.18 | 26.25 | 25.10 | 82.57 | 106.51 | 383.14 | 1149.42 | 595.78 | 164.75 | 56.13 | 41.57 |
| 37.93 | 32.18 | 25.48 | 25.48 | 90.80 | 126.44 | 360.15 | 1160.91 | 567.05 | 155.17 | 55.17 | 41.57 |
| 37.93 | 32.57 | 25.67 | 24.90 | 85.25 | 150.19 | 434.86 | 1103.44 | 507.66 | 138.31 | 55.17 | 41.57 |
| 37.93 | 32.18 | 25.48 | 23.75 | 72.80 | 175.29 | 528.73 | 986.58 | 496.17 | 117.82 | 55.17 | 41.57 |
| 37.93 | 32.18 | 24.90 | 25.67 | 68.20 | 188.70 | 689.65 | 975.09 | 465.51 | 109.77 | 54.60 | 41.19 |
| 38.12 | 31.80 | 24.90 | 26.05 | 54.02 | 216.47 | 806.51 | 842.91 | 440.61 | 107.28 | 54.60 | 41.19 |
| 38.12 | 32.18 | 24.90 | 28.54 | 46.36 | 283.52 | 867.81 | 779.69 | 429.12 | 105.75 | 56.13 | 41.19 |
| 37.55 | 32.57 | 24.71 | 34.48 | 40.61 | 350.57 | 867.81 | 724.13 | 417.62 | 100.96 | 56.13 | 40.80 |
| 38.12 | 32.76 | 24.33 | 32.57 | 44.06 | 413.79 | 783.52 | 693.48 | 444.44 | 97.13 | 56.13 | 40.80 |
| 38.51 | 33.14 | 24.33 | 31.23 | 55.56 | 542.14 | 766.28 | 791.18 | 436.78 | 96.36 | 51.72 | 40.80 |
| 38.12 | 33.14 | 24.90 | 29.69 | 65.52 | 639.84 | 716.47 | 785.44 | 452.10 | 94.83 | 47.51 | 40.80 |
| 37.55 | 42.72 | 24.33 | 33.33 | 88.51 | 641.76 | 624.52 | 879.30 | 411.87 | 94.06 | 46.55 | 41.19 |
| 36.40 | 40.23 | 24.14 | 36.78 | 106.51 | 825.67 | 626.43 | 931.03 | 327.58 | 91.95 | 45.21 | 41.57 |
| 36.21 | 34.67 | 22.22 | 39.85 | 122.22 | 862.06 | 749.04 | 1024.90 | 287.35 | 91.19 | 45.79 | 41.95 |
| 36.40 | 33.14 | 22.22 | 40.61 | 107.85 | 871.64 | 816.09 | 961.68 | 249.04 | 89.65 | 44.83 | 41.95 |
| 35.82 | 32.57 | 23.56 | 41.38 | 91.95 | 808.42 | 934.86 | 814.17 | 224.14 | 84.67 | 44.83 | 42.34 |
| 35.44 | 31.80 | 22.41 | 41.38 | 88.51 | 831.41 | 1013.40 | 747.12 | 218.39 | 77.97 | 44.44 | 42.34 |
| 35.06 | 31.61 | 22.41 | 42.72 | 79.31 | 925.28 | 1067.04 | 724.13 | 208.81 | 7.61 | 44.44 | 42.34 |
| 35.06 | 31.23 | 22.22 | 46.36 | 79.88 | 1013.40 | 1151.33 | 639.84 | 199.23 | 74.71 | 44.06 | 41.57 |
| 34.67 | 32.76 | 22.03 | 50.57 | 80.46 | 1042.14 | 1074.71 | 588.12 | 187.74 | 73.37 | 44.06 | 41.57 |
| 34.48 | 32.18 | 23.56 | 49.04 | 81.03 | 1032.56 | 1061.30 | 607.28 | 185.82 | 72.80 | 44.06 | 41.57 |
| 34.10 | 31.61 | 22.03 | 40.61 | 80.46 | 1040.22 | 886.97 | 655.17 | 186.78 | 70.88 | 44.06 | 41.19 |
| 33.33 | | 21.84 | 37.16 | 91.38 | 988.50 | 919.53 | 655.17 | 187.74 | 70.31 | 43.68 | 40.80 |
| 34.10 | | 22.03 | 35.44 | 93.68 | 1005.74 | 1024.90 | 785.44 | 197.32 | 67.82 | 43.68 | 40.80 |
| 34.10 | | 22.41 | | 94.25 | | 1139.84 | 810.34 | | 68.39 | | 40.80 |
| **36.77** | **33.20** | **24.57** | **32.85** | **72.82** | **524.16** | **797.86** | **883.32** | **421.55** | **111.78** | **51.08** | **41.63** |



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| 1967 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 37.84 | 34.62 | 34.62 | 34.26 | 58.65 | 152.63 | 778.40 | 1000.80 | 360.50 | 150.48 | 55.78 | 39.10 |
| 37.13 | 34.62 | 34.26 | 34.26 | 53.09 | 179.36 | 717.42 | 1042.06 | 344.36 | 149.22 | 54.52 | 38.38 |
| 37.13 | 34.62 | 34.26 | 34.26 | 50.94 | 200.88 | 686.93 | 1092.27 | 333.60 | 145.82 | 53.63 | 36.23 |
| 37.13 | 34.62 | 34.26 | 33.90 | 52.37 | 209.85 | 670.79 | 1223.20 | 330.01 | 142.41 | 53.09 | 35.15 |
| 37.13 | 35.15 | 34.26 | 33.90 | 48.96 | 191.91 | 652.85 | 1178.37 | 358.71 | 132.90 | 52.73 | 34.62 |
| 36.77 | 35.15 | 34.26 | 33.90 | 49.32 | 193.70 | 749.71 | 1101.24 | 382.03 | 130.39 | 51.83 | 34.62 |
| 36.77 | 35.15 | 34.26 | 33.90 | 56.68 | 233.16 | 823.24 | 999.01 | 466.32 | 128.42 | 51.48 | 34.26 |
| 36.23 | 35.15 | 34.26 | 33.90 | 62.60 | 290.56 | 877.05 | 875.25 | 493.23 | 118.02 | 50.58 | 33.90 |
| 36.23 | 35.87 | 34.62 | 33.54 | 67.62 | 301.32 | 859.11 | 756.88 | 577.52 | 106.90 | 48.96 | 33.90 |
| 35.51 | 35.87 | 34.62 | 33.54 | 77.12 | 353.33 | 821.45 | 767.64 | 618.78 | 100.26 | 48.25 | 34.97 |
| 35.51 | 35.87 | 34.62 | 35.33 | 67.62 | 390.99 | 826.83 | 841.18 | 643.89 | 94.88 | 47.35 | 34.97 |
| 35.51 | 35.87 | 34.62 | 33.54 | 56.68 | 439.42 | 886.02 | 959.55 | 697.69 | 88.60 | 45.91 | 34.26 |
| 35.51 | 35.15 | 35.15 | 33.90 | 50.58 | 464.53 | 988.25 | 1009.77 | 695.90 | 85.19 | 45.38 | 33.90 |
| 36.59 | 35.15 | 35.15 | 34.26 | 45.02 | 399.96 | 1013.36 | 1063.58 | 672.58 | 83.58 | 45.02 | 33.36 |
| 37.49 | 35.15 | 35.15 | 34.62 | 52.37 | 410.72 | 1042.06 | 1092.27 | 615.19 | 80.35 | 44.66 | 32.64 |
| 37.49 | 35.15 | 35.15 | 35.15 | 57.75 | 346.16 | 999.01 | 1097.66 | 502.20 | 78.74 | 44.66 | 32.64 |
| 37.49 | 34.62 | 34.62 | 37.13 | 57.21 | 261.86 | 984.66 | 1025.91 | 392.79 | 78.20 | 44.30 | 32.10 |
| 36.77 | 34.62 | 34.62 | 37.49 | 57.21 | 251.10 | 860.91 | 862.70 | 338.98 | 75.51 | 44.30 | 31.75 |
| 35.87 | 34.62 | 34.62 | 37.84 | 70.67 | 251.10 | 796.34 | 857.32 | 303.11 | 72.82 | 43.05 | 31.57 |
| 35.87 | 34.62 | 34.26 | 38.38 | 78.20 | 261.86 | 916.51 | 911.13 | 279.79 | 71.20 | 42.69 | 31.57 |
| 35.15 | 34.62 | 34.26 | 38.74 | 96.13 | 279.79 | 1020.53 | 875.25 | 267.24 | 68.51 | 42.69 | 31.75 |
| 34.62 | 35.15 | 34.26 | 37.84 | 102.05 | 331.81 | 1153.26 | 855.53 | 263.65 | 67.08 | 42.69 | 32.10 |
| 34.62 | 35.15 | 33.90 | 38.74 | 106.36 | 392.79 | 1185.54 | 898.57 | 283.38 | 65.64 | 41.97 | 32.10 |
| 34.26 | 35.15 | 33.90 | 61.52 | 89.68 | 451.98 | 1203.47 | 825.03 | 301.32 | 63.49 | 41.25 | 31.75 |
| 34.26 | 34.62 | 33.90 | 63.13 | 83.04 | 521.92 | 1180.16 | 792.75 | 299.52 | 62.60 | 41.25 | 31.57 |
| 34.26 | 34.62 | 33.90 | 72.82 | 72.82 | 577.52 | 1101.24 | 564.97 | 288.76 | 62.06 | 40.89 | 31.21 |
| 34.26 | 34.62 | 33.90 | 81.97 | 66.00 | 670.79 | 1052.82 | 455.56 | 242.13 | 60.98 | 39.82 | 30.85 |
| 33.90 | 34.62 | 33.54 | 88.06 | 65.64 | 690.52 | 1042.06 | 453.77 | 200.88 | 58.65 | 39.82 | 30.67 |
| 33.90 | | 34.62 | 83.04 | 73.36 | 755.09 | 955.96 | 448.39 | 179.36 | 57.21 | 39.82 | 30.31 |
| 34.26 | | 34.62 | 73.36 | 90.40 | 1303.91 | 970.31 | 401.76 | 160.70 | 56.68 | 39.10 | 29.77 |
| 34.26 | | 34.26 | | 130.93 | | 1027.71 | 380.23 | | 56.68 | | 28.70 |
| **35.80** | **35.01** | **34.41** | **44.54** | **69.26** | **392.02** | **930.45** | **861.60** | **396.47** | **90.11** | **45.91** | **33.05** |



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| 1968 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 27.44 | 26.37 | 26.37 | 18.47 | 59.55 | 197.29 | 518.34 | 1160.43 | 245.72 | 163.57 | 55.78 | 36.59 |
| 26.90 | 26.37 | 26.37 | 18.65 | 58.65 | 222.40 | 604.43 | 1171.19 | 263.65 | 164.83 | 53.09 | 37.84 |
| 26.37 | 26.37 | 26.37 | 18.65 | 52.37 | 213.43 | 686.93 | 1181.95 | 322.84 | 164.11 | 53.09 | 38.38 |
| 26.19 | 26.19 | 26.90 | 18.83 | 49.86 | 211.64 | 744.33 | 1151.46 | 369.47 | 146.53 | 48.96 | 39.10 |
| 28.70 | 26.19 | 26.19 | 19.37 | 46.99 | 218.81 | 834.00 | 1198.09 | 365.89 | 130.93 | 46.27 | 38.38 |
| 27.98 | 25.83 | 25.83 | 19.37 | 45.91 | 236.75 | 941.62 | 1285.98 | 369.47 | 128.42 | 45.02 | 38.38 |
| 27.44 | 25.47 | 25.83 | 19.37 | 41.97 | 263.65 | 1070.75 | 1329.02 | 344.36 | 115.50 | 45.02 | 37.84 |
| 27.44 | 24.93 | 25.65 | 18.83 | 39.82 | 324.63 | 1158.64 | 1291.36 | 333.60 | 103.31 | 45.02 | 37.84 |
| 27.44 | 24.39 | 25.65 | 18.65 | 38.38 | 392.79 | 1199.89 | 1332.61 | 328.22 | 96.13 | 53.09 | 36.77 |
| 27.44 | 23.50 | 25.47 | 18.83 | 37.49 | 455.56 | 1242.93 | 1294.95 | 312.08 | 91.47 | 53.09 | 36.77 |
| 27.44 | 23.50 | 25.11 | 19.37 | 37.13 | 521.92 | 1296.74 | 1248.31 | 313.87 | 85.73 | 53.09 | 36.23 |
| 27.44 | 22.06 | 25.65 | 19.37 | 40.18 | 532.69 | 1285.98 | 1126.35 | 326.43 | 80.35 | 52.37 | 37.13 |
| 27.44 | 23.67 | 25.65 | 19.73 | 45.02 | 441.21 | 1271.63 | 1158.64 | 344.36 | 74.97 | 52.37 | 37.13 |
| 26.72 | 24.39 | 25.83 | 19.73 | 49.86 | 389.20 | 1264.46 | 1171.19 | 365.89 | 71.20 | 49.86 | 36.59 |
| 25.83 | 24.39 | 24.57 | 20.27 | 51.83 | 417.90 | 1110.21 | 1221.41 | 374.85 | 70.13 | 47.35 | 36.23 |
| 25.65 | 23.85 | 23.85 | 20.27 | 58.11 | 453.77 | 954.17 | 1142.49 | 360.50 | 68.16 | 45.91 | 36.23 |
| 25.83 | 23.50 | 23.50 | 21.16 | 63.13 | 507.58 | 886.02 | 1122.76 | 321.05 | 65.11 | 43.94 | 36.59 |
| 25.83 | 23.67 | 22.78 | 23.85 | 73.89 | 536.27 | 868.08 | 1162.22 | 308.49 | 65.11 | 43.40 | 36.59 |
| 26.19 | 23.85 | 22.24 | 25.83 | 79.28 | 550.62 | 834.00 | 1155.05 | 258.27 | 64.03 | 41.97 | 36.59 |
| 26.19 | 24.39 | 21.16 | 26.90 | 89.68 | 579.32 | 774.82 | 1153.26 | 231.37 | 61.52 | 41.97 | 35.87 |
| 26.37 | 24.93 | 19.91 | 30.85 | 95.42 | 685.14 | 731.77 | 1103.04 | 217.02 | 60.08 | 41.97 | 35.15 |
| 26.37 | 25.47 | 18.65 | 38.38 | 102.05 | 581.11 | 638.51 | 970.31 | 231.37 | 59.01 | 41.25 | 35.15 |
| 26.19 | 25.65 | 18.47 | 41.97 | 106.90 | 608.01 | 543.45 | 719.22 | 249.30 | 59.55 | 41.25 | 34.62 |
| 26.19 | 25.11 | 19.73 | 41.97 | 111.20 | 640.30 | 520.13 | 604.43 | 263.65 | 58.65 | 41.25 | 34.62 |
| 26.19 | 25.47 | 19.73 | 45.91 | 103.85 | 735.36 | 588.29 | 532.69 | 247.51 | 59.55 | 40.53 | 34.62 |
| 26.37 | 25.47 | 19.37 | 49.86 | 144.38 | 753.29 | 704.87 | 401.76 | 229.57 | 58.65 | 40.53 | 34.62 |
| 26.37 | 25.65 | 19.37 | 53.99 | 139.72 | 758.67 | 819.65 | 330.01 | 222.40 | 58.65 | 39.10 | 33.90 |
| 26.37 | 25.83 | 18.83 | 51.48 | 134.88 | 701.28 | 977.49 | 317.46 | 193.70 | 58.11 | 38.38 | 32.28 |
| 26.37 | | 18.65 | 49.86 | 144.38 | 541.65 | 1108.42 | 295.94 | 173.08 | 57.75 | 37.84 | 31.57 |
| 26.19 | | 18.65 | 57.21 | 166.26 | 520.13 | 1146.08 | 265.45 | 166.26 | 57.75 | 36.59 | 31.57 |
| 26.19 | | 18.47 | | 156.76 | | 1181.95 | 243.92 | | 56.32 | | 31.57 |
| **26.68** | **24.87** | **22.93** | **28.90** | **79.51** | **473.08** | **919.63** | **962.68** | **288.48** | **85.65** | **45.65** | **35.89** |



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| 1969 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 31.57 | 26.37 | 24.03 | 24.03 | 26.19 | 286.97 | 511.16 | 826.83 | 563.18 | 175.77 | 60.26 | 48.43 |
| 30.85 | 26.90 | 24.03 | 25.11 | 24.75 | 312.08 | 545.24 | 943.41 | 568.56 | 171.28 | 58.11 | 47.53 |
| 31.21 | 27.26 | 24.03 | 25.65 | 27.26 | 295.94 | 608.01 | 1077.93 | 495.02 | 165.90 | 57.57 | 45.74 |
| 31.75 | 27.26 | 24.03 | 25.65 | 27.44 | 252.89 | 710.25 | 1203.47 | 435.83 | 173.08 | 56.50 | 43.94 |
| 31.75 | 27.26 | 23.50 | 25.65 | 33.54 | 222.40 | 733.56 | 1298.53 | 419.69 | 157.83 | 55.06 | 43.94 |
| 31.75 | 26.72 | 23.50 | 30.85 | 39.64 | 202.67 | 760.47 | 1363.10 | 387.41 | 154.25 | 53.63 | 45.74 |
| 29.95 | 26.72 | 23.50 | 34.26 | 47.53 | 200.88 | 832.21 | 1386.42 | 401.76 | 152.45 | 53.09 | 43.94 |
| 28.34 | 26.90 | 23.50 | 45.74 | 59.73 | 222.40 | 871.67 | 1402.56 | 376.65 | 152.45 | 52.55 | 43.94 |
| 28.34 | 27.44 | 24.03 | 50.22 | 74.79 | 243.92 | 893.19 | 1416.91 | 322.84 | 153.35 | 53.09 | 43.94 |
| 27.80 | 27.44 | 24.03 | 50.22 | 75.51 | 260.07 | 864.49 | 1390.00 | 294.14 | 156.04 | 53.09 | 45.74 |
| 27.80 | 27.44 | 24.57 | 55.06 | 71.20 | 274.41 | 823.24 | 1406.15 | 285.18 | 156.94 | 53.09 | 46.63 |
| 27.44 | 27.44 | 24.57 | 60.26 | 65.29 | 252.89 | 780.20 | 1318.26 | 288.76 | 149.76 | 52.55 | 46.09 |
| 27.44 | 27.80 | 27.80 | 53.09 | 71.20 | 25.11 | 812.48 | 1275.22 | 297.73 | 145.28 | 52.55 | 45.74 |
| 28.16 | 27.80 | 27.80 | 50.22 | 71.20 | 267.24 | 900.36 | 1253.69 | 319.25 | 143.48 | 52.01 | 43.94 |
| 28.16 | 27.80 | 27.80 | 59.19 | 69.95 | 285.18 | 914.71 | 1124.56 | 312.08 | 143.48 | 52.01 | 43.22 |
| 26.72 | 27.80 | 30.85 | 60.26 | 65.82 | 338.98 | 835.80 | 1147.87 | 256.48 | 127.70 | 52.01 | 47.71 |
| 26.72 | 27.80 | 30.85 | 53.09 | 83.22 | 398.17 | 783.78 | 1120.97 | 224.19 | 116.58 | 52.01 | 41.97 |
| 26.01 | 27.26 | 30.85 | 50.22 | 85.37 | 444.80 | 860.91 | 1167.60 | 220.61 | 110.30 | 51.12 | 47.71 |
| 26.72 | 25.11 | 30.13 | 41.97 | 79.28 | 503.99 | 993.63 | 1106.62 | 218.81 | 94.52 | 50.76 | 41.97 |
| 26.37 | 25.11 | 29.59 | 41.61 | 83.94 | 722.80 | 1081.51 | 877.05 | 231.37 | 90.22 | 50.22 | 41.97 |
| 26.37 | 25.11 | 27.80 | 38.20 | 100.44 | 561.38 | 1174.78 | 669.00 | 208.05 | 79.99 | 50.76 | 40.00 |
| 26.37 | 25.11 | 27.80 | 34.26 | 116.58 | 521.92 | 1216.03 | 599.05 | 188.32 | 76.05 | 50.76 | 38.56 |
| 26.37 | 25.11 | 27.80 | 31.57 | 118.91 | 489.64 | 1257.28 | 564.97 | 186.53 | 74.25 | 50.76 | 37.84 |
| 26.37 | 25.11 | 28.34 | 30.49 | 107.25 | 416.10 | 1284.18 | 536.27 | 177.56 | 73.54 | 50.22 | 36.41 |
| 29.59 | 25.11 | 28.34 | 30.85 | 115.86 | 412.52 | 1302.12 | 525.51 | 164.11 | 70.49 | 49.32 | 36.41 |
| 26.72 | 25.11 | 28.34 | 31.21 | 136.31 | 421.49 | 1239.35 | 527.30 | 156.94 | 71.20 | 48.43 | 35.69 |
| 26.72 | 25.11 | 26.72 | 30.13 | 149.76 | 477.09 | 1203.47 | 509.37 | 156.04 | 71.20 | 46.63 | 34.97 |
| 26.72 | 24.03 | 25.65 | 29.23 | 165.90 | 509.37 | 1122.76 | 489.64 | 158.73 | 71.74 | 45.74 | 36.41 |
| 26.37 | | 25.11 | 28.88 | 193.70 | 541.65 | 871.67 | 498.61 | 162.32 | 68.69 | 44.84 | 36.41 |
| 26.37 | | 25.11 | 27.26 | 238.54 | 532.69 | 794.54 | 532.69 | 165.90 | 65.29 | 51.12 | 35.69 |
| 26.37 | | 25.11 | | 270.83 | | 755.09 | 561.38 | | 61.88 | | 37.13 |
| **28.04** | **26.48** | **26.42** | **39.15** | **93.45** | **363.25** | **914.13** | **971.64** | **288.13** | **118.55** | **52.00** | **42.11** |



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| 1970 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 36.77 | 32.28 | 27.98 | 27.98 | 54.34 | 322.84 | 1160.43 | 925.47 | 1011.56 | 199.08 | 59.90 | 38.20 |
| 36.05 | 32.10 | 27.98 | 28.52 | 52.55 | 349.74 | 1165.81 | 941.62 | 905.74 | 206.26 | 58.47 | 39.10 |
| 36.59 | 31.75 | 27.98 | 28.52 | 49.14 | 396.38 | 1106.62 | 1000.80 | 907.54 | 225.99 | 57.75 | 39.10 |
| 36.59 | 31.57 | 27.44 | 29.41 | 46.27 | 408.93 | 952.38 | 1020.53 | 970.31 | 243.92 | 55.42 | 38.56 |
| 36.59 | 31.39 | 27.44 | 30.67 | 46.45 | 378.44 | 869.87 | 1040.26 | 988.25 | 242.13 | 55.78 | 38.56 |
| 35.51 | 30.49 | 27.44 | 33.36 | 47.89 | 340.78 | 850.14 | 1027.71 | 934.44 | 254.68 | 55.06 | 37.84 |
| 33.90 | 30.13 | 27.08 | 34.08 | 52.55 | 306.70 | 771.23 | 1029.50 | 945.20 | 208.05 | 53.99 | 36.77 |
| 34.97 | 29.95 | 27.08 | 33.90 | 51.12 | 288.76 | 753.29 | 1074.34 | 932.65 | 175.77 | 53.99 | 36.77 |
| 34.44 | 29.77 | 27.08 | 34.62 | 52.19 | 301.32 | 758.67 | 1129.94 | 851.94 | 159.99 | 52.91 | 36.23 |
| 34.97 | 29.23 | 27.08 | 35.69 | 55.06 | 340.78 | 690.52 | 1174.78 | 835.80 | 150.66 | 52.55 | 35.69 |
| 34.44 | 29.23 | 27.08 | 39.10 | 58.11 | 426.87 | 590.08 | 1201.68 | 814.27 | 143.48 | 51.48 | 35.15 |
| 34.44 | 29.77 | 27.08 | 44.12 | 63.13 | 505.78 | 568.56 | 1174.78 | 790.96 | 147.79 | 50.58 | 35.15 |
| 34.44 | 29.23 | 26.72 | 47.17 | 71.56 | 464.53 | 634.92 | 1063.58 | 808.89 | 144.20 | 50.04 | 35.15 |
| 33.90 | 29.23 | 26.72 | 48.07 | 75.15 | 383.82 | 554.21 | 841.18 | 774.82 | 139.18 | 49.86 | 35.15 |
| 33.90 | 29.77 | 26.72 | 47.53 | 75.15 | 313.87 | 575.73 | 792.75 | 622.36 | 139.90 | 49.50 | 34.62 |
| 33.90 | 29.23 | 26.72 | 49.14 | 82.50 | 261.86 | 677.96 | 789.16 | 505.78 | 142.05 | 49.14 | 34.62 |
| 33.36 | 29.23 | 26.72 | 49.14 | 99.18 | 276.21 | 735.36 | 778.40 | 412.52 | 139.18 | 48.07 | 35.15 |
| 33.36 | 28.88 | 26.72 | 48.07 | 117.12 | 367.68 | 762.26 | 756.88 | 358.71 | 142.05 | 45.91 | 34.62 |
| 33.36 | 28.88 | 26.37 | 47.89 | 145.64 | 489.64 | 783.78 | 785.58 | 317.46 | 136.31 | 45.20 | 34.62 |
| 32.82 | 28.34 | 26.37 | 47.53 | 161.60 | 288.76 | 855.53 | 896.78 | 276.21 | 134.16 | 44.66 | 33.90 |
| 33.90 | 28.34 | 26.37 | 51.48 | 179.36 | 330.01 | 737.15 | 1007.98 | 231.37 | 119.81 | 44.12 | 32.82 |
| 33.36 | 28.16 | 26.37 | 57.21 | 215.23 | 410.72 | 573.94 | 1018.74 | 208.05 | 109.94 | 44.12 | 32.82 |
| 32.82 | 28.16 | 26.72 | 62.77 | 258.27 | 450.18 | 559.59 | 999.01 | 204.47 | 93.62 | 43.76 | 32.82 |
| 32.82 | 27.98 | 26.72 | 63.13 | 209.85 | 541.65 | 491.43 | 1020.53 | 200.88 | 87.35 | 42.87 | 32.82 |
| 33.36 | 27.98 | 26.90 | 71.02 | 227.78 | 625.95 | 512.96 | 1065.37 | 197.29 | 81.07 | 41.97 | 32.64 |
| 33.90 | 27.44 | 26.90 | 81.07 | 215.23 | 765.85 | 575.73 | 1095.86 | 191.91 | 75.15 | 40.53 | 32.10 |
| 33.90 | 27.44 | 27.44 | 83.58 | 195.50 | 884.22 | 665.41 | 938.03 | 193.70 | 70.67 | 40.00 | 32.10 |
| 33.90 | 27.44 | 27.44 | 79.63 | 222.40 | 986.45 | 756.88 | 835.80 | 191.91 | 69.77 | 39.46 | 31.57 |
| 32.64 | | 27.26 | 69.41 | 236.75 | 1079.72 | 769.43 | 896.78 | 191.91 | 66.36 | 39.10 | 31.57 |
| 33.00 | | 27.26 | 60.80 | 243.92 | 1144.29 | 851.94 | 957.76 | 193.70 | 63.85 | 38.20 | 31.57 |
| 32.82 | | 27.44 | | 281.59 | | 921.89 | 984.66 | | 61.52 | | 31.57 |
| **34.22** | **29.41** | **27.05** | **48.82** | **127.18** | **481.09** | **749.47** | **976.33** | **565.69** | **141.09** | **48.48** | **34.82** |



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| 1971 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 31.57 | 28.88 | 27.08 | 29.23 | 73.72 | 498.61 | 1124.56 | 1336.20 | 591.87 | 109.41 | 59.55 | 46.27 |
| 31.03 | 28.88 | 26.72 | 28.88 | 67.62 | 514.75 | 1088.69 | 1321.85 | 613.40 | 115.86 | 57.75 | 46.27 |
| 31.03 | 29.23 | 26.37 | 29.23 | 62.77 | 511.16 | 925.47 | 1146.08 | 658.23 | 113.35 | 55.78 | 45.56 |
| 30.49 | 29.23 | 25.83 | 31.57 | 63.49 | 541.65 | 688.72 | 1095.86 | 658.23 | 109.41 | 53.99 | 45.56 |
| 30.49 | 28.88 | 26.37 | 31.03 | 66.72 | 595.46 | 512.96 | 1156.84 | 563.18 | 110.48 | 53.99 | 45.56 |
| 30.49 | 28.88 | 26.37 | 30.49 | 63.49 | 676.17 | 423.28 | 1207.06 | 464.53 | 106.72 | 52.19 | 45.56 |
| 30.49 | 28.88 | 26.37 | 30.67 | 60.80 | 755.09 | 403.55 | 1280.60 | 394.58 | 103.49 | 52.19 | 45.56 |
| 29.77 | 28.88 | 26.72 | 31.57 | 70.13 | 880.64 | 428.66 | 1314.68 | 360.50 | 106.18 | 52.19 | 45.56 |
| 29.77 | 29.23 | 26.37 | 31.57 | 81.07 | 945.20 | 509.37 | 1171.19 | 313.87 | 105.64 | 51.48 | 45.02 |
| 29.77 | 29.23 | 26.37 | 32.82 | 89.86 | 907.54 | 649.27 | 947.00 | 288.76 | 107.79 | 50.58 | 45.02 |
| 29.23 | 29.23 | 25.83 | 34.08 | 90.40 | 864.49 | 790.96 | 738.94 | 286.97 | 111.56 | 50.58 | 44.12 |
| 29.23 | 28.34 | 25.83 | 35.15 | 101.87 | 823.24 | 966.73 | 573.94 | 251.10 | 109.41 | 50.22 | 44.12 |
| 29.23 | 28.16 | 25.83 | 36.05 | 106.72 | 868.08 | 1095.86 | 518.34 | 211.64 | 111.56 | 49.50 | 44.12 |
| 30.13 | 28.16 | 25.83 | 38.56 | 105.10 | 868.08 | 1189.13 | 520.13 | 178.46 | 112.81 | 48.78 | 43.76 |
| 30.13 | 28.16 | 25.83 | 41.43 | 108.33 | 851.94 | 1169.40 | 503.99 | 168.77 | 110.48 | 48.78 | 43.76 |
| 30.13 | 28.16 | 26.37 | 42.51 | 100.26 | 773.02 | 1138.91 | 482.47 | 161.60 | 99.72 | 48.07 | 43.76 |
| 29.77 | 28.34 | 27.44 | 41.61 | 117.12 | 643.89 | 1033.09 | 451.98 | 173.08 | 95.60 | 48.07 | 43.05 |
| 29.77 | 28.16 | 27.98 | 41.61 | 141.33 | 638.51 | 905.74 | 448.39 | 204.47 | 94.52 | 47.53 | 43.05 |
| 29.23 | 28.16 | 28.16 | 42.15 | 159.99 | 669.00 | 780.20 | 487.85 | 222.40 | 93.98 | 46.81 | 41.07 |
| 28.88 | 27.98 | 28.88 | 48.43 | 204.47 | 738.94 | 613.40 | 518.34 | 220.61 | 93.62 | 46.27 | 39.64 |
| 28.88 | 27.98 | 28.16 | 49.14 | 186.53 | 807.10 | 482.47 | 541.65 | 220.61 | 91.47 | 46.27 | 37.84 |
| 29.77 | 27.98 | 27.44 | 49.14 | 195.50 | 930.85 | 466.32 | 586.49 | 218.81 | 88.96 | 46.27 | 35.15 |
| 29.23 | 27.44 | 27.08 | 45.91 | 191.91 | 1054.61 | 464.53 | 652.85 | 218.81 | 84.48 | 46.27 | 34.08 |
| 29.23 | 27.26 | 27.44 | 44.12 | 195.50 | 1086.89 | 525.51 | 817.86 | 233.16 | 77.30 | 46.27 | 32.64 |
| 29.77 | 26.72 | 27.08 | 46.81 | 204.47 | 990.04 | 667.20 | 905.74 | 243.92 | 72.46 | 46.27 | 32.10 |
| 29.23 | 26.72 | 27.08 | 56.14 | 220.61 | 868.08 | 862.70 | 977.49 | 243.92 | 66.36 | 46.81 | 31.57 |
| 29.23 | 27.08 | 28.16 | 67.26 | 285.18 | 869.87 | 1112.00 | 993.63 | 211.64 | 64.39 | 46.81 | 31.03 |
| 28.88 | 27.44 | 28.16 | 76.41 | 317.46 | 896.78 | 1259.08 | 1006.18 | 165.55 | 63.49 | 46.81 | 31.03 |
| 28.88 | | 27.44 | 71.92 | 355.12 | 925.47 | 1337.99 | 853.73 | 137.03 | 62.77 | 46.27 | 30.67 |
| 28.88 | | 27.08 | 75.51 | 398.17 | 1067.16 | 1363.10 | 738.94 | 116.58 | 62.24 | 46.27 | 30.67 |
| 28.88 | | 28.16 | | 439.42 | | 1336.20 | 708.45 | | 61.52 | | 30.49 |
| **29.73** | **28.27** | **26.96** | **43.03** | **158.87** | **802.08** | **848.87** | **838.86** | **299.88** | **94.10** | **49.62** | **40.12** |



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|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 30.49 | 28.52 | 24.03 | 25.65 | 43.76 | 104.56 | 451.98 | 421.49 | 552.41 | 149.22 | 58.47 | 36.23 |
| 30.49 | 28.52 | 24.21 | 26.19 | 41.43 | 134.88 | 426.87 | 435.83 | 552.41 | 156.76 | 57.75 | 35.69 |
| 30.49 | 28.34 | 24.39 | 26.19 | 41.97 | 152.09 | 480.67 | 538.07 | 564.97 | 156.76 | 56.86 | 36.23 |
| 30.49 | 28.16 | 24.21 | 26.37 | 44.30 | 147.07 | 536.27 | 669.00 | 557.80 | 155.86 | 53.99 | 36.05 |
| 30.49 | 27.98 | 24.39 | 26.37 | 48.07 | 132.72 | 547.03 | 823.24 | 550.62 | 157.47 | 55.78 | 36.77 |
| 30.49 | 27.80 | 24.57 | 26.54 | 49.86 | 131.29 | 448.39 | 981.07 | 545.24 | 156.76 | 55.06 | 37.84 |
| 30.49 | 27.08 | 24.39 | 26.19 | 48.07 | 128.42 | 319.25 | 993.63 | 556.00 | 148.51 | 54.34 | 39.10 |
| 30.67 | 27.08 | 24.57 | 25.65 | 48.43 | 132.72 | 278.00 | 982.87 | 556.00 | 148.51 | 53.63 | 39.64 |
| 31.03 | 26.54 | 24.75 | 25.29 | 47.17 | 144.92 | 342.57 | 830.42 | 541.65 | 145.64 | 52.91 | 37.84 |
| 31.03 | 26.37 | 24.57 | 25.65 | 44.66 | 173.08 | 444.80 | 640.30 | 484.26 | 144.20 | 51.48 | 36.23 |
| 31.03 | 25.65 | 24.93 | 26.19 | 43.05 | 213.43 | 502.20 | 505.78 | 478.88 | 132.72 | 50.58 | 35.51 |
| 31.03 | 25.65 | 25.29 | 26.54 | 54.34 | 233.16 | 460.94 | 512.96 | 434.04 | 124.83 | 50.22 | 35.15 |
| 31.57 | 25.65 | 25.29 | 27.80 | 65.64 | 234.96 | 374.85 | 525.51 | 410.72 | 124.83 | 49.14 | 35.15 |
| 31.57 | 25.29 | 24.93 | 28.52 | 62.77 | 254.68 | 407.14 | 482.47 | 364.09 | 112.10 | 47.89 | 35.15 |
| 31.57 | 25.29 | 24.93 | 27.80 | 61.16 | 286.97 | 475.29 | 401.76 | 376.65 | 108.33 | 46.81 | 34.08 |
| 31.03 | 24.93 | 25.29 | 28.16 | 57.75 | 338.98 | 566.76 | 471.70 | 390.99 | 100.26 | 46.27 | 33.54 |
| 31.03 | 24.93 | 25.29 | 29.06 | 87.88 | 419.69 | 647.47 | 482.47 | 430.45 | 93.98 | 44.66 | 34.08 |
| 31.03 | 24.93 | 25.29 | 29.41 | 95.06 | 460.94 | 573.94 | 428.66 | 338.98 | 89.50 | 44.12 | 35.15 |
| 31.03 | 24.57 | 25.65 | 30.67 | 104.03 | 408.93 | 457.36 | 434.04 | 265.45 | 83.58 | 43.76 | 37.31 |
| 30.67 | 24.21 | 25.65 | 31.03 | 132.72 | 403.55 | 407.14 | 450.18 | 197.29 | 77.84 | 43.76 | 34.62 |
| 30.67 | 24.21 | 25.29 | 30.13 | 159.09 | 451.98 | 385.61 | 468.12 | 155.14 | 72.82 | 44.12 | 33.90 |
| 30.13 | 24.21 | 25.29 | 29.41 | 151.38 | 448.39 | 340.78 | 444.80 | 134.16 | 70.13 | 43.76 | 33.90 |
| 30.13 | 23.67 | 25.29 | 29.23 | 161.60 | 451.98 | 462.74 | 451.98 | 117.12 | 67.62 | 43.76 | 33.54 |
| 30.13 | 23.85 | 24.93 | 29.95 | 168.06 | 469.91 | 520.13 | 371.27 | 115.86 | 66.72 | 43.05 | 33.36 |
| 30.13 | 23.67 | 24.93 | 31.57 | 156.76 | 480.67 | 469.91 | 378.44 | 118.37 | 65.11 | 43.05 | 34.08 |
| 30.49 | 23.67 | 25.29 | 34.97 | 96.13 | 545.24 | 383.82 | 310.28 | 124.11 | 63.85 | 41.43 | 34.62 |
| 30.31 | 23.85 | 25.65 | 39.64 | 85.37 | 514.75 | 330.01 | 297.73 | 130.57 | 63.13 | 40.53 | 34.08 |
| 29.95 | 24.03 | 25.65 | 45.91 | 83.94 | 491.43 | 344.36 | 322.84 | 133.44 | 60.80 | 38.74 | 32.10 |
| 29.41 | | 26.19 | 51.12 | 70.67 | 439.42 | 423.28 | 378.44 | 139.18 | 59.90 | 37.84 | 31.57 |
| 29.23 | | 26.19 | 47.17 | 71.92 | 459.15 | 444.80 | 451.98 | 140.61 | 60.26 | 39.64 | 31.57 |
| 29.06 | | 25.65 | | 84.48 | | 448.39 | 552.41 | | 59.90 | | 31.03 |
| **30.56** | **25.67** | **25.06** | **30.48** | **81.02** | **313.00** | **442.02** | **530.31** | **348.58** | **105.74** | **47.78** | **35.00** |



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|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 31.57 | 28.16 | 25.29 | 28.70 | 74.43 | 261.86 | 1095.86 | 785.58 | 771.23 | 161.42 | 78.02 | 43.22 |
| 31.57 | 27.98 | 25.11 | 29.41 | 82.50 | 292.35 | 1198.09 | 848.35 | 645.68 | 151.20 | 75.15 | 43.05 |
| 30.85 | 28.34 | 24.93 | 32.10 | 85.19 | 308.49 | 1300.33 | 936.24 | 559.59 | 135.59 | 71.56 | 42.87 |
| 30.49 | 27.98 | 24.75 | 33.36 | 81.79 | 324.63 | 1262.66 | 1108.42 | 539.86 | 134.52 | 69.77 | 42.33 |
| 30.49 | 28.16 | 24.39 | 34.79 | 86.81 | 355.12 | 1120.97 | 1151.46 | 509.37 | 130.21 | 69.05 | 42.15 |
| 30.85 | 27.98 | 24.21 | 34.44 | 93.09 | 387.41 | 1058.20 | 1303.91 | 500.40 | 124.83 | 66.90 | 40.53 |
| 31.03 | 28.16 | 24.03 | 36.41 | 96.13 | 428.66 | 846.56 | 1210.65 | 486.05 | 124.29 | 63.67 | 39.64 |
| 30.85 | 28.70 | 23.67 | 35.51 | 98.47 | 468.12 | 697.69 | 1221.41 | 548.83 | 123.76 | 62.24 | 39.28 |
| 30.85 | 28.52 | 24.21 | 36.23 | 100.26 | 489.64 | 686.93 | 1027.71 | 521.92 | 122.14 | 59.73 | 39.10 |
| 32.28 | 31.21 | 24.39 | 37.66 | 87.17 | 493.23 | 695.90 | 799.93 | 457.36 | 122.14 | 57.75 | 38.92 |
| 31.39 | 28.70 | 23.50 | 38.02 | 72.64 | 550.62 | 764.05 | 801.72 | 521.92 | 123.76 | 55.60 | 38.74 |
| 31.03 | 28.16 | 24.75 | 38.74 | 75.15 | 627.74 | 871.67 | 950.58 | 550.62 | 122.68 | 54.70 | 39.28 |
| 30.85 | 27.98 | 23.85 | 38.38 | 82.14 | 713.83 | 1022.33 | 982.87 | 532.69 | 128.60 | 52.91 | 38.74 |
| 30.49 | 27.80 | 24.03 | 38.38 | 85.19 | 731.77 | 1300.33 | 966.73 | 448.39 | 128.60 | 51.83 | 38.02 |
| 30.49 | 27.26 | 24.21 | 38.38 | 88.42 | 706.66 | 1445.60 | 1029.50 | 457.36 | 122.14 | 52.73 | 37.84 |
| 30.13 | 27.26 | 24.39 | 37.84 | 97.93 | 704.87 | 1546.04 | 963.14 | 464.53 | 121.60 | 50.94 | 37.84 |
| 29.95 | 26.72 | 24.03 | 36.41 | 110.12 | 710.25 | 1621.37 | 894.98 | 505.78 | 114.07 | 50.58 | 37.66 |
| 29.95 | 26.01 | 24.03 | 38.02 | 111.56 | 688.72 | 1589.09 | 799.93 | 473.50 | 107.25 | 50.58 | 37.31 |
| 29.59 | 26.01 | 23.85 | 40.00 | 113.53 | 685.14 | 1533.49 | 629.54 | 581.11 | 104.92 | 50.22 | 37.13 |
| 29.41 | 25.47 | 23.85 | 41.61 | 122.14 | 755.09 | 1524.52 | 694.11 | 663.62 | 105.46 | 49.68 | 36.77 |
| 30.13 | 25.11 | 23.85 | 48.07 | 130.21 | 774.82 | 1341.58 | 814.27 | 575.73 | 103.13 | 49.32 | 36.41 |
| 29.95 | 25.11 | 24.03 | 47.35 | 144.74 | 769.43 | 1325.44 | 950.58 | 457.36 | 101.69 | 48.43 | 36.41 |
| 30.85 | 24.93 | 24.03 | 50.94 | 161.96 | 798.13 | 1327.23 | 1059.99 | 365.89 | 98.47 | 47.89 | 35.87 |
| 30.49 | 24.93 | 24.39 | 48.96 | 184.74 | 846.56 | 1325.44 | 1108.42 | 312.08 | 97.03 | 47.17 | 35.15 |
| 31.03 | 25.29 | 24.75 | 51.83 | 186.53 | 920.09 | 1337.99 | 1144.29 | 292.35 | 95.78 | 46.45 | 34.79 |
| 31.75 | 27.44 | 24.93 | 58.83 | 186.53 | 1018.74 | 1287.77 | 1155.05 | 261.86 | 93.98 | 46.09 | 34.44 |
| 29.59 | 25.65 | 25.11 | 65.46 | 215.23 | 1015.15 | 1079.72 | 1090.48 | 254.68 | 91.47 | 45.38 | 33.90 |
| 29.95 | 24.93 | 26.01 | 64.57 | 181.15 | 999.01 | 979.28 | 889.60 | 252.89 | 86.63 | 45.20 | 33.72 |
| 29.41 | | 26.72 | 65.11 | 199.08 | 945.20 | 719.22 | 911.13 | 206.26 | 81.79 | 45.02 | 33.54 |
| 28.16 | | 26.90 | 71.20 | 227.78 | 972.11 | 690.52 | 1031.29 | 191.91 | 80.17 | 43.76 | 33.18 |
| 28.52 | | 27.80 | | 245.72 | | 724.60 | 1043.85 | | 78.74 | | 33.00 |
| **30.45** | **27.14** | **24.65** | **43.22** | **126.08** | **658.11** | **1139.37** | **977.60** | **463.69** | **113.49** | **55.28** | **37.77** |



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|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 32.64 | 31.57 | 30.67 | 32.46 | 80.89 | 231.37 | 383.82 | 521.92 | 380.23 | 119.09 | 65.64 | 35.33 |
| 32.46 | 31.21 | 30.85 | 32.82 | 76.23 | 225.99 | 477.09 | 685.14 | 324.63 | 118.02 | 66.00 | 35.15 |
| 32.28 | 31.21 | 31.21 | 33.00 | 72.28 | 227.78 | 478.88 | 805.31 | 295.94 | 117.12 | 64.75 | 34.79 |
| 32.64 | 31.57 | 30.67 | 33.90 | 62.77 | 231.37 | 394.58 | 889.60 | 279.79 | 116.04 | 64.03 | 34.79 |
| 33.00 | 31.21 | 30.13 | 34.26 | 56.68 | 238.54 | 321.05 | 740.74 | 272.62 | 114.07 | 62.77 | 34.44 |
| 33.36 | 31.57 | 30.13 | 34.79 | 55.24 | 234.96 | 326.43 | 649.27 | 274.41 | 113.53 | 60.80 | 35.15 |
| 33.72 | 31.57 | 30.13 | 36.23 | 55.60 | 195.50 | 342.57 | 566.76 | 286.97 | 112.46 | 59.90 | 35.33 |
| 34.08 | 31.57 | 30.67 | 35.15 | 59.73 | 149.04 | 390.99 | 527.30 | 297.73 | 111.02 | 57.93 | 35.33 |
| 34.08 | 31.21 | 30.31 | 35.51 | 69.05 | 157.12 | 469.91 | 444.80 | 304.90 | 110.12 | 56.86 | 35.33 |
| 33.90 | 31.21 | 30.13 | 36.41 | 76.94 | 176.13 | 543.45 | 541.65 | 278.00 | 109.59 | 55.24 | 35.15 |
| 33.72 | 31.21 | 29.95 | 38.20 | 76.23 | 193.70 | 611.60 | 699.49 | 252.89 | 108.15 | 53.99 | 34.97 |
| 33.72 | 31.57 | 30.13 | 38.56 | 76.23 | 224.19 | 597.25 | 794.54 | 225.99 | 106.90 | 51.83 | 34.62 |
| 34.08 | 31.21 | 30.13 | 38.56 | 78.02 | 233.16 | 643.89 | 911.13 | 217.02 | 104.56 | 50.04 | 34.26 |
| 34.08 | 30.85 | 30.67 | 28.34 | 78.38 | 249.30 | 742.53 | 995.42 | 215.23 | 100.80 | 48.43 | 33.72 |
| 33.90 | 30.67 | 30.13 | 27.08 | 79.10 | 303.11 | 884.22 | 805.31 | 213.43 | 95.78 | 44.84 | 33.36 |
| 33.72 | 30.49 | 30.13 | 25.83 | 82.14 | 353.33 | 950.58 | 579.32 | 193.70 | 91.47 | 42.51 | 33.18 |
| 33.54 | 30.67 | 29.95 | 24.57 | 82.86 | 394.58 | 816.07 | 505.78 | 179.18 | 86.45 | 40.71 | 33.00 |
| 33.00 | 30.49 | 30.13 | 23.32 | 81.79 | 425.07 | 814.27 | 547.03 | 167.88 | 86.09 | 40.35 | 32.82 |
| 32.64 | 30.31 | 29.95 | 22.06 | 75.15 | 425.07 | 898.57 | 543.45 | 157.12 | 85.73 | 40.89 | 32.46 |
| 33.18 | 30.13 | 30.13 | 22.06 | 74.43 | 446.60 | 975.69 | 530.89 | 160.88 | 84.48 | 39.64 | 32.28 |
| 33.72 | 30.13 | 30.67 | 27.08 | 78.74 | 459.15 | 995.42 | 534.48 | 162.50 | 84.48 | 38.38 | 32.28 |
| 33.18 | 30.13 | 30.85 | 29.41 | 85.19 | 469.91 | 1011.56 | 532.69 | 172.90 | 82.86 | 37.66 | 32.28 |
| 32.64 | 30.13 | 32.64 | 31.57 | 95.78 | 460.94 | 1072.55 | 500.40 | 179.36 | 82.50 | 37.31 | 32.10 |
| 32.28 | 30.13 | 31.93 | 35.15 | 105.82 | 380.23 | 963.14 | 487.85 | 206.26 | 81.25 | 37.13 | 32.10 |
| 32.28 | 30.13 | 30.67 | 38.02 | 128.60 | 249.30 | 767.64 | 505.78 | 217.02 | 76.23 | 37.13 | 32.10 |
| 32.10 | 30.13 | 31.03 | 52.73 | 164.83 | 202.67 | 597.25 | 547.03 | 215.23 | 74.07 | 37.13 | 31.93 |
| 32.28 | 30.31 | 31.39 | 65.64 | 165.37 | 208.05 | 451.98 | 538.07 | 213.43 | 71.56 | 36.95 | 31.75 |
| 32.10 | 30.13 | 32.10 | 70.13 | 181.15 | 220.61 | 460.94 | 439.42 | 202.67 | 70.13 | 36.95 | 31.75 |
| 31.75 | | 31.57 | 77.30 | 184.74 | 242.13 | 530.89 | 434.04 | 167.34 | 69.05 | 36.23 | 31.75 |
| 31.57 | | 31.57 | 84.84 | 186.53 | 303.11 | 498.61 | 487.85 | 130.75 | 68.16 | 35.69 | 31.57 |
| 31.57 | | 32.28 | | 229.57 | | 487.85 | 453.77 | | 66.54 | | 31.03 |
| **33.01** | **30.81** | **30.74** | **38.17** | **98.58** | **283.73** | **641.98** | **604.72** | **228.20** | **94.14** | **47.92** | **33.42** |



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|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 30.13 | 27.08 | 26.90 | 24.75 | 60.08 | 135.59 | 342.57 | 651.06 | 500.40 | 114.43 | 58.83 | 36.59 |
| 29.95 | 27.08 | 26.72 | 24.93 | 66.00 | 150.12 | 297.73 | 762.26 | 516.54 | 117.84 | 57.93 | 35.87 |
| 29.77 | 27.08 | 26.72 | 24.93 | 67.98 | 191.91 | 338.98 | 850.14 | 518.34 | 120.89 | 56.68 | 35.15 |
| 29.77 | 26.90 | 26.72 | 24.93 | 69.77 | 193.70 | 398.17 | 950.58 | 529.10 | 123.93 | 55.60 | 34.26 |
| 29.41 | 27.26 | 26.72 | 24.93 | 71.56 | 195.50 | 396.38 | 927.27 | 539.86 | 121.60 | 54.70 | 33.54 |
| 29.23 | 27.44 | 26.54 | 25.11 | 73.00 | 197.29 | 369.47 | 886.02 | 505.78 | 135.59 | 54.17 | 33.18 |
| 29.06 | 27.44 | 26.54 | 25.11 | 73.36 | 197.29 | 374.85 | 842.97 | 478.88 | 137.57 | 53.45 | 32.46 |
| 29.06 | 27.44 | 26.37 | 25.11 | 75.15 | 200.88 | 423.28 | 780.20 | 376.65 | 139.36 | 52.19 | 31.75 |
| 28.70 | 27.44 | 26.37 | 24.93 | 75.51 | 204.47 | 480.67 | 740.74 | 358.71 | 132.90 | 50.58 | 31.03 |
| 28.70 | 27.44 | 26.19 | 24.57 | 75.87 | 204.47 | 554.21 | 765.85 | 349.74 | 127.88 | 48.61 | 30.31 |
| 28.52 | 27.44 | 26.01 | 24.57 | 79.28 | 188.32 | 651.06 | 762.26 | 326.43 | 122.50 | 47.17 | 29.59 |
| 28.52 | 27.62 | 25.83 | 24.57 | 76.58 | 190.12 | 740.74 | 859.11 | 322.84 | 119.99 | 45.91 | 29.06 |
| 28.34 | 27.62 | 25.83 | 24.75 | 76.58 | 181.15 | 846.56 | 1006.18 | 328.22 | 114.97 | 45.20 | 28.52 |
| 28.34 | 27.62 | 25.65 | 25.29 | 79.28 | 206.26 | 975.69 | 948.79 | 322.84 | 114.43 | 44.30 | 27.98 |
| 28.34 | 27.62 | 25.47 | 26.01 | 80.89 | 260.07 | 866.29 | 914.71 | 358.71 | 112.46 | 43.58 | 27.44 |
| 28.34 | 27.80 | 25.29 | 27.26 | 84.84 | 306.70 | 787.37 | 918.30 | 392.79 | 107.79 | 42.87 | 27.08 |
| 28.16 | 27.80 | 25.11 | 28.52 | 82.14 | 390.99 | 726.39 | 1072.55 | 389.20 | 105.28 | 42.51 | 26.72 |
| 28.16 | 27.80 | 24.93 | 31.57 | 80.89 | 491.43 | 706.66 | 1115.59 | 394.58 | 102.77 | 42.15 | 26.19 |
| 27.98 | 27.80 | 24.93 | 33.54 | 82.86 | 559.59 | 688.72 | 1070.75 | 387.41 | 95.60 | 41.79 | 25.83 |
| 27.98 | 27.80 | 24.57 | 37.49 | 86.81 | 478.88 | 703.07 | 1120.97 | 367.68 | 92.37 | 41.43 | 25.47 |
| 27.98 | 27.80 | 24.39 | 41.43 | 90.75 | 428.66 | 712.04 | 1027.71 | 313.87 | 90.40 | 41.07 | 25.11 |
| 27.80 | 27.80 | 24.21 | 45.02 | 92.37 | 484.26 | 753.29 | 916.51 | 252.89 | 88.06 | 40.53 | 24.93 |
| 27.80 | 27.62 | 24.03 | 43.22 | 95.06 | 376.65 | 677.96 | 703.07 | 227.78 | 85.73 | 40.00 | 24.57 |
| 27.62 | 27.44 | 24.03 | 42.87 | 97.03 | 245.72 | 582.91 | 527.30 | 220.61 | 78.92 | 39.64 | 24.21 |
| 27.62 | 27.26 | 24.03 | 45.20 | 102.77 | 245.72 | 509.37 | 518.34 | 209.85 | 75.15 | 39.10 | 24.03 |
| 27.62 | 27.08 | 24.03 | 47.89 | 111.20 | 306.70 | 538.07 | 577.52 | 188.32 | 69.05 | 38.92 | 23.85 |
| 27.62 | 27.08 | 24.03 | 46.09 | 115.68 | 353.33 | 582.91 | 631.33 | 178.10 | 63.85 | 38.56 | 23.67 |
| 27.44 | 26.90 | 24.03 | 46.63 | 121.60 | 414.31 | 638.51 | 539.86 | 165.19 | 62.42 | 38.38 | 23.67 |
| 27.26 | | 24.21 | 49.32 | 128.96 | 450.18 | 670.79 | 459.15 | 137.74 | 61.34 | 38.02 | 23.50 |
| 29.06 | | 24.39 | 55.06 | 133.98 | 394.58 | 545.24 | 426.87 | 123.40 | 60.08 | 37.31 | 23.50 |
| 29.06 | | 24.39 | | 135.05 | | 582.91 | 444.80 | | 59.19 | | 23.50 |
| **28.49** | **27.45** | **25.33** | **33.19** | **88.48** | **294.16** | **595.58** | **797.38** | **342.75** | **101.75** | **45.71** | **28.15** |



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|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 22.42 | 22.06 | 22.96 | 22.96 | 37.31 | 224.19 | 525.51 | 514.75 | 547.03 | 170.57 | 49.50 | 34.44 |
| 22.60 | 22.06 | 23.14 | 22.96 | 36.41 | 254.68 | 550.62 | 416.10 | 419.69 | 152.81 | 48.96 | 34.26 |
| 22.60 | 22.06 | 23.14 | 22.96 | 39.28 | 288.76 | 554.21 | 344.36 | 491.43 | 135.05 | 48.25 | 34.08 |
| 22.60 | 22.24 | 23.14 | 22.96 | 42.15 | 331.81 | 570.35 | 414.31 | 489.64 | 126.98 | 47.35 | 34.08 |
| 22.60 | 22.24 | 22.96 | 22.96 | 47.35 | 326.43 | 613.40 | 509.37 | 426.87 | 121.24 | 46.27 | 33.90 |
| 22.60 | 22.24 | 22.96 | 22.96 | 53.45 | 270.83 | 713.83 | 521.92 | 378.44 | 116.58 | 44.30 | 33.54 |
| 22.42 | 22.24 | 22.96 | 22.96 | 56.50 | 267.24 | 844.76 | 557.80 | 362.30 | 112.46 | 43.76 | 33.18 |
| 22.42 | 22.24 | 23.14 | 22.96 | 61.34 | 278.00 | 975.69 | 595.46 | 364.09 | 94.70 | 43.40 | 33.00 |
| 22.42 | 22.24 | 23.14 | 22.96 | 61.34 | 303.11 | 1065.37 | 638.51 | 290.56 | 87.17 | 42.69 | 32.64 |
| 22.42 | 22.24 | 22.96 | 23.32 | 69.05 | 340.78 | 1104.83 | 643.89 | 274.41 | 82.14 | 41.61 | 32.64 |
| 22.42 | 22.24 | 23.14 | 23.32 | 86.09 | 331.81 | 1024.12 | 656.44 | 276.21 | 78.56 | 40.53 | 32.64 |
| 22.42 | 22.24 | 23.14 | 23.50 | 95.96 | 337.19 | 988.25 | 686.93 | 301.32 | 75.15 | 39.82 | 32.46 |
| 22.42 | 22.24 | 23.14 | 23.32 | 112.46 | 349.74 | 1016.95 | 722.80 | 299.52 | 74.43 | 39.46 | 32.28 |
| 22.42 | 22.24 | 23.14 | 23.32 | 123.04 | 367.68 | 1092.27 | 776.61 | 265.45 | 73.72 | 38.20 | 32.28 |
| 22.42 | 22.42 | 23.32 | 23.50 | 140.44 | 378.44 | 1140.70 | 805.31 | 238.54 | 70.85 | 37.49 | 32.10 |
| 22.24 | 22.42 | 23.32 | 23.67 | 152.27 | 365.89 | 1164.02 | 805.31 | 222.40 | 70.13 | 36.95 | 31.75 |
| 22.24 | 22.42 | 23.50 | 23.85 | 162.50 | 330.01 | 1228.58 | 724.60 | 209.85 | 68.69 | 36.59 | 31.39 |
| 22.24 | 22.42 | 23.50 | 24.21 | 173.26 | 308.49 | 1232.17 | 681.55 | 181.15 | 68.69 | 36.23 | 31.03 |
| 22.24 | 22.42 | 23.32 | 25.11 | 178.10 | 290.56 | 1284.18 | 649.27 | 159.81 | 67.98 | 36.05 | 31.03 |
| 22.24 | 22.42 | 23.32 | 28.16 | 176.13 | 260.07 | 1330.82 | 572.14 | 152.27 | 68.33 | 35.87 | 31.03 |
| 22.24 | 22.42 | 23.32 | 30.49 | 177.38 | 256.48 | 1323.64 | 591.87 | 152.81 | 66.72 | 35.69 | 30.85 |
| 22.24 | 22.42 | 23.32 | 37.31 | 172.18 | 254.68 | 1284.18 | 460.94 | 152.81 | 63.85 | 35.51 | 30.67 |
| 22.06 | 22.42 | 23.32 | 37.49 | 181.15 | 234.96 | 1199.89 | 502.20 | 152.27 | 62.42 | 35.51 | 30.67 |
| 22.06 | 22.42 | 23.32 | 38.74 | 191.91 | 224.19 | 1153.26 | 444.80 | 153.35 | 60.80 | 35.33 | 30.67 |
| 22.06 | 22.60 | 23.32 | 41.43 | 191.91 | 229.57 | 1086.89 | 459.15 | 154.96 | 58.29 | 35.33 | 30.67 |
| 22.06 | 22.60 | 23.32 | 42.15 | 172.18 | 252.89 | 1004.39 | 478.88 | 157.12 | 54.70 | 35.33 | 30.49 |
| 22.24 | 22.60 | 23.14 | 41.43 | 146.35 | 303.11 | 790.96 | 478.88 | 157.65 | 39.46 | 34.97 | 30.31 |
| 22.24 | 22.78 | 23.14 | 47.53 | 153.89 | 353.33 | 785.58 | 462.74 | 163.03 | 52.01 | 34.97 | 30.13 |
| 22.24 | | 23.14 | 43.05 | 167.34 | 416.10 | 839.38 | 484.26 | 168.95 | 50.76 | 34.79 | 30.13 |
| 22.24 | | 23.14 | 38.56 | 178.10 | 495.02 | 686.93 | 495.02 | 173.26 | 50.22 | 34.62 | 30.13 |
| 22.06 | | 22.96 | | 202.67 | | 591.87 | 527.30 | | 49.68 | | 29.95 |
| **22.33** | **22.34** | **23.18** | **29.00** | **123.85** | **307.53** | **960.25** | **568.50** | **264.57** | **81.46** | **39.51** | **31.88** |



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| 1977 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 29.95 | 27.80 | 24.39 | 27.08 | 57.04 | 229.57 | 1307.50 | 846.56 | 604.43 | 231.37 | 64.57 | 36.41 |
| 29.95 | 27.80 | 24.93 | 27.62 | 58.11 | 218.81 | 1273.42 | 970.31 | 534.48 | 188.32 | 63.67 | 34.79 |
| 29.95 | 27.80 | 25.47 | 29.23 | 59.55 | 209.85 | 1228.58 | 1113.80 | 498.61 | 176.13 | 63.31 | 33.90 |
| 29.95 | 27.08 | 25.65 | 29.77 | 61.52 | 225.99 | 1246.52 | 1237.55 | 446.60 | 134.16 | 62.95 | 33.00 |
| 29.95 | 26.72 | 25.29 | 30.13 | 55.06 | 252.89 | 1228.58 | 1221.41 | 387.41 | 133.08 | 57.93 | 33.00 |
| 29.77 | 26.37 | 24.93 | 31.21 | 52.73 | 251.10 | 1296.74 | 938.03 | 390.99 | 130.03 | 57.57 | 32.64 |
| 29.77 | 26.90 | 24.75 | 31.75 | 56.32 | 270.83 | 1373.86 | 733.56 | 376.65 | 120.17 | 56.68 | 31.93 |
| 29.59 | 27.62 | 24.75 | 32.28 | 61.52 | 270.83 | 1337.99 | 729.98 | 315.67 | 109.41 | 52.91 | 31.57 |
| 29.59 | 28.52 | 24.57 | 33.18 | 72.46 | 288.76 | 1307.50 | 850.14 | 267.24 | 111.74 | 50.58 | 30.85 |
| 29.59 | 28.34 | 24.57 | 32.46 | 72.10 | 285.18 | 1300.33 | 814.27 | 254.68 | 107.43 | 48.78 | 30.31 |
| 29.41 | 27.26 | 24.57 | 33.00 | 72.10 | 283.38 | 1284.18 | 866.29 | 227.78 | 102.23 | 48.07 | 30.31 |
| 29.41 | 26.72 | 24.57 | 33.00 | 77.30 | 290.56 | 1370.28 | 891.40 | 213.43 | 97.75 | 47.17 | 29.95 |
| 28.70 | 26.72 | 24.93 | 31.93 | 82.68 | 290.56 | 1434.84 | 805.31 | 206.26 | 96.85 | 45.91 | 29.77 |
| 28.52 | 26.54 | 25.11 | 31.39 | 77.30 | 294.14 | 1531.70 | 764.05 | 206.26 | 97.39 | 45.02 | 29.59 |
| 28.34 | 26.37 | 25.11 | 32.28 | 74.43 | 295.94 | 1506.59 | 801.72 | 213.43 | 96.85 | 44.30 | 29.41 |
| 28.34 | 26.01 | 24.39 | 36.95 | 72.82 | 297.73 | 1312.88 | 887.81 | 234.96 | 95.60 | 43.76 | 29.41 |
| 28.70 | 27.08 | 24.57 | 40.18 | 76.58 | 312.08 | 972.11 | 868.08 | 263.65 | 91.29 | 43.22 | 29.23 |
| 28.52 | 27.62 | 24.57 | 46.09 | 87.17 | 328.22 | 855.53 | 878.84 | 272.62 | 89.50 | 42.69 | 29.06 |
| 28.34 | 28.52 | 25.11 | 46.45 | 99.18 | 351.54 | 780.20 | 900.36 | 317.46 | 82.68 | 42.15 | 29.41 |
| 27.62 | 28.34 | 24.93 | 45.91 | 98.65 | 425.07 | 712.04 | 886.02 | 344.36 | 78.20 | 41.07 | 29.23 |
| 27.44 | 27.44 | 23.50 | 46.09 | 106.90 | 541.65 | 785.58 | 932.65 | 312.08 | 76.58 | 40.53 | 28.70 |
| 27.26 | 27.08 | 23.85 | 46.99 | 109.41 | 660.03 | 1000.80 | 851.94 | 286.97 | 77.84 | 40.18 | 27.98 |
| 27.08 | 26.54 | 24.39 | 49.68 | 113.71 | 760.47 | 1067.16 | 701.28 | 231.37 | 77.84 | 39.64 | 27.80 |
| 27.44 | 25.65 | 25.47 | 45.02 | 123.76 | 920.09 | 1151.46 | 679.76 | 178.64 | 78.56 | 39.10 | 27.26 |
| 27.44 | 25.11 | 25.65 | 40.35 | 156.04 | 1051.02 | 1251.90 | 613.40 | 172.36 | 77.84 | 38.74 | 27.08 |
| 27.44 | 24.75 | 26.19 | 39.46 | 162.32 | 1083.31 | 997.22 | 523.72 | 182.94 | 74.43 | 38.38 | 26.90 |
| 27.26 | 24.57 | 26.37 | 42.87 | 174.87 | 1101.24 | 778.40 | 532.69 | 195.50 | 70.13 | 38.74 | 26.37 |
| 27.08 | 24.57 | 26.72 | 48.25 | 202.67 | 1147.87 | 771.23 | 616.98 | 202.67 | 69.05 | 38.20 | 26.37 |
| 27.08 | | 26.54 | 53.99 | 233.16 | 1174.78 | 866.29 | 672.58 | 225.99 | 67.26 | 38.02 | 26.37 |
| 27.08 | | 26.54 | 52.73 | 254.68 | 1273.42 | 923.68 | 672.58 | 227.78 | 66.00 | 37.49 | 26.19 |
| 26.90 | | 26.54 | | 249.30 | | 810.69 | 674.38 | | 65.29 | | 26.19 |
| **28.50** | **26.85** | **25.13** | **38.24** | **106.82** | **512.90** | **1131.15** | **821.85** | **293.11** | **102.29** | **47.04** | **29.71** |



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| 1978 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 26.37 | 23.14 | 25.11 | 20.81 | 46.99 | 215.23 | 1483.27 | 1101.24 | 426.87 | 251.10 | 61.88 | 30.49 |
| 26.37 | 23.32 | 25.11 | 19.91 | 53.09 | 233.16 | 1542.46 | 1172.98 | 412.52 | 233.16 | 59.90 | 30.31 |
| 26.37 | 23.32 | 25.11 | 19.01 | 81.07 | 242.13 | 1526.31 | 1311.09 | 423.28 | 206.26 | 58.47 | 30.13 |
| 26.19 | 23.32 | 25.47 | 18.83 | 99.54 | 265.45 | 1492.24 | 1225.00 | 405.34 | 178.10 | 55.96 | 29.95 |
| 26.01 | 23.32 | 25.47 | 18.11 | 104.56 | 338.98 | 1494.03 | 1176.57 | 342.57 | 153.71 | 54.17 | 29.95 |
| 26.01 | 23.32 | 25.47 | 17.94 | 99.54 | 387.41 | 1549.63 | 1277.01 | 321.05 | 136.85 | 52.73 | 30.31 |
| 26.01 | 23.32 | 25.47 | 18.29 | 103.13 | 444.80 | 1400.77 | 1287.77 | 337.19 | 118.55 | 50.58 | 30.13 |
| 25.83 | 23.32 | 25.11 | 17.94 | 103.13 | 487.85 | 1434.84 | 1314.68 | 342.57 | 112.28 | 48.78 | 29.95 |
| 25.47 | 23.50 | 24.93 | 18.11 | 114.25 | 529.10 | 1208.86 | 1363.10 | 342.57 | 110.30 | 47.17 | 30.13 |
| 25.47 | 23.67 | 24.93 | 18.65 | 125.37 | 374.85 | 1042.06 | 1452.78 | 446.60 | 106.36 | 46.09 | 29.95 |
| 25.47 | 24.21 | 24.75 | 21.52 | 126.80 | 358.71 | 1047.44 | 1311.09 | 460.94 | 104.92 | 44.48 | 28.52 |
| 25.47 | 25.47 | 24.93 | 20.09 | 112.81 | 351.54 | 918.30 | 1198.09 | 428.66 | 104.92 | 42.33 | 28.34 |
| 25.47 | 24.93 | 24.75 | 22.42 | 109.77 | 380.23 | 964.93 | 963.14 | 469.91 | 104.56 | 43.22 | 28.34 |
| 25.47 | 24.75 | 24.93 | 26.01 | 114.25 | 443.01 | 990.04 | 952.38 | 457.36 | 104.56 | 42.69 | 28.52 |
| 25.11 | 24.57 | 25.11 | 33.54 | 122.14 | 441.21 | 1086.89 | 930.85 | 443.01 | 104.56 | 41.79 | 28.34 |
| 24.93 | 24.57 | 25.29 | 42.87 | 128.96 | 419.69 | 1095.86 | 966.73 | 313.87 | 103.13 | 41.07 | 28.34 |
| 24.93 | 24.57 | 25.47 | 53.99 | 133.62 | 414.31 | 1113.80 | 1022.33 | 270.83 | 100.98 | 40.53 | 28.16 |
| 24.57 | 24.93 | 24.93 | 42.33 | 146.35 | 407.14 | 1140.70 | 1323.64 | 258.27 | 100.08 | 40.18 | 28.34 |
| 24.57 | 25.11 | 24.75 | 37.13 | 160.52 | 478.88 | 1237.55 | 1183.75 | 249.30 | 96.85 | 39.82 | 27.98 |
| 24.03 | 25.29 | 23.14 | 36.23 | 153.71 | 538.07 | 1303.91 | 1155.05 | 242.13 | 88.60 | 39.46 | 27.98 |
| 23.67 | 24.93 | 22.96 | 34.79 | 155.50 | 611.60 | 1355.93 | 1052.82 | 249.30 | 84.12 | 38.74 | 27.80 |
| 23.50 | 24.93 | 20.81 | 33.72 | 167.34 | 742.53 | 1303.91 | 972.11 | 249.30 | 81.97 | 38.20 | 27.62 |
| 23.50 | 24.75 | 20.63 | 29.95 | 213.43 | 717.42 | 1164.02 | 963.14 | 245.72 | 79.63 | 37.13 | 27.44 |
| 23.32 | 24.93 | 20.81 | 29.95 | 233.16 | 894.98 | 1086.89 | 862.70 | 254.68 | 77.84 | 35.51 | 27.08 |
| 23.14 | 24.93 | 20.63 | 33.90 | 256.48 | 923.68 | 1022.33 | 900.36 | 260.07 | 75.51 | 34.62 | 27.08 |
| 23.32 | 24.93 | 21.34 | 38.02 | 191.91 | 1092.27 | 979.28 | 882.43 | 260.07 | 74.07 | 34.26 | 27.08 |
| 23.14 | 25.47 | 22.06 | 39.82 | 169.31 | 1077.93 | 959.55 | 893.19 | 263.65 | 72.46 | 33.72 | 27.08 |
| 22.96 | 25.29 | 22.60 | 41.79 | 163.03 | 1316.47 | 932.65 | 936.24 | 263.65 | 70.49 | 33.54 | 27.08 |
| 23.14 | | 22.78 | 43.22 | 179.36 | 1443.81 | 927.27 | 934.44 | 263.65 | 69.05 | 33.00 | 26.90 |
| 23.14 | | 22.42 | 44.84 | 197.29 | 1472.51 | 896.78 | 710.25 | 258.27 | 67.98 | 32.82 | 27.08 |
| 23.14 | | 22.96 | | 193.70 | | 1004.39 | 523.72 | | 63.85 | | 26.90 |
| **24.71** | **24.36** | **23.88** | **29.79** | **140.65** | **601.50** | **1184.09** | **1074.86** | **332.11** | **110.86** | **43.43** | **28.49** |



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|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 37.31 | 33.54 | 30.31 | 32.64 | 88.24 | 69.41 | 823.24 | 1156.84 | 358.71 | 134.16 | 79.10 | 41.61 |
| 37.49 | 33.36 | 31.03 | 33.36 | 89.86 | 68.51 | 704.87 | 1398.97 | 392.79 | 134.16 | 78.56 | 41.79 |
| 37.31 | 33.18 | 30.85 | 33.72 | 93.26 | 74.25 | 640.30 | 1477.89 | 414.31 | 129.67 | 77.84 | 40.89 |
| 37.13 | 33.18 | 31.39 | 33.72 | 96.85 | 82.14 | 634.92 | 1492.24 | 419.69 | 130.93 | 77.84 | 40.71 |
| 36.95 | 32.82 | 31.21 | 33.72 | 100.80 | 103.13 | 683.34 | 1289.57 | 310.28 | 129.67 | 77.48 | 39.82 |
| 36.59 | 32.64 | 31.21 | 33.54 | 88.78 | 126.09 | 783.78 | 1108.42 | 317.46 | 128.78 | 76.58 | 39.10 |
| 36.59 | 32.46 | 30.85 | 33.18 | 83.94 | 143.30 | 912.92 | 1225.00 | 333.60 | 121.06 | 75.33 | 38.38 |
| 36.23 | 32.46 | 30.85 | 33.72 | 79.10 | 186.53 | 1162.22 | 1280.60 | 365.89 | 118.91 | 73.72 | 37.31 |
| 36.05 | 32.46 | 30.85 | 34.62 | 77.48 | 211.64 | 1339.79 | 1314.68 | 356.92 | 117.12 | 66.90 | 37.49 |
| 35.87 | 32.10 | 30.13 | 35.33 | 78.56 | 245.72 | 1443.81 | 1110.21 | 367.68 | 121.06 | 59.55 | 37.49 |
| 35.69 | 31.93 | 29.41 | 36.59 | 79.81 | 288.76 | 1442.02 | 968.52 | 364.09 | 124.65 | 54.70 | 37.49 |
| 35.69 | 31.75 | 28.88 | 39.82 | 82.14 | 319.25 | 1424.08 | 1004.39 | 385.61 | 122.50 | 53.45 | 37.31 |
| 35.51 | 31.75 | 28.52 | 45.20 | 74.25 | 286.97 | 1562.19 | 855.53 | 365.89 | 118.37 | 51.83 | 36.95 |
| 35.33 | 31.57 | 28.16 | 47.89 | 67.80 | 243.92 | 1442.02 | 821.45 | 364.09 | 118.02 | 52.01 | 36.95 |
| 35.33 | 31.39 | 27.98 | 46.27 | 65.46 | 234.96 | 1248.31 | 878.84 | 358.71 | 114.79 | 51.65 | 36.95 |
| 35.15 | 31.21 | 29.23 | 47.17 | 62.24 | 234.96 | 1223.20 | 1110.21 | 355.12 | 111.74 | 51.48 | 36.95 |
| 34.97 | 31.21 | 30.31 | 45.74 | 62.60 | 267.24 | 1352.34 | 1117.38 | 290.56 | 106.72 | 51.48 | 36.95 |
| 34.79 | 30.85 | 30.13 | 47.17 | 66.18 | 304.90 | 1298.53 | 1164.02 | 233.16 | 100.44 | 50.76 | 36.95 |
| 34.62 | 30.85 | 30.31 | 66.90 | 74.07 | 346.16 | 1189.13 | 1320.06 | 213.43 | 98.47 | 49.86 | 36.95 |
| 34.44 | 30.85 | 30.13 | 59.37 | 80.53 | 419.69 | 1332.61 | 1361.31 | 204.47 | 95.24 | 48.96 | 37.13 |
| 34.26 | 30.67 | 30.31 | 51.48 | 76.58 | 477.09 | 1529.90 | 1049.23 | 184.74 | 93.26 | 48.25 | 37.31 |
| 34.08 | 30.31 | 30.49 | 51.65 | 71.92 | 527.30 | 1443.81 | 832.21 | 178.46 | 90.22 | 46.81 | 37.31 |
| 33.90 | 30.31 | 31.21 | 51.83 | 73.36 | 611.60 | 1268.04 | 608.01 | 175.05 | 87.88 | 45.38 | 37.49 |
| 33.72 | 30.67 | 31.39 | 55.96 | 82.14 | 652.85 | 1045.64 | 498.61 | 175.59 | 85.73 | 43.58 | 37.84 |
| 33.72 | 30.49 | 32.28 | 64.93 | 85.01 | 681.55 | 821.45 | 383.82 | 169.85 | 86.09 | 43.05 | 37.31 |
| 33.54 | 30.31 | 31.75 | 75.33 | 81.61 | 746.12 | 744.33 | 330.01 | 146.35 | 85.73 | 42.69 | 37.13 |
| 33.36 | 30.31 | 30.67 | 82.14 | 79.10 | 826.83 | 794.54 | 328.22 | 144.20 | 84.66 | 42.15 | 36.77 |
| 33.18 | 29.95 | 30.31 | 85.73 | 81.25 | 959.55 | 842.97 | 351.54 | 133.80 | 84.66 | 41.79 | 36.91 |
| 33.54 | | 30.31 | 94.52 | 74.97 | 1092.27 | 828.62 | 322.84 | 130.93 | 82.50 | 41.61 | 36.41 |
| 33.36 | | 31.57 | 102.05 | 72.10 | 905.74 | 853.73 | 335.39 | 133.26 | 82.14 | 41.61 | 36.23 |
| 33.18 | | 32.10 | | 70.67 | | 934.44 | 337.19 | | 80.89 | | 36.05 |
| **35.12** | **31.59** | **30.46** | **51.18** | **78.73** | **391.28** | **1088.75** | **930.10** | **278.16** | **107.10** | **56.53** | **37.80** |



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|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 37.66 | 32.64 | 30.49 | 38.20 | 58.65 | 247.51 | 491.43 | 778.40 | 654.65 | 166.62 | 66.36 | 40.53 |
| 37.31 | 32.46 | 32.10 | 38.20 | 67.08 | 272.62 | 509.37 | 790.96 | 527.30 | 162.85 | 65.82 | 40.00 |
| 37.13 | 32.28 | 32.82 | 37.66 | 80.35 | 217.02 | 534.48 | 903.95 | 455.56 | 149.94 | 63.13 | 39.82 |
| 36.77 | 32.10 | 33.18 | 37.13 | 89.68 | 209.85 | 647.47 | 1007.98 | 398.17 | 147.79 | 60.44 | 39.82 |
| 36.59 | 32.10 | 33.54 | 36.59 | 101.52 | 213.43 | 722.80 | 984.66 | 344.36 | 146.17 | 58.29 | 39.28 |
| 36.59 | 31.93 | 33.72 | 37.13 | 109.05 | 231.37 | 631.33 | 1011.56 | 299.52 | 148.33 | 57.21 | 38.92 |
| 36.23 | 31.93 | 33.90 | 37.66 | 117.66 | 274.41 | 566.76 | 977.49 | 260.07 | 155.86 | 56.14 | 38.92 |
| 37.13 | 31.75 | 33.90 | 38.20 | 123.04 | 294.14 | 566.76 | 943.41 | 292.35 | 164.47 | 52.19 | 38.74 |
| 37.31 | 31.75 | 34.44 | 38.20 | 122.50 | 317.46 | 674.38 | 948.79 | 338.98 | 152.63 | 50.76 | 38.38 |
| 37.13 | 31.75 | 34.97 | 38.38 | 119.81 | 364.09 | 676.17 | 721.01 | 390.99 | 131.11 | 50.04 | 38.38 |
| 36.59 | 31.39 | 34.62 | 38.92 | 113.89 | 399.96 | 737.15 | 491.43 | 428.66 | 128.42 | 49.50 | 38.20 |
| 36.23 | 31.39 | 35.15 | 38.92 | 124.11 | 439.42 | 790.96 | 383.82 | 414.31 | 112.81 | 48.96 | 37.84 |
| 36.05 | 31.21 | 35.15 | 39.28 | 122.50 | 455.56 | 758.67 | 306.70 | 353.33 | 101.87 | 48.61 | 37.84 |
| 35.69 | 31.21 | 35.69 | 39.46 | 108.51 | 369.47 | 751.50 | 396.38 | 306.70 | 92.55 | 48.07 | 37.31 |
| 35.69 | 31.03 | 35.69 | 43.05 | 90.75 | 321.05 | 729.98 | 437.63 | 249.30 | 91.47 | 47.53 | 36.77 |
| 35.51 | 31.03 | 36.05 | 43.76 | 93.26 | 317.46 | 764.05 | 417.90 | 270.83 | 90.75 | 47.35 | 36.59 |
| 35.51 | 30.85 | 36.05 | 50.58 | 99.72 | 324.63 | 776.61 | 374.85 | 234.96 | 90.04 | 47.35 | 36.05 |
| 35.15 | 30.85 | 36.23 | 54.88 | 94.34 | 503.99 | 873.46 | 398.17 | 218.81 | 89.32 | 46.81 | 35.15 |
| 35.15 | 30.67 | 36.59 | 61.88 | 100.08 | 487.85 | 961.35 | 351.54 | 213.43 | 87.53 | 46.45 | 34.62 |
| 35.15 | 30.67 | 37.84 | 63.49 | 103.31 | 484.26 | 713.83 | 342.57 | 202.67 | 87.17 | 45.91 | 34.44 |
| 34.97 | 30.49 | 37.84 | 58.11 | 98.29 | 502.20 | 661.82 | 335.39 | 188.32 | 85.37 | 45.38 | 33.90 |
| 34.62 | 30.49 | 38.38 | 54.34 | 102.59 | 561.38 | 660.03 | 355.12 | 182.94 | 82.86 | 45.20 | 33.72 |
| 34.08 | 30.49 | 38.38 | 51.65 | 105.82 | 613.40 | 712.04 | 371.27 | 195.50 | 81.07 | 44.12 | 33.36 |
| 33.72 | 30.49 | 38.38 | 50.58 | 121.42 | 774.82 | 740.74 | 428.66 | 195.50 | 77.84 | 43.58 | 33.36 |
| 33.54 | 30.31 | 37.84 | 52.73 | 131.65 | 658.23 | 812.48 | 487.85 | 195.50 | 74.61 | 43.05 | 33.36 |
| 33.54 | 30.13 | 37.66 | 57.21 | 133.26 | 670.79 | 837.59 | 545.24 | 190.12 | 76.76 | 42.15 | 33.54 |
| 33.36 | 30.31 | 36.23 | 58.29 | 154.25 | 679.76 | 844.76 | 606.22 | 181.15 | 76.05 | 41.61 | 33.90 |
| 33.18 | 30.31 | 34.62 | 57.21 | 181.15 | 600.84 | 877.05 | 665.41 | 190.12 | 76.41 | 41.43 | 33.90 |
| 33.00 | | 35.51 | 59.73 | 188.32 | 503.99 | 871.67 | 658.23 | 176.31 | 76.05 | 41.07 | 33.72 |
| 32.82 | | 37.13 | 58.29 | 208.05 | 495.02 | 850.14 | 649.27 | 178.46 | 73.54 | 40.89 | 33.72 |
| 32.64 | | 37.66 | | 231.37 | | 807.10 | 677.96 | | 67.44 | | 33.54 |
| **35.36** | **31.21** | **35.54** | **46.99** | **119.23** | **426.87** | **727.55** | **604.83** | **290.96** | **107.93** | **49.51** | **36.37** |



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| 1981 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 33.54 | 28.70 | 22.78 | 31.21 | 69.41 | 265.45 | 851.94 | 568.56 | 270.83 | 171.64 | 49.68 | 36.77 |
| 33.36 | 28.70 | 22.78 | 31.75 | 87.53 | 251.10 | 694.11 | 570.35 | 265.45 | 136.67 | 48.96 | 36.23 |
| 33.36 | 28.52 | 22.96 | 32.10 | 109.94 | 199.08 | 634.92 | 631.33 | 267.24 | 131.47 | 48.25 | 36.05 |
| 33.00 | 28.52 | 22.78 | 32.46 | 126.09 | 191.91 | 559.59 | 731.77 | 267.24 | 126.09 | 47.71 | 35.69 |
| 32.64 | 28.34 | 22.96 | 33.18 | 161.78 | 191.91 | 530.89 | 781.99 | 260.07 | 121.06 | 47.35 | 35.33 |
| 32.64 | 28.16 | 23.14 | 34.08 | 172.72 | 209.85 | 518.34 | 853.73 | 229.57 | 102.41 | 46.63 | 34.97 |
| 32.46 | 28.16 | 23.67 | 34.97 | 169.85 | 242.13 | 543.45 | 964.93 | 209.85 | 96.13 | 46.27 | 34.79 |
| 32.46 | 27.62 | 23.85 | 35.69 | 164.11 | 231.37 | 606.22 | 1043.85 | 190.12 | 93.26 | 45.74 | 34.44 |
| 32.28 | 27.44 | 23.67 | 35.69 | 175.05 | 209.85 | 651.06 | 1029.50 | 173.97 | 90.22 | 45.56 | 34.08 |
| 31.93 | 27.26 | 23.67 | 36.23 | 184.74 | 178.46 | 561.38 | 977.49 | 166.98 | 86.09 | 45.56 | 33.90 |
| 31.93 | 27.08 | 23.50 | 36.23 | 170.39 | 156.40 | 536.27 | 1031.29 | 158.91 | 89.86 | 45.38 | 33.72 |
| 31.75 | 26.72 | 23.50 | 36.59 | 171.11 | 128.78 | 575.73 | 1011.56 | 144.20 | 83.58 | 45.38 | 33.72 |
| 31.57 | 26.72 | 23.67 | 36.77 | 173.97 | 143.84 | 712.04 | 988.25 | 135.23 | 77.30 | 45.38 | 33.36 |
| 31.57 | 26.37 | 23.67 | 37.49 | 176.84 | 153.35 | 816.07 | 842.97 | 131.83 | 72.82 | 45.20 | 33.18 |
| 31.21 | 26.54 | 23.67 | 37.84 | 174.51 | 178.46 | 884.22 | 783.78 | 140.79 | 72.82 | 47.53 | 32.82 |
| 31.21 | 26.37 | 23.85 | 38.92 | 175.59 | 197.29 | 936.24 | 656.44 | 143.84 | 71.92 | 42.69 | 32.28 |
| 31.03 | 25.65 | 23.85 | 39.64 | 182.94 | 217.02 | 1025.91 | 505.78 | 163.03 | 71.20 | 41.79 | 31.75 |
| 30.85 | 24.93 | 23.67 | 40.35 | 217.02 | 265.45 | 1040.26 | 464.53 | 184.74 | 68.51 | 41.61 | 31.75 |
| 30.85 | 24.39 | 23.67 | 41.61 | 229.57 | 295.94 | 907.54 | 516.54 | 186.53 | 63.31 | 41.25 | 31.57 |
| 30.49 | 24.21 | 24.57 | 42.51 | 229.57 | 308.49 | 907.54 | 564.97 | 191.91 | 62.06 | 40.89 | 31.21 |
| 30.31 | 24.03 | 24.93 | 62.06 | 218.81 | 330.01 | 993.63 | 609.81 | 195.50 | 60.98 | 40.71 | 31.21 |
| 30.31 | 23.67 | 24.93 | 47.89 | 162.50 | 322.84 | 1040.26 | 489.64 | 213.43 | 58.83 | 40.35 | 30.85 |
| 30.13 | 23.50 | 24.93 | 45.38 | 171.46 | 333.60 | 991.84 | 342.57 | 208.05 | 57.04 | 40.00 | 30.67 |
| 29.95 | 23.32 | 25.29 | 45.02 | 200.88 | 401.76 | 943.41 | 312.08 | 208.05 | 55.78 | 39.64 | 30.67 |
| 29.95 | 22.96 | 25.83 | 45.02 | 233.16 | 478.88 | 900.36 | 313.87 | 204.47 | 54.88 | 38.92 | 30.49 |
| 29.77 | 22.78 | 26.19 | 48.25 | 335.39 | 512.96 | 798.13 | 346.16 | 179.36 | 53.99 | 38.20 | 30.31 |
| 29.59 | 22.60 | 26.19 | 48.25 | 321.05 | 559.59 | 753.29 | 398.17 | 172.18 | 52.55 | 37.66 | 30.13 |
| 29.59 | 22.60 | 27.08 | 57.75 | 346.16 | 665.41 | 884.22 | 378.44 | 176.13 | 52.37 | 37.49 | 29.95 |
| 29.41 | | 27.62 | 60.62 | 321.05 | 753.29 | 932.65 | 364.09 | 176.84 | 51.83 | 37.13 | 29.77 |
| 29.06 | | 29.06 | 64.21 | 347.95 | 825.03 | 835.80 | 326.43 | 179.00 | 51.12 | 36.77 | 29.59 |
| 29.06 | | 30.85 | | 356.92 | | 715.63 | 285.18 | | 50.58 | | 29.23 |
| **31.20** | **25.92** | **24.61** | **41.66** | **204.45** | **313.32** | **783.32** | **635.03** | **193.18** | **80.27** | **43.19** | **32.60** |



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| 1982 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 30.49 | 27.08 | 27.08 | 20.81 | 49.86 | 163.03 | 421.49 | 1024.12 | 181.15 | 64.75 | 46.63 | 36.41 |
| 30.31 | 27.08 | 27.80 | 19.73 | 61.16 | 146.71 | 416.10 | 1047.44 | 186.53 | 64.21 | 46.27 | 36.05 |
| 30.31 | 27.08 | 28.16 | 19.37 | 77.84 | 152.81 | 403.55 | 1042.06 | 195.50 | 63.31 | 45.74 | 35.87 |
| 30.13 | 27.08 | 28.34 | 19.01 | 89.14 | 165.90 | 362.30 | 1043.85 | 224.19 | 64.21 | 45.38 | 35.69 |
| 30.13 | 27.08 | 28.34 | 18.29 | 104.74 | 182.94 | 360.50 | 1047.44 | 243.92 | 65.46 | 44.84 | 35.51 |
| 29.95 | 27.08 | 28.34 | 18.11 | 116.58 | 215.23 | 342.57 | 1033.09 | 265.45 | 66.90 | 43.94 | 35.51 |
| 29.95 | 27.26 | 28.70 | 17.22 | 124.65 | 252.89 | 326.43 | 1043.85 | 261.86 | 65.82 | 43.05 | 35.51 |
| 29.59 | 27.44 | 28.70 | 17.85 | 150.84 | 294.14 | 288.76 | 997.22 | 247.51 | 64.57 | 42.69 | 35.33 |
| 29.59 | 27.62 | 28.70 | 24.39 | 166.44 | 319.25 | 288.76 | 997.22 | 225.99 | 63.67 | 41.97 | 35.33 |
| 29.59 | 27.80 | 28.70 | 28.34 | 178.46 | 360.50 | 330.01 | 1000.80 | 215.23 | 62.77 | 41.25 | 35.33 |
| 29.41 | 27.44 | 28.88 | 29.41 | 132.36 | 410.72 | 324.63 | 972.11 | 199.08 | 62.06 | 40.35 | 35.33 |
| 29.23 | 27.44 | 29.06 | 31.21 | 125.19 | 414.31 | 335.39 | 984.66 | 173.26 | 61.52 | 39.82 | 35.33 |
| 29.23 | 27.44 | 29.06 | 32.46 | 107.08 | 421.49 | 347.95 | 887.81 | 172.72 | 60.98 | 39.46 | 35.15 |
| 29.06 | 27.44 | 29.06 | 40.35 | 98.11 | 446.60 | 322.84 | 816.07 | 175.59 | 60.08 | 38.92 | 35.15 |
| 29.06 | 27.08 | 27.08 | 45.02 | 92.91 | 446.60 | 308.49 | 798.13 | 172.72 | 59.19 | 38.56 | 36.05 |
| 28.88 | 27.26 | 25.83 | 43.05 | 88.24 | 401.76 | 321.05 | 799.93 | 173.97 | 57.75 | 38.38 | 35.33 |
| 28.88 | 27.08 | 24.57 | 40.71 | 86.45 | 380.23 | 358.71 | 801.72 | 159.63 | 57.39 | 38.38 | 35.33 |
| 28.70 | 26.90 | 22.78 | 40.35 | 85.37 | 299.52 | 405.34 | 602.63 | 141.69 | 57.04 | 38.20 | 35.33 |
| 28.52 | 26.72 | 22.06 | 38.56 | 84.30 | 276.21 | 425.07 | 538.07 | 132.72 | 56.50 | 38.02 | 35.15 |
| 28.34 | 26.72 | 21.52 | 40.35 | 93.80 | 240.34 | 459.15 | 550.62 | 121.96 | 55.60 | 37.84 | 35.33 |
| 28.34 | 26.54 | 21.34 | 43.05 | 102.77 | 270.83 | 511.16 | 495.02 | 112.99 | 54.70 | 37.84 | 35.69 |
| 28.34 | 26.54 | 21.34 | 46.63 | 124.29 | 283.38 | 561.38 | 410.72 | 104.03 | 53.81 | 37.66 | 35.87 |
| 27.80 | 26.37 | 21.16 | 55.06 | 159.63 | 274.41 | 649.27 | 387.41 | 93.26 | 52.91 | 37.49 | 35.69 |
| 27.80 | 26.37 | 21.16 | 63.67 | 186.53 | 269.03 | 744.33 | 407.14 | 84.30 | 52.01 | 37.49 | 35.69 |
| 27.44 | 26.19 | 20.81 | 66.90 | 208.05 | 276.21 | 789.16 | 306.70 | 81.97 | 51.12 | 37.31 | 35.33 |
| 27.44 | 26.19 | 20.81 | 69.41 | 233.16 | 297.73 | 719.22 | 281.59 | 76.23 | 50.22 | 37.13 | 35.33 |
| 27.44 | 26.19 | 21.16 | 67.80 | 247.51 | 330.01 | 735.36 | 229.57 | 71.92 | 49.86 | 36.95 | 35.15 |
| 27.44 | 26.19 | 21.16 | 64.39 | 227.78 | 351.54 | 765.85 | 208.05 | 69.41 | 49.32 | 36.95 | 34.79 |
| 27.26 | | 21.34 | 58.29 | 195.50 | 373.06 | 844.76 | 191.91 | 66.36 | 48.78 | 36.77 | 34.44 |
| 27.26 | | 21.16 | 53.63 | 193.70 | 401.76 | 961.35 | 182.94 | 65.29 | 48.07 | 36.59 | 34.08 |
| 27.08 | | 21.16 | | 181.15 | | 1000.80 | 175.59 | | 47.53 | | 34.08 |
| **28.81** | **26.95** | **25.01** | **39.11** | **134.63** | **303.97** | **497.80** | **687.27** | **156.55** | **57.81** | **40.06** | **35.36** |



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| 1983 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 33.90 | 30.85 | 26.90 | 21.34 | 46.45 | 190.12 | 620.57 | 952.38 | 859.11 | 129.14 | 53.63 | 33.00 |
| 33.90 | 30.67 | 26.72 | 20.81 | 45.20 | 157.47 | 651.06 | 975.69 | 860.91 | 123.76 | 53.09 | 32.28 |
| 33.90 | 30.85 | 26.54 | 21.16 | 44.48 | 143.84 | 679.76 | 1024.12 | 841.18 | 118.37 | 52.19 | 31.93 |
| 34.26 | 30.85 | 26.54 | 21.16 | 45.02 | 125.01 | 545.24 | 1052.82 | 816.07 | 114.79 | 51.65 | 31.21 |
| 33.90 | 30.67 | 26.37 | 21.16 | 45.91 | 133.26 | 529.10 | 1095.86 | 742.53 | 109.41 | 51.12 | 30.85 |
| 33.90 | 30.67 | 25.83 | 21.52 | 46.81 | 123.76 | 444.80 | 1049.23 | 708.45 | 105.82 | 50.58 | 30.31 |
| 33.72 | 30.67 | 25.65 | 21.88 | 49.50 | 142.95 | 355.12 | 1004.39 | 647.47 | 102.23 | 50.22 | 29.95 |
| 33.90 | 30.67 | 25.47 | 23.14 | 69.05 | 149.40 | 360.50 | 938.03 | 670.79 | 98.65 | 50.04 | 29.23 |
| 33.72 | 30.67 | 25.47 | 24.75 | 77.66 | 149.94 | 344.36 | 902.16 | 676.17 | 95.06 | 49.50 | 29.06 |
| 33.90 | 30.31 | 25.29 | 26.54 | 99.36 | 152.27 | 344.36 | 808.89 | 701.28 | 92.37 | 49.32 | 28.70 |
| 33.72 | 30.13 | 24.93 | 27.08 | 102.59 | 163.03 | 360.50 | 746.12 | 597.25 | 89.68 | 48.96 | 28.52 |
| 33.72 | 30.13 | 24.57 | 27.44 | 92.01 | 178.82 | 360.50 | 717.42 | 627.74 | 86.99 | 48.78 | 27.98 |
| 33.90 | 30.13 | 24.39 | 27.08 | 101.87 | 204.47 | 333.60 | 665.41 | 600.84 | 84.30 | 48.43 | 27.62 |
| 33.72 | 30.13 | 24.21 | 26.90 | 115.86 | 252.89 | 344.36 | 624.16 | 480.67 | 81.61 | 48.07 | 27.08 |
| 33.72 | 29.95 | 23.67 | 26.54 | 138.64 | 278.00 | 349.74 | 645.68 | 396.38 | 79.81 | 47.17 | 26.72 |
| 33.18 | 29.77 | 23.50 | 26.37 | 166.80 | 292.35 | 369.47 | 679.76 | 331.81 | 78.02 | 46.27 | 26.37 |
| 33.00 | 29.59 | 23.32 | 25.83 | 179.36 | 292.35 | 360.50 | 751.50 | 308.49 | 75.33 | 44.66 | 26.01 |
| 32.82 | 29.06 | 23.14 | 25.65 | 206.26 | 265.45 | 380.23 | 808.89 | 278.00 | 73.54 | 44.30 | 25.83 |
| 32.46 | 28.88 | 23.14 | 25.29 | 233.16 | 238.54 | 468.12 | 862.70 | 252.89 | 71.74 | 42.51 | 25.65 |
| 32.28 | 28.88 | 22.78 | 24.93 | 243.92 | 218.81 | 507.58 | 859.11 | 234.96 | 69.95 | 40.53 | 25.47 |
| 32.28 | 28.70 | 22.60 | 25.65 | 188.32 | 224.19 | 554.21 | 848.35 | 224.19 | 69.05 | 38.38 | 25.29 |
| 31.93 | 28.52 | 22.24 | 26.37 | 174.51 | 251.10 | 660.03 | 816.07 | 206.26 | 67.26 | 37.66 | 24.93 |
| 31.75 | 28.16 | 21.88 | 26.90 | 142.41 | 313.87 | 828.62 | 801.72 | 190.12 | 66.36 | 37.13 | 24.75 |
| 31.39 | 27.98 | 21.88 | 29.95 | 131.47 | 347.95 | 724.60 | 862.70 | 178.82 | 64.57 | 37.13 | 26.54 |
| 31.21 | 27.80 | 21.70 | 35.15 | 146.17 | 369.47 | 900.36 | 921.89 | 165.72 | 62.77 | 36.41 | 26.37 |
| 31.03 | 27.62 | 21.52 | 48.25 | 130.75 | 426.87 | 808.89 | 841.18 | 157.83 | 60.98 | 36.23 | 26.01 |
| 30.85 | 27.08 | 21.34 | 52.73 | 175.05 | 432.25 | 638.51 | 855.53 | 152.81 | 59.19 | 35.51 | 25.65 |
| 30.85 | 27.08 | 21.16 | 51.12 | 182.94 | 462.74 | 767.64 | 742.53 | 145.28 | 58.47 | 34.97 | 25.47 |
| 31.03 | | 20.98 | 50.22 | 178.28 | 539.86 | 853.73 | 751.50 | 139.90 | 57.39 | 34.26 | 25.47 |
| 30.85 | | 22.60 | 48.25 | 166.80 | 584.70 | 981.07 | 787.37 | 134.52 | 55.42 | 33.36 | 24.93 |
| 30.67 | | 21.88 | | 169.67 | | 1016.95 | 830.42 | | 54.70 | | 24.93 |
| **32.75** | **29.52** | **23.81** | **29.37** | **126.98** | **260.19** | **562.71** | **845.92** | **444.28** | **82.47** | **44.40** | **27.55** |



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|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 25.29 | 24.75 | 22.96 | 25.83 | 36.41 | 119.27 | 658.23 | 950.58 | 825.03 | 87.88 | 54.52 | 39.64 |
| 25.29 | 24.75 | 22.96 | 25.29 | 36.41 | 144.02 | 695.90 | 923.68 | 747.91 | 85.19 | 54.88 | 39.28 |
| 25.29 | 24.75 | 22.96 | 25.11 | 36.77 | 197.29 | 676.17 | 948.79 | 663.62 | 83.40 | 52.01 | 38.92 |
| 25.47 | 24.57 | 22.96 | 24.75 | 37.66 | 236.75 | 570.35 | 1006.18 | 541.65 | 81.61 | 52.37 | 38.56 |
| 25.47 | 24.57 | 22.78 | 24.39 | 38.74 | 245.72 | 573.94 | 1045.64 | 561.38 | 78.92 | 52.01 | 39.10 |
| 25.65 | 24.57 | 22.78 | 24.21 | 36.59 | 267.24 | 602.63 | 991.84 | 566.76 | 77.12 | 52.55 | 37.84 |
| 25.83 | 24.57 | 22.60 | 24.21 | 42.33 | 249.30 | 618.78 | 981.07 | 403.55 | 74.43 | 51.30 | 37.31 |
| 26.01 | 24.39 | 22.60 | 23.50 | 51.48 | 249.30 | 609.81 | 1016.95 | 274.41 | 71.74 | 50.58 | 36.95 |
| 26.01 | 24.39 | 22.60 | 22.06 | 48.96 | 278.00 | 570.35 | 1070.75 | 238.54 | 69.59 | 49.86 | 36.59 |
| 26.37 | 24.21 | 22.42 | 20.98 | 46.81 | 297.73 | 500.40 | 1056.40 | 208.05 | 71.02 | 49.50 | 36.23 |
| 26.54 | 24.21 | 22.42 | 20.45 | 46.45 | 267.24 | 525.51 | 1052.82 | 204.47 | 68.33 | 48.78 | 35.87 |
| 26.72 | 24.21 | 22.60 | 20.63 | 51.30 | 252.89 | 568.56 | 1051.02 | 200.88 | 66.00 | 48.61 | 34.79 |
| 26.72 | 24.21 | 22.60 | 20.98 | 56.68 | 265.45 | 597.25 | 1040.26 | 199.08 | 65.11 | 47.71 | 34.08 |
| 26.90 | 24.03 | 22.78 | 21.34 | 49.32 | 295.94 | 582.91 | 1000.80 | 197.29 | 63.85 | 47.53 | 33.72 |
| 26.72 | 24.03 | 23.32 | 22.60 | 51.48 | 326.43 | 547.03 | 966.73 | 215.23 | 63.31 | 46.81 | 33.36 |
| 26.72 | 24.03 | 23.50 | 22.96 | 41.61 | 416.10 | 713.83 | 921.89 | 199.08 | 62.95 | 46.45 | 32.82 |
| 26.54 | 24.03 | 23.67 | 23.14 | 36.59 | 457.36 | 751.50 | 1043.85 | 217.02 | 62.77 | 46.09 | 32.46 |
| 26.37 | 23.85 | 23.50 | 23.67 | 38.56 | 423.28 | 841.18 | 991.84 | 215.23 | 61.70 | 45.74 | 32.28 |
| 26.19 | 23.85 | 23.14 | 24.21 | 40.18 | 408.93 | 875.25 | 964.93 | 188.32 | 60.62 | 45.20 | 31.93 |
| 26.01 | 23.67 | 23.50 | 24.75 | 36.77 | 383.82 | 803.51 | 977.49 | 166.80 | 59.73 | 44.48 | 31.57 |
| 26.01 | 23.67 | 23.50 | 25.29 | 37.13 | 365.89 | 769.43 | 993.63 | 142.95 | 59.01 | 43.94 | 31.39 |
| 25.83 | 23.50 | 24.03 | 26.01 | 40.53 | 373.06 | 717.42 | 943.41 | 133.08 | 57.75 | 43.76 | 31.21 |
| 25.65 | 23.50 | 24.21 | 26.37 | 43.94 | 460.94 | 744.33 | 1004.39 | 114.79 | 57.21 | 42.69 | 31.03 |
| 25.47 | 23.50 | 24.21 | 29.06 | 43.22 | 552.41 | 760.47 | 1070.75 | 106.72 | 57.75 | 42.33 | 30.85 |
| 25.29 | 23.50 | 24.57 | 33.72 | 44.84 | 611.60 | 790.96 | 1045.64 | 100.80 | 57.75 | 41.79 | 30.49 |
| 25.29 | 23.32 | 25.11 | 40.18 | 53.99 | 690.52 | 857.32 | 1000.80 | 93.26 | 57.57 | 41.25 | 30.31 |
| 25.11 | 23.32 | 25.47 | 52.01 | 58.11 | 758.67 | 790.96 | 916.51 | 92.91 | 57.57 | 40.89 | 30.13 |
| 25.11 | 23.14 | 26.01 | 55.06 | 70.67 | 828.62 | 792.75 | 830.42 | 92.19 | 56.86 | 40.71 | 29.77 |
| 24.93 | | 26.01 | 50.76 | 61.70 | 758.67 | 787.37 | 780.20 | 91.11 | 56.68 | 40.35 | 29.59 |
| 24.75 | | 26.19 | 29.77 | 74.43 | 663.62 | 903.95 | 816.07 | 89.86 | 55.96 | 40.00 | 29.23 |
| 24.75 | | 26.01 | | 95.42 | | 993.63 | 825.03 | | 55.60 | | 29.06 |
| **25.82** | **24.04** | **23.67** | **27.78** | **47.91** | **394.87** | **702.96** | **975.17** | **269.73** | **65.97** | **46.82** | **33.75** |



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| 1985 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 29.06 | 26.54 | 24.03 | 24.75 | 52.73 | 133.08 | 412.52 | 1101.24 | 591.87 | 159.99 | 52.37 | 33.00 |
| 29.06 | 26.72 | 24.39 | 25.11 | 54.88 | 147.61 | 394.58 | 1085.10 | 568.56 | 163.75 | 51.30 | 33.18 |
| 29.23 | 26.90 | 24.75 | 25.29 | 37.31 | 149.22 | 394.58 | 911.13 | 536.27 | 166.80 | 50.04 | 33.00 |
| 29.23 | 27.26 | 25.29 | 25.83 | 36.77 | 164.29 | 421.49 | 799.93 | 559.59 | 188.32 | 48.78 | 33.00 |
| 29.41 | 27.26 | 25.47 | 26.01 | 37.66 | 182.94 | 516.54 | 764.05 | 586.49 | 190.12 | 47.53 | 33.36 |
| 29.41 | 26.72 | 26.01 | 28.70 | 38.38 | 224.19 | 622.36 | 690.52 | 444.80 | 158.01 | 46.27 | 33.36 |
| 29.59 | 26.01 | 26.01 | 29.59 | 49.32 | 218.81 | 729.98 | 640.30 | 353.33 | 149.58 | 45.02 | 33.72 |
| 29.59 | 25.29 | 26.37 | 29.95 | 52.01 | 225.99 | 764.05 | 652.85 | 328.22 | 139.72 | 44.30 | 33.18 |
| 29.59 | 24.93 | 26.37 | 30.31 | 57.21 | 234.96 | 729.98 | 645.68 | 315.67 | 129.32 | 43.05 | 33.00 |
| 29.23 | 25.29 | 26.54 | 29.59 | 59.90 | 265.45 | 683.34 | 708.45 | 269.03 | 118.73 | 42.51 | 32.46 |
| 28.88 | 25.65 | 26.54 | 28.88 | 62.77 | 267.24 | 699.49 | 731.77 | 240.34 | 107.08 | 41.97 | 32.10 |
| 28.70 | 25.47 | 26.72 | 28.16 | 69.23 | 265.45 | 776.61 | 785.58 | 240.34 | 99.36 | 41.25 | 31.39 |
| 28.16 | 25.65 | 26.72 | 28.16 | 57.57 | 258.27 | 882.43 | 785.58 | 243.92 | 94.88 | 41.07 | 32.28 |
| 28.16 | 25.47 | 26.72 | 29.23 | 52.73 | 272.62 | 905.74 | 794.54 | 245.72 | 86.09 | 40.53 | 33.00 |
| 27.62 | 25.47 | 26.90 | 31.03 | 59.01 | 278.00 | 914.71 | 794.54 | 247.51 | 83.76 | 40.00 | 33.00 |
| 27.44 | 25.29 | 27.26 | 29.95 | 65.82 | 286.97 | 936.24 | 755.09 | 254.68 | 79.63 | 39.28 | 33.18 |
| 27.44 | 25.29 | 27.08 | 31.39 | 57.21 | 292.35 | 927.27 | 789.16 | 265.45 | 71.74 | 38.74 | 32.82 |
| 27.08 | 25.11 | 26.54 | 30.85 | 61.52 | 295.94 | 930.85 | 828.62 | 272.62 | 66.72 | 38.74 | 32.46 |
| 26.90 | 24.93 | 25.65 | 29.59 | 65.46 | 292.35 | 832.21 | 896.78 | 267.24 | 65.11 | 38.02 | 31.57 |
| 26.54 | 24.75 | 25.29 | 28.34 | 69.59 | 306.70 | 733.56 | 853.73 | 254.68 | 64.21 | 37.84 | 31.21 |
| 26.19 | 24.75 | 24.93 | 28.88 | 76.76 | 303.11 | 740.74 | 764.05 | 258.27 | 62.42 | 37.31 | 30.85 |
| 26.01 | 24.57 | 24.75 | 34.97 | 93.26 | 297.73 | 801.72 | 649.27 | 274.41 | 61.52 | 36.77 | 30.49 |
| 25.47 | 24.57 | 24.57 | 36.77 | 112.10 | 299.52 | 866.29 | 642.09 | 283.38 | 61.52 | 36.23 | 30.13 |
| 25.29 | 24.39 | 24.57 | 38.56 | 127.88 | 294.14 | 943.41 | 683.34 | 261.86 | 60.62 | 35.69 | 29.77 |
| 24.75 | 24.39 | 24.21 | 39.82 | 121.06 | 297.73 | 977.49 | 728.18 | 238.54 | 59.73 | 35.33 | 29.77 |
| 25.11 | 24.21 | 24.21 | 43.05 | 112.46 | 306.70 | 1011.56 | 712.04 | 202.67 | 56.68 | 34.44 | 30.13 |
| 25.29 | 24.03 | 24.03 | 42.51 | 110.66 | 333.60 | 1024.12 | 581.11 | 184.74 | 55.06 | 33.36 | 29.77 |
| 25.83 | 24.57 | 23.85 | 48.96 | 107.08 | 351.54 | 988.25 | 496.81 | 174.15 | 54.88 | 33.00 | 29.59 |
| 26.01 | | 24.39 | 51.48 | 115.15 | 389.20 | 1029.50 | 564.97 | 160.52 | 53.99 | 32.82 | 29.41 |
| 26.19 | | 24.57 | 50.76 | 123.22 | 396.38 | 1070.75 | 611.60 | 155.86 | 54.34 | 32.64 | 29.23 |
| 26.19 | | 24.57 | | 130.39 | | 1085.10 | 599.05 | | 53.09 | | 29.23 |
| **27.51** | **25.41** | **25.46** | **32.88** | **75.07** | **267.74** | **798.31** | **743.46** | **309.36** | **97.31** | **40.54** | **31.70** |



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| 1986 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 28.52 | 26.01 | 24.93 | 22.60 | 32.64 | 100.80 | 464.53 | 1027.71 | 331.81 | 204.47 | 63.13 | 40.00 |
| 28.34 | 26.01 | 25.11 | 22.42 | 31.21 | 98.47 | 480.67 | 1061.78 | 344.36 | 199.08 | 63.13 | 39.10 |
| 28.16 | 25.83 | 24.93 | 22.24 | 30.85 | 101.69 | 557.80 | 1016.95 | 365.89 | 197.29 | 63.13 | 39.10 |
| 27.98 | 25.47 | 24.75 | 22.24 | 34.62 | 110.66 | 660.03 | 999.01 | 382.03 | 193.70 | 60.44 | 39.28 |
| 27.80 | 25.47 | 24.57 | 22.42 | 38.02 | 109.59 | 781.99 | 930.85 | 405.34 | 195.50 | 58.47 | 38.56 |
| 27.44 | 24.93 | 24.39 | 23.14 | 43.05 | 106.72 | 853.73 | 764.05 | 367.68 | 193.70 | 57.75 | 39.10 |
| 27.26 | 25.29 | 24.21 | 23.67 | 59.37 | 118.91 | 896.78 | 715.63 | 331.81 | 190.12 | 58.83 | 38.38 |
| 27.80 | 25.29 | 23.85 | 24.39 | 68.51 | 111.92 | 889.60 | 665.41 | 322.84 | 186.53 | 57.21 | 37.66 |
| 27.08 | 25.11 | 23.85 | 23.85 | 72.46 | 117.48 | 832.21 | 645.68 | 328.22 | 181.15 | 56.68 | 36.59 |
| 26.54 | 24.75 | 23.85 | 24.57 | 79.81 | 139.18 | 695.90 | 611.60 | 324.63 | 181.15 | 56.14 | 36.95 |
| 27.26 | 25.11 | 23.85 | 25.11 | 78.38 | 159.27 | 652.85 | 532.69 | 313.87 | 175.23 | 55.24 | 36.23 |
| 27.44 | 24.93 | 23.67 | 26.19 | 79.45 | 158.37 | 620.57 | 498.61 | 294.14 | 172.18 | 53.27 | 36.23 |
| 27.26 | 24.75 | 23.67 | 26.01 | 80.35 | 160.16 | 591.87 | 475.29 | 269.03 | 168.77 | 52.01 | 36.05 |
| 27.08 | 24.57 | 23.67 | 26.19 | 85.91 | 157.47 | 496.81 | 486.05 | 252.89 | 149.40 | 51.48 | 34.79 |
| 26.72 | 24.57 | 23.32 | 27.62 | 93.44 | 157.83 | 597.25 | 462.74 | 224.19 | 141.87 | 50.58 | 34.44 |
| 26.72 | 24.75 | 23.67 | 28.34 | 107.97 | 169.67 | 728.18 | 559.59 | 193.70 | 131.29 | 50.76 | 33.90 |
| 26.54 | 24.39 | 24.03 | 29.59 | 116.22 | 172.72 | 810.69 | 618.78 | 177.20 | 115.86 | 49.86 | 33.72 |
| 26.37 | 24.39 | 23.50 | 29.95 | 121.78 | 182.94 | 860.91 | 645.68 | 169.31 | 103.13 | 47.53 | 32.82 |
| 26.19 | 24.57 | 23.50 | 32.10 | 111.56 | 224.19 | 916.51 | 669.00 | 165.72 | 95.06 | 45.91 | 32.28 |
| 26.37 | 24.39 | 23.14 | 35.33 | 94.34 | 263.65 | 835.80 | 550.62 | 176.31 | 94.70 | 46.09 | 31.75 |
| 26.37 | 24.57 | 22.96 | 41.61 | 92.73 | 322.84 | 756.88 | 541.65 | 191.91 | 83.40 | 45.38 | 31.75 |
| 26.01 | 24.57 | 22.96 | 44.12 | 89.68 | 407.14 | 740.74 | 489.64 | 195.50 | 75.51 | 44.30 | 31.39 |
| 26.37 | 24.57 | 22.78 | 46.27 | 86.27 | 509.37 | 677.96 | 462.74 | 204.47 | 73.72 | 43.94 | 33.18 |
| 26.37 | 24.39 | 22.60 | 44.48 | 82.86 | 613.40 | 620.57 | 455.56 | 208.05 | 71.92 | 42.87 | 32.10 |
| 26.37 | 24.21 | 22.60 | 45.56 | 81.07 | 616.98 | 627.74 | 469.91 | 215.23 | 69.41 | 43.05 | 31.75 |
| 26.19 | 24.21 | 22.42 | 46.81 | 98.11 | 591.87 | 713.83 | 462.74 | 218.81 | 67.62 | 42.51 | 31.57 |
| 26.19 | 24.21 | 22.60 | 44.66 | 95.42 | 530.89 | 792.75 | 428.66 | 217.02 | 65.46 | 41.97 | 31.21 |
| 25.83 | 25.29 | 22.60 | 41.79 | 99.72 | 491.43 | 828.62 | 364.09 | 213.43 | 66.18 | 41.07 | 30.85 |
| 26.01 | | 22.60 | 38.20 | 102.77 | 482.47 | 853.73 | 328.22 | 208.05 | 65.82 | 40.89 | 30.85 |
| 26.19 | | 22.60 | 34.62 | 103.13 | 471.70 | 902.16 | 319.25 | 199.08 | 64.93 | 40.35 | 30.67 |
| 26.37 | | 22.60 | | 100.44 | | 950.58 | 322.84 | | 64.57 | | 30.49 |
| **26.87** | **24.88** | **23.54** | **31.54** | **80.39** | **265.33** | **731.94** | **599.45** | **260.42** | **130.28** | **50.80** | **34.60** |



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|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 30.49 | 27.08 | 24.75 | 23.85 | 38.20 | 204.47 | 286.97 | 306.70 | 647.47 | 151.20 | 52.73 | 41.43 |
| 30.85 | 26.90 | 24.75 | 24.21 | 35.51 | 220.61 | 283.38 | 283.38 | 645.68 | 153.35 | 52.01 | 41.61 |
| 30.67 | 26.54 | 24.75 | 25.29 | 35.15 | 240.34 | 297.73 | 274.41 | 547.03 | 150.66 | 50.58 | 41.61 |
| 29.95 | 26.54 | 24.75 | 25.47 | 36.77 | 224.19 | 338.98 | 218.81 | 509.37 | 139.90 | 50.22 | 41.25 |
| 29.95 | 26.90 | 24.57 | 24.93 | 41.25 | 225.99 | 383.82 | 209.85 | 559.59 | 134.70 | 50.04 | 41.07 |
| 29.77 | 26.90 | 24.57 | 25.11 | 42.87 | 249.30 | 423.28 | 217.02 | 636.71 | 133.62 | 50.04 | 40.35 |
| 29.59 | 26.90 | 24.57 | 26.37 | 46.81 | 312.08 | 425.07 | 261.86 | 652.85 | 130.03 | 49.32 | 40.00 |
| 29.59 | 26.90 | 24.57 | 26.01 | 45.38 | 367.68 | 410.72 | 304.90 | 640.30 | 131.65 | 49.32 | 40.00 |
| 29.06 | 26.90 | 24.57 | 26.37 | 44.48 | 335.39 | 410.72 | 390.99 | 538.07 | 135.59 | 49.32 | 40.18 |
| 29.23 | 29.23 | 24.57 | 26.54 | 43.40 | 310.28 | 414.31 | 358.71 | 399.96 | 137.57 | 49.14 | 40.18 |
| 28.88 | 28.34 | 24.57 | 25.11 | 41.97 | 245.72 | 417.90 | 383.82 | 362.30 | 150.66 | 49.32 | 40.53 |
| 28.88 | 28.16 | 24.57 | 24.93 | 43.05 | 222.40 | 428.66 | 401.76 | 299.52 | 140.26 | 49.14 | 40.35 |
| 28.88 | 27.80 | 24.39 | 24.57 | 49.32 | 211.64 | 353.33 | 425.07 | 285.18 | 133.98 | 48.96 | 39.64 |
| 29.41 | 26.90 | 24.21 | 24.39 | 47.17 | 217.02 | 279.79 | 466.32 | 288.76 | 124.11 | 48.43 | 39.28 |
| 28.52 | 26.90 | 24.03 | 25.11 | 46.81 | 222.40 | 272.62 | 509.37 | 294.14 | 115.68 | 47.17 | 39.64 |
| 28.34 | 26.90 | 24.21 | 25.11 | 46.81 | 211.64 | 276.21 | 557.80 | 330.01 | 105.82 | 46.99 | 40.00 |
| 28.34 | 26.37 | 24.21 | 25.11 | 49.14 | 184.74 | 279.79 | 586.49 | 319.25 | 98.65 | 46.63 | 40.18 |
| 27.98 | 25.65 | 24.03 | 25.47 | 64.03 | 181.15 | 322.84 | 575.73 | 312.08 | 92.37 | 45.91 | 40.00 |
| 27.80 | 25.47 | 24.21 | 26.54 | 78.38 | 190.12 | 330.01 | 536.27 | 310.28 | 86.99 | 45.56 | 39.10 |
| 33.36 | 25.29 | 23.85 | 28.16 | 64.03 | 211.64 | 331.81 | 591.87 | 322.84 | 83.40 | 45.38 | 38.74 |
| 34.97 | 25.47 | 23.85 | 29.59 | 67.44 | 204.47 | 331.81 | 685.14 | 324.63 | 78.92 | 44.66 | 38.74 |
| 33.54 | 25.11 | 23.85 | 37.84 | 79.99 | 161.42 | 389.20 | 740.74 | 263.65 | 74.43 | 44.48 | 38.38 |
| 31.57 | 25.11 | 23.85 | 41.25 | 79.81 | 149.04 | 541.65 | 819.65 | 243.92 | 69.95 | 44.12 | 39.28 |
| 30.49 | 25.11 | 23.67 | 31.03 | 71.56 | 152.45 | 611.60 | 816.07 | 227.78 | 67.44 | 44.12 | 38.92 |
| 29.95 | 25.11 | 23.32 | 29.95 | 72.28 | 164.65 | 715.63 | 798.13 | 211.64 | 64.57 | 44.12 | 38.74 |
| 28.88 | 24.93 | 23.85 | 29.59 | 76.23 | 181.15 | 670.79 | 744.33 | 204.47 | 62.77 | 43.58 | 38.56 |
| 28.88 | 24.75 | 23.32 | 29.59 | 92.01 | 186.53 | 566.76 | 749.71 | 178.28 | 60.08 | 43.22 | 38.38 |
| 27.98 | 24.75 | 23.67 | 31.03 | 107.08 | 218.81 | 460.94 | 762.26 | 160.16 | 57.39 | 43.05 | 38.20 |
| 27.62 | | 23.67 | 33.72 | 132.72 | 269.03 | 385.61 | 762.26 | 154.78 | 56.14 | 42.15 | 38.02 |
| 27.26 | | 23.50 | 37.31 | 141.87 | 286.97 | 376.65 | 721.01 | 149.76 | 54.70 | 41.97 | 37.84 |
| 26.90 | | 23.67 | | 155.68 | | 369.47 | 670.79 | | 53.81 | | 38.74 |
| **29.60** | **26.39** | **24.16** | **27.99** | **65.07** | **225.44** | **399.62** | **520.36** | **367.35** | **104.21** | **47.06** | **39.64** |



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|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 38.56 | 28.88 | 26.37 | 23.50 | 160.52 | 261.86 | 694.11 | 975.69 | 258.27 | 124.83 | 56.86 | 42.33 |
| 38.02 | 28.70 | 25.65 | 23.50 | 140.44 | 200.88 | 708.45 | 808.89 | 276.21 | 117.12 | 56.68 | 42.69 |
| 37.31 | 29.06 | 24.93 | 23.67 | 123.93 | 190.12 | 712.04 | 667.20 | 286.97 | 107.08 | 56.14 | 42.15 |
| 37.31 | 28.70 | 24.57 | 23.50 | 135.95 | 188.32 | 747.91 | 568.56 | 294.14 | 102.59 | 55.24 | 41.25 |
| 36.95 | 28.88 | 24.57 | 23.32 | 160.52 | 178.10 | 729.98 | 548.83 | 290.56 | 93.98 | 54.52 | 41.25 |
| 36.23 | 28.70 | 24.57 | 22.78 | 144.38 | 142.23 | 737.15 | 595.46 | 294.14 | 86.81 | 54.17 | 40.00 |
| 35.87 | 28.52 | 26.01 | 26.37 | 126.45 | 143.13 | 627.74 | 712.04 | 333.60 | 85.01 | 54.17 | 39.46 |
| 35.51 | 28.52 | 29.77 | 23.32 | 104.38 | 146.71 | 584.70 | 830.42 | 342.57 | 81.43 | 53.63 | 39.28 |
| 35.15 | 28.52 | 24.93 | 24.21 | 96.49 | 138.10 | 647.47 | 862.70 | 355.12 | 78.02 | 53.45 | 39.10 |
| 34.26 | 27.98 | 24.75 | 24.75 | 99.36 | 135.95 | 683.34 | 846.56 | 351.54 | 74.25 | 52.91 | 39.10 |
| 33.36 | 27.98 | 25.83 | 24.21 | 101.87 | 133.62 | 785.58 | 819.65 | 355.12 | 72.82 | 52.55 | 38.74 |
| 32.82 | 27.62 | 25.11 | 26.54 | 110.66 | 137.21 | 886.02 | 774.82 | 365.89 | 70.31 | 52.01 | 38.56 |
| 32.10 | 27.44 | 24.75 | 30.49 | 122.68 | 171.82 | 925.47 | 819.65 | 374.85 | 70.13 | 51.83 | 38.38 |
| 31.75 | 27.80 | 24.03 | 33.18 | 143.48 | 184.74 | 923.68 | 923.68 | 399.96 | 69.05 | 51.83 | 40.00 |
| 31.75 | 27.98 | 24.75 | 36.05 | 138.64 | 206.26 | 842.97 | 966.73 | 421.49 | 66.36 | 51.48 | 39.64 |
| 31.39 | 27.62 | 24.57 | 40.00 | 146.17 | 208.05 | 889.60 | 769.43 | 365.89 | 65.29 | 51.30 | 39.82 |
| 31.21 | 27.62 | 24.39 | 48.25 | 154.78 | 240.34 | 828.62 | 602.63 | 312.08 | 65.46 | 50.94 | 39.82 |
| 31.21 | 27.44 | 24.21 | 55.78 | 152.09 | 272.62 | 731.77 | 629.54 | 270.83 | 64.93 | 51.30 | 39.46 |
| 31.21 | 27.44 | 24.21 | 48.96 | 136.85 | 355.12 | 708.45 | 591.87 | 242.13 | 63.85 | 50.94 | 39.10 |
| 31.03 | 27.80 | 24.75 | 45.56 | 117.12 | 364.09 | 774.82 | 556.00 | 225.99 | 63.13 | 49.68 | 39.10 |
| 30.67 | 27.62 | 24.93 | 42.33 | 134.52 | 435.83 | 907.54 | 588.29 | 209.85 | 62.06 | 49.32 | 39.28 |
| 30.67 | 27.44 | 24.03 | 50.76 | 137.21 | 487.85 | 970.31 | 636.71 | 200.88 | 61.16 | 48.43 | 39.64 |
| 30.67 | 27.44 | 23.67 | 60.08 | 135.41 | 563.18 | 938.03 | 643.89 | 190.12 | 61.52 | 48.07 | 39.82 |
| 30.49 | 27.44 | 23.32 | 79.28 | 139.00 | 613.40 | 860.91 | 606.22 | 184.74 | 60.44 | 47.17 | 39.64 |
| 30.13 | 27.44 | 23.67 | 90.75 | 142.59 | 597.25 | 670.79 | 564.97 | 166.80 | 60.44 | 46.63 | 38.92 |
| 29.77 | 27.44 | 23.67 | 96.49 | 141.69 | 683.34 | 645.68 | 518.34 | 168.24 | 59.90 | 46.27 | 38.38 |
| 30.13 | 27.44 | 23.32 | 108.15 | 153.89 | 742.53 | 697.69 | 460.94 | 172.72 | 60.08 | 45.74 | 38.02 |
| 29.95 | 26.90 | 23.14 | 123.58 | 156.94 | 710.25 | 794.54 | 390.99 | 167.70 | 60.08 | 45.02 | 37.84 |
| 29.59 | | 23.14 | 142.59 | 169.49 | 701.28 | 889.60 | 290.56 | 151.56 | 59.01 | 44.66 | 37.31 |
| 29.59 | | 23.32 | 168.24 | 197.29 | 665.41 | 970.31 | 261.86 | 134.16 | 58.47 | 42.87 | 38.20 |
| 29.23 | | 23.32 | | 229.57 | | 1002.60 | 256.48 | | 57.39 | | 37.84 |
| **32.71** | **27.94** | **24.59** | **53.01** | **140.46** | **339.99** | **790.90** | **648.05** | **272.14** | **73.65** | **50.86** | **39.49** |



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|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 36.69 | 28.59 | 27.17 | 26.20 | 32.07 | 186.41 | 427.54 | 720.80 | 238.66 | 134.91 | 60.48 | 42.02 |
| 36.10 | 28.29 | 26.69 | 25.58 | 44.85 | 243.85 | 379.21 | 510.26 | 237.14 | 134.34 | 58.94 | 42.03 |
| 35.74 | 28.57 | 26.41 | 26.03 | 37.53 | 279.32 | 308.33 | 428.49 | 246.13 | 132.57 | 57.54 | 42.05 |
| 35.38 | 28.27 | 26.11 | 26.51 | 32.82 | 310.49 | 298.07 | 423.74 | 260.64 | 129.59 | 55.48 | 42.32 |
| 35.03 | 28.36 | 26.19 | 26.80 | 29.40 | 300.86 | 286.42 | 452.56 | 274.83 | 129.40 | 53.32 | 42.11 |
| 34.67 | 28.25 | 26.28 | 26.42 | 29.18 | 277.04 | 240.75 | 418.61 | 268.81 | 129.59 | 52.39 | 42.48 |
| 34.11 | 28.14 | 26.17 | 26.78 | 26.53 | 255.07 | 225.23 | 399.03 | 264.12 | 132.06 | 50.44 | 40.96 |
| 33.34 | 28.05 | 26.26 | 26.87 | 28.39 | 222.07 | 242.90 | 419.18 | 250.57 | 131.43 | 49.04 | 39.56 |
| 32.78 | 27.89 | 26.48 | 27.23 | 29.15 | 230.36 | 289.46 | 418.92 | 245.31 | 137.26 | 49.02 | 38.20 |
| 31.83 | 27.17 | 25.94 | 26.56 | 35.22 | 212.06 | 347.35 | 431.91 | 254.05 | 138.33 | 49.15 | 38.18 |
| 31.08 | 26.84 | 25.61 | 25.63 | 33.75 | 186.72 | 450.53 | 467.44 | 264.95 | 126.30 | 48.76 | 36.62 |
| 30.71 | 27.43 | 26.01 | 25.90 | 32.93 | 187.86 | 473.65 | 433.17 | 276.41 | 123.51 | 48.87 | 33.82 |
| 30.13 | 27.17 | 26.20 | 26.33 | 25.44 | 199.52 | 561.50 | 463.07 | 284.01 | 111.16 | 49.24 | 32.16 |
| 29.56 | 26.63 | 26.06 | 26.56 | 36.74 | 219.34 | 559.79 | 461.04 | 284.45 | 99.51 | 49.22 | 32.78 |
| 30.76 | 27.69 | 25.81 | 26.44 | 39.88 | 206.74 | 524.38 | 459.59 | 290.22 | 90.70 | 48.45 | 33.61 |
| 30.38 | 26.63 | 26.08 | 27.79 | 44.33 | 194.13 | 501.01 | 422.09 | 298.64 | 83.16 | 48.40 | 34.04 |
| 30.00 | 27.25 | 26.08 | 29.09 | 50.06 | 196.10 | 394.28 | 421.01 | 314.29 | 80.19 | 48.11 | 34.90 |
| 30.00 | 27.30 | 26.08 | 29.26 | 48.99 | 203.44 | 350.58 | 447.30 | 333.80 | 76.39 | 48.06 | 35.76 |
| 29.79 | 27.17 | 26.28 | 27.88 | 48.66 | 205.47 | 352.80 | 483.40 | 348.49 | 75.25 | 46.91 | 38.86 |
| 30.97 | 27.03 | 25.72 | 27.21 | 54.33 | 217.13 | 324.55 | 511.33 | 354.38 | 73.22 | 48.22 | 39.33 |
| 30.56 | 27.46 | 25.54 | 28.63 | 63.21 | 198.88 | 348.81 | 486.70 | 336.01 | 71.95 | 48.31 | 38.41 |
| 29.93 | 27.34 | 26.08 | 28.34 | 72.14 | 195.15 | 361.09 | 493.16 | 294.02 | 71.13 | 47.38 | 37.97 |
| 29.34 | 27.05 | 26.63 | 29.02 | 77.59 | 203.38 | 379.21 | 464.65 | 247.78 | 71.13 | 46.48 | 37.75 |
| 29.70 | 27.32 | 25.90 | 30.69 | 72.78 | 221.43 | 438.81 | 452.62 | 209.14 | 71.13 | 46.34 | 37.64 |
| 29.20 | 27.77 | 25.54 | 29.99 | 65.62 | 252.15 | 446.67 | 420.00 | 180.33 | 69.55 | 45.67 | 38.20 |
| 29.05 | 27.48 | 25.46 | 29.68 | 68.91 | 297.95 | 531.10 | 412.97 | 161.58 | 68.03 | 46.52 | 38.64 |
| 29.20 | 27.93 | 25.54 | 28.98 | 88.55 | 330.19 | 619.33 | 403.97 | 156.32 | 65.81 | 45.37 | 38.54 |
| 29.54 | 26.80 | 25.46 | 30.43 | 105.21 | 364.20 | 757.53 | 365.72 | 149.35 | 63.97 | 44.01 | 37.86 |
| 28.91 | | 25.99 | 31.30 | 121.99 | 387.82 | 864.57 | 308.02 | 141.82 | 62.09 | 42.89 | 37.50 |
| 28.88 | | 26.28 | 31.40 | 135.86 | 416.14 | 1012.79 | 269.32 | 138.65 | 61.52 | 42.44 | 36.95 |
| 29.20 | | 26.48 | | 155.18 | | 898.14 | 249.55 | | 61.50 | | 37.25 |
| **31.37** | **27.57** | **26.08** | **27.85** | **57.01** | **246.71** | **457.95** | **436.12** | **253.50** | **96.99** | **49.18** | **38.02** |



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| 1990 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 36.95 | 30.45 | 25.96 | 23.80 | 37.48 | 199.77 | 816.44 | 806.94 | 578.85 | 254.88 | 66.06 | 44.51 |
| 36.37 | 30.04 | 25.74 | 23.50 | 40.76 | 205.98 | 843.04 | 848.74 | 553.58 | 234.42 | 63.26 | 44.58 |
| 35.55 | 31.05 | 25.42 | 23.59 | 47.81 | 229.54 | 877.24 | 860.14 | 584.49 | 230.68 | 61.46 | 43.74 |
| 34.92 | 30.73 | 25.70 | 24.06 | 59.89 | 254.37 | 881.68 | 854.44 | 629.33 | 215.54 | 60.28 | 43.29 |
| 34.97 | 30.52 | 25.18 | 25.24 | 69.99 | 239.99 | 854.44 | 821.50 | 604.32 | 206.29 | 57.92 | 44.15 |
| 34.81 | 30.33 | 25.47 | 25.72 | 82.40 | 218.58 | 818.34 | 804.40 | 504.49 | 200.02 | 57.06 | 43.52 |
| 34.65 | 31.01 | 26.17 | 26.53 | 102.80 | 282.05 | 863.94 | 812.64 | 466.55 | 191.16 | 55.93 | 42.63 |
| 34.23 | 30.74 | 25.74 | 25.90 | 114.71 | 316.19 | 938.68 | 822.77 | 476.69 | 179.95 | 55.44 | 44.10 |
| 35.12 | 30.71 | 25.72 | 25.18 | 142.20 | 341.52 | 952.62 | 799.97 | 504.62 | 165.25 | 54.69 | 42.95 |
| 34.85 | 29.36 | 25.70 | 25.47 | 158.60 | 314.54 | 847.47 | 834.17 | 489.10 | 154.74 | 53.92 | 42.84 |
| 34.32 | 28.98 | 25.68 | 25.35 | 189.76 | 288.63 | 687.86 | 826.57 | 387.70 | 151.44 | 53.45 | 42.23 |
| 33.82 | 29.38 | 25.67 | 25.40 | 195.59 | 311.18 | 557.63 | 805.67 | 375.98 | 150.62 | 52.70 | 41.10 |
| 33.32 | 29.67 | 24.84 | 25.44 | 204.33 | 331.01 | 499.17 | 806.30 | 393.33 | 142.26 | 52.24 | 41.03 |
| 33.97 | 29.63 | 25.63 | 25.90 | 262.48 | 319.54 | 575.94 | 725.86 | 384.47 | 131.81 | 52.34 | 40.82 |
| 31.08 | 29.36 | 25.56 | 28.86 | 306.75 | 318.53 | 662.52 | 632.37 | 376.42 | 118.00 | 52.14 | 40.75 |
| 31.73 | 29.11 | 25.29 | 28.48 | 317.52 | 315.81 | 715.09 | 568.28 | 361.85 | 111.16 | 51.66 | 40.54 |
| 31.80 | 28.32 | 26.22 | 28.10 | 347.54 | 330.31 | 760.07 | 604.19 | 371.23 | 102.36 | 51.46 | 39.35 |
| 31.73 | 29.02 | 25.35 | 28.57 | 332.02 | 365.08 | 632.18 | 657.46 | 383.45 | 98.11 | 51.27 | 39.15 |
| 31.21 | 28.66 | 24.29 | 28.83 | 262.60 | 428.80 | 606.34 | 656.82 | 388.08 | 89.81 | 50.23 | 38.95 |
| 31.35 | 28.31 | 24.02 | 29.09 | 251.96 | 493.35 | 651.76 | 717.63 | 425.83 | 82.28 | 49.76 | 38.59 |
| 31.28 | 28.57 | 24.54 | 28.59 | 226.82 | 568.28 | 703.69 | 734.10 | 419.94 | 75.31 | 49.30 | 37.98 |
| 31.23 | 27.19 | 23.89 | 27.15 | 219.79 | 682.79 | 618.88 | 666.96 | 447.68 | 71.70 | 48.56 | 37.60 |
| 31.03 | 27.50 | 25.01 | 26.37 | 224.28 | 780.97 | 517.22 | 630.66 | 459.97 | 71.26 | 47.82 | 37.02 |
| 31.08 | 26.85 | 24.83 | 26.01 | 244.04 | 832.90 | 547.82 | 578.60 | 456.55 | 69.99 | 49.04 | 37.52 |
| 31.31 | 26.53 | 23.68 | 32.52 | 267.80 | 893.08 | 604.76 | 541.74 | 421.65 | 69.23 | 48.57 | 37.03 |
| 31.12 | 26.41 | 23.32 | 34.75 | 245.18 | 877.24 | 680.89 | 546.11 | 340.64 | 68.66 | 46.23 | 37.52 |
| 32.03 | 26.08 | 23.56 | 35.26 | 238.22 | 757.53 | 741.06 | 574.17 | 275.33 | 68.34 | 45.51 | 37.43 |
| 32.95 | 25.67 | 25.29 | 36.74 | 250.88 | 653.66 | 786.03 | 629.27 | 257.54 | 68.09 | 44.81 | 36.84 |
| 31.62 | | 23.37 | 36.55 | 234.86 | 658.72 | 713.83 | 669.49 | 252.60 | 67.84 | 44.62 | 37.45 |
| 30.97 | | 23.56 | 36.84 | 225.17 | 749.93 | 757.53 | 694.83 | 254.50 | 66.89 | 44.70 | 38.07 |
| 31.21 | | 23.93 | | 203.19 | | 806.30 | 620.09 | | 66.32 | | 38.97 |
| **32.99** | **28.93** | **24.98** | **28.13** | **197.01** | **452.00** | **726.47** | **714.61** | **427.56** | **128.21** | **52.41** | **40.39** |



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| 1991 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 37.82 | 30.22 | 26.13 | 29.59 | 59.39 | 97.48 | 415.76 | 671.39 | 539.58 | 122.94 | 48.63 | 35.67 |
| 37.55 | 30.00 | 26.80 | 30.71 | 58.27 | 111.67 | 444.64 | 638.45 | 565.43 | 116.10 | 47.30 | 35.62 |
| 36.07 | 30.21 | 27.14 | 30.43 | 50.21 | 132.88 | 481.18 | 550.73 | 584.24 | 109.89 | 47.18 | 34.92 |
| 35.15 | 30.04 | 26.58 | 30.24 | 48.22 | 158.54 | 509.31 | 582.72 | 600.07 | 107.04 | 46.32 | 34.68 |
| 34.25 | 29.81 | 25.42 | 31.06 | 46.80 | 184.51 | 479.92 | 587.15 | 620.28 | 104.38 | 45.67 | 35.87 |
| 34.08 | 30.06 | 25.03 | 32.21 | 46.26 | 226.37 | 475.55 | 599.69 | 628.70 | 102.48 | 45.44 | 36.00 |
| 33.37 | 30.38 | 25.63 | 32.71 | 46.46 | 261.27 | 410.56 | 608.31 | 605.46 | 97.23 | 44.40 | 36.12 |
| 32.16 | 29.76 | 26.87 | 32.07 | 44.34 | 302.44 | 347.60 | 627.24 | 485.43 | 93.11 | 43.56 | 36.60 |
| 31.64 | 30.17 | 27.60 | 32.48 | 46.15 | 326.26 | 364.20 | 616.67 | 441.53 | 86.58 | 42.84 | 36.17 |
| 31.64 | 30.17 | 27.95 | 32.71 | 48.22 | 324.61 | 404.67 | 478.33 | 479.41 | 82.15 | 42.52 | 36.10 |
| 32.16 | 30.51 | 28.68 | 32.14 | 49.45 | 304.15 | 478.90 | 350.71 | 495.88 | 77.46 | 40.82 | 35.67 |
| 32.68 | 29.86 | 28.55 | 31.73 | 52.31 | 277.17 | 548.51 | 332.09 | 464.15 | 73.41 | 39.81 | 35.37 |
| 32.32 | 29.22 | 29.13 | 31.83 | 54.88 | 297.44 | 525.71 | 378.64 | 559.15 | 71.32 | 39.42 | 36.24 |
| 32.32 | 28.95 | 28.48 | 33.16 | 61.74 | 338.04 | 485.94 | 442.99 | 586.45 | 68.34 | 39.45 | 35.76 |
| 31.30 | 28.66 | 28.16 | 31.64 | 66.70 | 381.93 | 404.61 | 504.94 | 569.23 | 65.43 | 38.99 | 35.10 |
| 29.31 | 28.55 | 49.22 | 29.09 | 73.98 | 419.68 | 422.09 | 559.34 | 553.71 | 62.56 | 38.54 | 36.62 |
| 31.44 | 28.77 | 40.85 | 28.31 | 77.72 | 448.88 | 481.12 | 581.20 | 518.43 | 61.14 | 37.71 | 36.96 |
| 31.06 | 29.63 | 36.46 | 27.95 | 86.01 | 443.69 | 547.75 | 622.81 | 398.53 | 60.39 | 37.17 | 37.10 |
| 30.78 | 29.85 | 32.95 | 27.88 | 104.57 | 393.71 | 591.39 | 670.76 | 319.67 | 59.99 | 37.48 | 35.98 |
| 31.51 | 29.56 | 30.38 | 29.26 | 113.31 | 334.24 | 637.82 | 714.46 | 274.70 | 59.85 | 37.52 | 35.22 |
| 31.47 | 28.25 | 29.29 | 30.19 | 133.20 | 290.34 | 673.29 | 737.90 | 243.92 | 59.48 | 37.16 | 33.58 |
| 31.10 | 28.45 | 28.68 | 30.62 | 96.15 | 286.54 | 594.24 | 553.01 | 227.51 | 58.47 | 36.82 | 33.56 |
| 30.56 | 27.88 | 27.30 | 30.81 | 82.28 | 269.70 | 506.08 | 539.39 | 221.43 | 57.99 | 37.21 | 33.00 |
| 30.26 | 27.68 | 26.42 | 32.18 | 78.16 | 268.81 | 472.06 | 448.31 | 218.33 | 57.59 | 36.96 | 32.20 |
| 30.62 | 27.80 | 26.01 | 36.82 | 74.11 | 250.19 | 484.92 | 416.39 | 220.23 | 56.50 | 36.53 | 31.90 |
| 30.40 | 27.37 | 25.60 | 37.93 | 74.55 | 244.42 | 436.40 | 425.00 | 213.13 | 55.53 | 36.57 | 31.83 |
| 31.17 | 26.96 | 26.10 | 39.43 | 71.57 | 260.32 | 430.07 | 448.31 | 196.79 | 54.46 | 36.32 | 31.92 |
| 31.37 | 26.71 | 26.37 | 45.48 | 72.27 | 301.56 | 465.79 | 490.18 | 172.03 | 52.59 | 36.51 | 31.60 |
| 32.42 | | 26.82 | 54.14 | 76.51 | 337.09 | 504.56 | 521.28 | 155.56 | 51.89 | 36.46 | 31.69 |
| 30.92 | | 27.71 | 54.47 | 81.77 | 368.12 | 559.98 | 562.13 | 143.08 | 50.64 | 36.03 | 31.53 |
| 30.28 | | 28.81 | | 92.41 | | 625.15 | 535.21 | | 49.51 | | 31.38 |
| **32.23** | **29.12** | **28.94** | **33.64** | **69.93** | **288.07** | **490.64** | **541.80** | **410.07** | **73.76** | **40.24** | **34.58** |



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| 1992 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 30.33 | 30.49 | 28.10 | 24.29 | 41.51 | 83.67 | 332.21 | 673.92 | 499.62 | 144.16 | 69.99 | 44.47 |
| 31.57 | 30.00 | 28.25 | 25.15 | 42.18 | 90.45 | 340.51 | 742.33 | 554.66 | 138.21 | 69.36 | 44.17 |
| 31.66 | 29.48 | 27.32 | 24.86 | 38.14 | 97.80 | 349.12 | 774.00 | 547.75 | 128.83 | 69.48 | 43.82 |
| 31.83 | 29.26 | 26.93 | 24.86 | 37.93 | 107.93 | 336.71 | 801.24 | 482.32 | 118.06 | 68.91 | 45.29 |
| 31.51 | 29.59 | 26.69 | 26.03 | 36.69 | 113.06 | 337.47 | 752.46 | 413.29 | 111.41 | 67.90 | 44.74 |
| 32.20 | 29.29 | 26.15 | 26.33 | 33.75 | 126.36 | 348.55 | 688.49 | 344.56 | 106.35 | 66.51 | 43.79 |
| 31.71 | 30.11 | 25.77 | 26.71 | 31.78 | 134.47 | 350.14 | 672.02 | 324.55 | 100.96 | 64.29 | 43.65 |
| 31.38 | 29.48 | 25.99 | 25.74 | 31.42 | 135.16 | 354.00 | 624.58 | 340.76 | 96.15 | 63.66 | 43.11 |
| 31.16 | 29.67 | 26.21 | 25.94 | 30.56 | 133.26 | 394.73 | 473.52 | 333.61 | 93.17 | 63.22 | 42.55 |
| 30.74 | 29.45 | 26.26 | 25.24 | 32.54 | 146.76 | 416.01 | 380.35 | 298.52 | 92.60 | 62.76 | 43.32 |
| 30.85 | 29.38 | 25.74 | 24.72 | 37.52 | 152.58 | 415.88 | 345.64 | 239.23 | 88.48 | 62.79 | 42.11 |
| 31.01 | 29.40 | 26.03 | 24.06 | 46.35 | 158.98 | 435.58 | 307.51 | 214.59 | 85.70 | 60.69 | 41.10 |
| 31.69 | 29.57 | 26.19 | 24.81 | 58.67 | 160.75 | 448.95 | 354.89 | 190.84 | 84.56 | 58.63 | 40.69 |
| 31.53 | 29.36 | 25.60 | 24.86 | 70.18 | 173.55 | 469.21 | 423.86 | 174.56 | 83.29 | 56.61 | 39.52 |
| 31.96 | 29.15 | 25.74 | 28.20 | 89.69 | 188.81 | 515.89 | 503.10 | 159.04 | 81.96 | 54.64 | 38.18 |
| 31.71 | 29.16 | 26.03 | 30.15 | 84.87 | 191.85 | 499.81 | 549.91 | 149.48 | 82.15 | 52.68 | 37.23 |
| 31.64 | 28.70 | 26.11 | 29.72 | 87.53 | 211.36 | 537.49 | 583.54 | 152.39 | 81.90 | 50.14 | 37.19 |
| 31.40 | 28.64 | 25.89 | 29.54 | 90.19 | 221.81 | 537.75 | 595.13 | 151.70 | 81.07 | 48.29 | 35.91 |
| 31.49 | 28.43 | 26.19 | 31.46 | 82.40 | 236.19 | 598.30 | 486.32 | 146.19 | 78.54 | 47.84 | 35.17 |
| 31.92 | 28.68 | 25.96 | 29.56 | 73.66 | 251.01 | 674.56 | 392.51 | 145.93 | 76.39 | 47.16 | 34.27 |
| 31.85 | 28.53 | 26.41 | 29.93 | 70.62 | 277.42 | 731.56 | 392.64 | 145.49 | 74.61 | 47.34 | 33.20 |
| 31.60 | 28.09 | 25.81 | 29.99 | 73.03 | 287.56 | 776.53 | 412.72 | 144.16 | 73.92 | 46.46 | 32.33 |
| 31.30 | 27.57 | 25.74 | 28.14 | 89.94 | 274.32 | 805.04 | 425.51 | 144.86 | 72.71 | 45.81 | 31.46 |
| 31.16 | 27.34 | 25.51 | 29.45 | 98.94 | 259.12 | 745.50 | 435.01 | 144.98 | 71.95 | 45.26 | 31.94 |
| 31.83 | 27.12 | 25.29 | 31.78 | 108.50 | 265.96 | 649.86 | 455.09 | 145.43 | 71.19 | 45.22 | 32.61 |
| 31.51 | 27.53 | 25.01 | 35.81 | 124.02 | 279.01 | 571.44 | 458.26 | 142.70 | 71.07 | 45.31 | 32.42 |
| 31.05 | 27.58 | 24.58 | 37.77 | 121.80 | 289.01 | 558.90 | 459.27 | 143.46 | 69.36 | 44.70 | 31.40 |
| 30.74 | 27.66 | 24.58 | 42.39 | 100.71 | 298.64 | 596.78 | 448.76 | 146.82 | 69.61 | 44.79 | 31.23 |
| 30.76 | | 24.43 | 43.75 | 95.51 | 309.28 | 696.09 | 420.06 | 148.09 | 69.36 | 44.49 | 30.64 |
| 30.11 | | 24.29 | 45.35 | 90.51 | 317.64 | 735.36 | 424.05 | 150.43 | 69.55 | 44.99 | 30.21 |
| 30.13 | | 24.00 | | 81.26 | | 662.52 | 470.61 | | 69.61 | | 30.67 |
| **31.33** | **28.88** | **25.90** | **29.55** | **68.79** | **199.13** | **523.30** | **513.78** | **244.00** | **88.29** | **55.33** | **37.69** |



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| 1993 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 31.03 | 27.25 | 24.06 | 19.65 | 115.53 | 115.97 | 375.16 | 510.19 | 408.66 | 149.29 | 61.25 | 41.53 |
| 30.81 | 27.30 | 23.91 | 19.52 | 111.10 | 122.12 | 422.47 | 545.22 | 400.55 | 136.31 | 60.82 | 40.90 |
| 30.62 | 27.34 | 23.77 | 20.49 | 105.02 | 121.10 | 460.92 | 545.92 | 393.97 | 128.64 | 60.37 | 40.10 |
| 30.42 | 27.23 | 23.56 | 20.49 | 96.40 | 134.09 | 509.69 | 528.12 | 387.13 | 128.89 | 59.94 | 39.31 |
| 30.04 | 26.87 | 23.34 | 20.36 | 100.14 | 148.78 | 585.25 | 498.86 | 350.07 | 132.12 | 59.62 | 38.50 |
| 29.67 | 26.84 | 23.12 | 20.63 | 107.87 | 173.48 | 707.49 | 499.74 | 329.87 | 130.67 | 59.30 | 37.73 |
| 30.08 | 26.63 | 23.36 | 22.23 | 111.86 | 181.15 | 791.10 | 505.51 | 335.57 | 129.84 | 57.99 | 37.34 |
| 29.29 | 26.19 | 23.16 | 22.66 | 120.41 | 191.66 | 817.07 | 502.40 | 338.23 | 124.40 | 56.80 | 36.57 |
| 28.68 | 25.92 | 22.64 | 22.96 | 126.74 | 205.47 | 689.76 | 509.75 | 358.50 | 120.91 | 55.66 | 36.21 |
| 28.59 | 25.26 | 22.44 | 23.11 | 105.90 | 214.91 | 673.29 | 522.16 | 364.01 | 112.93 | 53.54 | 35.85 |
| 27.73 | 24.90 | 23.57 | 23.71 | 83.04 | 241.45 | 552.82 | 470.48 | 376.55 | 111.29 | 52.68 | 35.79 |
| 28.05 | 24.77 | 23.80 | 24.49 | 64.73 | 271.15 | 402.01 | 412.65 | 350.77 | 111.67 | 51.61 | 35.15 |
| 26.72 | 24.90 | 23.28 | 25.74 | 58.11 | 305.93 | 376.04 | 386.75 | 278.50 | 112.68 | 50.55 | 34.32 |
| 26.13 | 24.54 | 22.64 | 28.01 | 58.35 | 291.55 | 403.91 | 379.53 | 244.30 | 107.11 | 50.87 | 33.80 |
| 26.58 | 24.34 | 22.73 | 29.90 | 60.60 | 279.51 | 456.61 | 382.25 | 238.03 | 103.56 | 50.39 | 33.27 |
| 27.21 | 24.31 | 22.37 | 30.42 | 67.71 | 283.50 | 411.64 | 361.03 | 238.91 | 99.63 | 49.90 | 32.75 |
| 27.26 | 24.27 | 22.01 | 31.30 | 72.46 | 288.89 | 392.38 | 361.98 | 234.16 | 96.08 | 49.31 | 32.59 |
| 27.73 | 24.38 | 21.67 | 32.55 | 68.22 | 275.02 | 411.83 | 370.22 | 211.61 | 93.04 | 50.34 | 32.44 |
| 27.44 | 23.89 | 21.46 | 35.33 | 71.26 | 272.61 | 468.64 | 377.18 | 198.00 | 90.13 | 49.40 | 33.00 |
| 27.50 | 24.54 | 21.55 | 39.04 | 71.32 | 296.74 | 524.38 | 355.96 | 196.03 | 87.53 | 48.13 | 33.04 |
| 26.98 | 23.80 | 21.92 | 44.13 | 68.60 | 333.80 | 577.71 | 350.58 | 197.43 | 83.48 | 47.21 | 32.16 |
| 26.39 | 24.23 | 21.56 | 55.48 | 75.88 | 381.62 | 635.29 | 362.49 | 191.85 | 79.49 | 46.75 | 31.90 |
| 26.53 | 24.51 | 21.66 | 65.81 | 71.38 | 447.81 | 596.71 | 364.01 | 185.08 | 76.26 | 46.73 | 31.23 |
| 26.74 | 24.31 | 21.88 | 74.74 | 83.61 | 453.13 | 491.45 | 360.08 | 187.36 | 73.03 | 46.50 | 30.88 |
| 27.12 | 24.47 | 21.98 | 86.77 | 98.81 | 398.02 | 421.58 | 366.86 | 187.55 | 69.80 | 45.85 | 30.65 |
| 27.08 | 24.32 | 21.04 | 99.76 | 113.82 | 342.85 | 367.49 | 357.23 | 188.75 | 67.01 | 44.97 | 30.94 |
| 27.21 | 24.32 | 21.14 | 102.36 | 109.45 | 320.94 | 338.86 | 362.17 | 178.49 | 64.61 | 44.13 | 31.31 |
| 27.19 | 23.89 | 20.65 | 110.59 | 116.86 | 308.33 | 345.32 | 357.93 | 169.49 | 63.72 | 43.50 | 31.17 |
| 27.41 | | 20.31 | 111.54 | 120.15 | 321.63 | 383.64 | 362.61 | 159.61 | 62.88 | 42.75 | 32.98 |
| 27.46 | | 19.77 | 106.66 | 122.62 | 346.21 | 417.09 | 375.79 | 151.82 | 62.16 | 42.14 | 32.64 |
| 27.67 | | 19.79 | | 121.42 | | 478.65 | 395.74 | | 61.72 | | 32.23 |
| **28.04** | **25.20** | **22.26** | **45.68** | **92.88** | **268.98** | **499.56** | **420.69** | **267.70** | **99.06** | **51.30** | **34.46** |



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| 1994 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 32.33 | 27.58 | 25.25 | 26.33 | 43.67 | 208.32 | 823.40 | 1072.33 | 752.46 | 116.99 | 58.33 | 37.46 |
| 32.01 | 27.51 | 25.31 | 27.93 | 41.70 | 199.14 | 837.97 | 1065.36 | 718.90 | 119.27 | 56.80 | 37.07 |
| 31.68 | 27.41 | 25.67 | 28.29 | 40.97 | 197.49 | 836.71 | 1127.43 | 703.69 | 122.56 | 56.04 | 36.87 |
| 31.35 | 27.21 | 25.72 | 28.98 | 44.67 | 198.31 | 794.27 | 1132.50 | 697.36 | 122.94 | 54.79 | 37.05 |
| 31.19 | 27.36 | 25.47 | 27.36 | 56.34 | 189.32 | 749.30 | 1147.07 | 642.89 | 122.81 | 53.32 | 36.28 |
| 31.10 | 26.99 | 25.22 | 25.92 | 66.00 | 236.57 | 809.47 | 1104.63 | 569.16 | 113.00 | 52.70 | 35.89 |
| 30.65 | 26.82 | 25.11 | 25.47 | 68.85 | 263.81 | 889.28 | 1086.89 | 511.46 | 105.59 | 51.94 | 36.07 |
| 30.38 | 26.62 | 25.03 | 25.04 | 82.02 | 267.61 | 903.84 | 1128.70 | 446.35 | 96.78 | 51.44 | 35.87 |
| 30.65 | 26.44 | 24.92 | 24.59 | 80.44 | 275.84 | 924.75 | 1123.63 | 355.08 | 94.18 | 50.84 | 35.87 |
| 30.38 | 26.08 | 24.73 | 24.16 | 73.54 | 298.26 | 1061.56 | 1028.62 | 299.34 | 90.13 | 49.78 | 34.70 |
| 30.38 | 25.90 | 24.58 | 23.73 | 73.16 | 254.18 | 1097.66 | 867.11 | 304.15 | 87.34 | 49.17 | 36.60 |
| 30.02 | 25.70 | 24.40 | 23.54 | 76.83 | 248.54 | 966.55 | 761.33 | 305.42 | 85.32 | 48.57 | 34.97 |
| 29.76 | 26.17 | 24.23 | 23.48 | 82.28 | 228.40 | 936.78 | 768.93 | 262.73 | 83.73 | 48.22 | 34.68 |
| 29.67 | 25.81 | 24.08 | 23.19 | 99.06 | 203.63 | 906.38 | 799.97 | 254.37 | 78.98 | 46.95 | 34.68 |
| 29.57 | 25.63 | 23.91 | 23.00 | 103.43 | 200.28 | 889.91 | 839.87 | 247.08 | 76.77 | 44.94 | 34.54 |
| 29.48 | 25.46 | 23.75 | 22.78 | 125.79 | 209.14 | 848.11 | 826.57 | 243.16 | 73.54 | 44.27 | 34.61 |
| 29.40 | 25.35 | 23.57 | 23.04 | 134.15 | 192.49 | 919.05 | 672.02 | 229.73 | 69.36 | 43.50 | 33.73 |
| 29.48 | 25.25 | 23.64 | 23.12 | 140.93 | 210.73 | 1005.19 | 585.88 | 196.03 | 68.66 | 42.52 | 33.43 |
| 29.22 | 25.15 | 23.41 | 22.93 | 169.37 | 221.18 | 1109.70 | 571.19 | 184.63 | 68.85 | 42.18 | 33.11 |
| 29.05 | 25.36 | 23.39 | 24.30 | 171.14 | 280.72 | 1135.03 | 612.23 | 171.71 | 68.15 | 41.84 | 32.18 |
| 29.05 | 25.42 | 23.23 | 24.32 | 168.35 | 317.52 | 1094.49 | 705.59 | 162.72 | 68.09 | 41.49 | 31.96 |
| 28.90 | 25.33 | 23.35 | 24.43 | 176.97 | 381.87 | 1112.86 | 767.03 | 153.41 | 68.03 | 40.96 | 31.83 |
| 29.05 | 25.22 | 23.35 | 24.52 | 182.54 | 460.54 | 1092.59 | 818.97 | 144.16 | 68.09 | 40.51 | 33.34 |
| 28.90 | 25.11 | 23.48 | 24.47 | 177.54 | 475.10 | 962.12 | 845.57 | 135.61 | 68.72 | 40.23 | 34.13 |
| 28.57 | 25.18 | 23.63 | 24.58 | 184.51 | 568.91 | 759.43 | 845.57 | 127.18 | 69.23 | 39.65 | 33.80 |
| 29.07 | 25.24 | 23.46 | 27.46 | 178.43 | 667.59 | 725.86 | 815.17 | 119.96 | 69.04 | 39.78 | 33.50 |
| 28.91 | 25.29 | 23.75 | 29.68 | 175.01 | 656.82 | 808.84 | 752.46 | 115.66 | 68.60 | 39.70 | 33.56 |
| 28.75 | 25.18 | 24.04 | 34.43 | 173.04 | 641.62 | 901.31 | 777.80 | 116.92 | 66.25 | 40.02 | 33.43 |
| 28.41 | | 24.72 | 42.79 | 174.12 | 678.36 | 988.72 | 742.33 | 118.19 | 63.47 | 38.85 | 33.06 |
| 27.75 | | 25.25 | 43.24 | 169.37 | 749.93 | 1041.29 | 725.86 | 117.49 | 61.57 | 38.16 | 32.33 |
| 27.58 | | 25.90 | | 162.02 | | 1063.46 | 757.53 | | 58.87 | | 31.96 |
| **29.77** | **25.99** | **24.37** | **26.57** | **119.23** | **339.41** | **935.35** | **866.97** | **313.57** | **83.71** | **46.25** | **34.47** |



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| 1995 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 30.90 | 29.40 | 24.30 | 22.33 | 41.35 | 83.61 | 404.29 | 500.38 | 343.61 | 172.47 | 31.49 | 39.74 |
| 30.45 | 29.31 | 23.99 | 21.46 | 44.81 | 91.84 | 417.53 | 559.91 | 250.12 | 158.47 | 31.73 | 38.68 |
| 29.85 | 29.33 | 24.27 | 21.46 | 42.32 | 97.92 | 453.70 | 604.76 | 200.85 | 154.80 | 32.30 | 38.33 |
| 29.41 | 29.41 | 24.11 | 21.17 | 45.53 | 90.89 | 496.96 | 669.49 | 205.53 | 137.70 | 33.07 | 36.60 |
| 29.24 | 29.86 | 24.25 | 21.31 | 53.04 | 110.84 | 519.25 | 680.89 | 186.79 | 119.96 | 33.48 | 35.60 |
| 29.24 | 28.27 | 23.93 | 21.46 | 67.84 | 128.96 | 573.09 | 721.43 | 177.54 | 109.13 | 34.10 | 34.61 |
| 29.15 | 26.60 | 24.06 | 22.33 | 74.55 | 166.14 | 602.16 | 775.90 | 179.57 | 96.40 | 34.51 | 33.82 |
| 28.72 | 27.43 | 23.89 | 23.23 | 97.80 | 179.31 | 649.22 | 684.06 | 198.88 | 94.56 | 34.85 | 33.21 |
| 28.46 | 27.37 | 23.43 | 24.14 | 97.80 | 202.87 | 689.13 | 511.59 | 191.79 | 92.73 | 35.94 | 33.18 |
| 28.63 | 27.15 | 23.41 | 23.84 | 109.89 | 228.15 | 666.96 | 519.88 | 182.29 | 88.17 | 36.37 | 32.39 |
| 28.50 | 28.09 | 23.25 | 24.14 | 124.65 | 249.36 | 672.02 | 621.16 | 192.23 | 81.83 | 36.80 | 31.82 |
| 28.84 | 27.19 | 23.23 | 23.84 | 132.44 | 283.63 | 666.32 | 701.16 | 182.16 | 72.84 | 37.45 | 31.40 |
| 28.72 | 28.14 | 23.05 | 23.25 | 136.43 | 307.51 | 686.59 | 718.26 | 172.22 | 64.61 | 38.09 | 30.83 |
| 28.59 | 27.41 | 22.61 | 24.18 | 155.18 | 315.43 | 696.73 | 671.39 | 162.91 | 60.39 | 38.93 | 30.80 |
| 28.31 | 27.68 | 22.59 | 24.83 | 174.18 | 320.30 | 704.33 | 670.76 | 174.05 | 52.86 | 39.80 | 30.74 |
| 28.36 | 26.98 | 22.73 | 24.68 | 178.81 | 350.20 | 755.00 | 719.53 | 134.15 | 45.55 | 40.92 | 30.71 |
| 28.83 | 26.44 | 22.30 | 25.49 | 173.04 | 371.67 | 804.40 | 730.30 | 120.03 | 40.15 | 42.72 | 30.65 |
| 28.61 | 26.71 | 22.30 | 26.15 | 155.18 | 372.50 | 908.91 | 687.86 | 125.41 | 35.80 | 43.68 | 30.78 |
| 28.83 | 26.98 | 22.59 | 27.96 | 133.39 | 347.79 | 939.95 | 682.79 | 129.59 | 34.51 | 44.88 | 30.74 |
| 28.88 | 27.41 | 22.30 | 29.36 | 117.94 | 293.70 | 862.04 | 691.66 | 135.54 | 32.09 | 46.76 | 30.69 |
| 28.84 | 26.85 | 22.30 | 29.93 | 95.20 | 268.11 | 846.84 | 718.90 | 136.69 | 31.06 | 48.68 | 30.65 |
| 28.63 | 25.99 | 22.45 | 30.51 | 87.91 | 244.49 | 932.98 | 720.80 | 144.29 | 30.06 | 50.19 | 30.43 |
| 28.84 | 27.26 | 22.61 | 31.98 | 80.25 | 203.51 | 911.45 | 592.60 | 161.89 | 29.41 | 48.99 | 30.22 |
| 29.05 | 26.93 | 23.80 | 33.50 | 76.51 | 208.64 | 921.58 | 585.76 | 167.15 | 28.95 | 47.81 | 29.65 |
| 28.68 | 25.47 | 25.98 | 35.05 | 73.22 | 245.25 | 848.74 | 624.58 | 158.41 | 29.34 | 45.96 | 29.26 |
| 28.86 | 24.66 | 24.88 | 40.40 | 67.96 | 296.36 | 694.19 | 676.46 | 160.37 | 30.08 | 43.95 | 28.72 |
| 28.77 | 24.65 | 24.11 | 33.27 | 64.86 | 325.05 | 514.18 | 647.32 | 176.65 | 29.86 | 43.27 | 28.50 |
| 28.95 | 24.32 | 23.66 | 42.41 | 64.54 | 336.52 | 510.19 | 621.16 | 189.89 | 30.43 | 42.35 | 28.83 |
| 28.95 | - | 24.11 | 39.59 | 70.12 | 358.50 | 499.36 | 606.72 | 197.55 | 30.65 | 42.30 | 28.48 |
| 29.22 | - | 22.91 | 39.65 | 71.38 | 389.66 | 475.86 | 573.47 | 179.25 | 30.69 | 41.21 | 28.81 |
| 29.65 | - | 22.91 | - | 71.26 | - | 468.52 | 435.01 | - | 31.08 | - | 28.10 |
| **29.00** | **27.26** | **23.43** | **27.76** | **96.11** | **248.96** | **670.72** | **642.77** | **177.25** | **66.99** | **40.09** | **31.84** |



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| 1996 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 27.50 | 23.85 | 22.37 | 20.55 | 40.82 | 116.80 | 399.73 | 830.37 | 325.50 | 184.82 | 51.41 | 36.02 |
| 28.01 | 23.79 | 21.55 | 20.86 | 40.17 | 119.77 | 412.27 | 768.30 | 328.16 | 187.23 | 50.43 | 35.67 |
| 28.22 | 23.61 | 21.41 | 20.71 | 39.86 | 122.75 | 463.77 | 724.60 | 339.94 | 169.94 | 49.40 | 35.31 |
| 27.67 | 23.54 | 21.27 | 20.79 | 38.87 | 126.04 | 531.16 | 684.69 | 328.98 | 133.71 | 48.44 | 35.10 |
| 27.08 | 23.37 | 21.47 | 20.64 | 35.39 | 134.47 | 466.05 | 710.03 | 309.54 | 130.79 | 47.73 | 34.89 |
| 26.53 | 23.76 | 21.44 | 20.72 | 23.36 | 147.52 | 414.11 | 708.13 | 293.77 | 127.18 | 46.83 | 34.69 |
| 26.74 | 24.14 | 21.30 | 20.57 | 22.69 | 173.93 | 414.43 | 709.39 | 294.91 | 126.99 | 45.38 | 34.64 |
| 26.32 | 24.31 | 21.38 | 20.88 | 25.11 | 194.32 | 435.14 | 696.73 | 295.10 | 123.89 | 44.24 | 33.97 |
| 26.15 | 24.13 | 21.59 | 20.95 | 25.20 | 224.35 | 441.41 | 631.42 | 298.39 | 101.91 | 43.06 | 33.56 |
| 26.36 | 23.83 | 21.79 | 20.80 | 22.42 | 262.54 | 490.75 | 737.26 | 316.63 | 79.17 | 42.08 | 33.36 |
| 26.26 | 23.89 | 22.33 | 20.60 | 22.61 | 310.99 | 555.54 | 760.07 | 323.98 | 76.07 | 41.09 | 32.74 |
| 26.16 | 23.71 | 22.64 | 20.62 | 25.46 | 386.62 | 605.01 | 830.37 | 347.41 | 75.18 | 40.27 | 32.69 |
| 25.42 | 23.53 | 22.95 | 20.43 | 33.68 | 440.46 | 621.92 | 863.31 | 363.37 | 73.66 | 39.45 | 32.64 |
| 26.20 | 23.32 | 23.90 | 20.26 | 31.30 | 433.49 | 532.87 | 833.54 | 371.04 | 72.97 | 39.43 | 32.60 |
| 26.23 | 22.10 | 23.90 | 20.48 | 29.24 | 420.00 | 431.08 | 841.77 | 365.02 | 72.14 | 39.42 | 32.56 |
| 26.00 | 22.24 | 24.13 | 23.76 | 32.61 | 362.04 | 397.32 | 812.00 | 365.15 | 71.19 | 39.35 | 32.51 |
| 26.15 | 22.62 | 23.40 | 27.95 | 35.96 | 304.66 | 382.06 | 732.83 | 306.75 | 70.62 | 38.58 | 32.47 |
| 25.54 | 22.66 | 22.26 | 32.08 | 39.46 | 270.33 | 418.73 | 607.17 | 281.48 | 70.94 | 38.00 | 32.28 |
| 26.07 | 22.00 | 22.04 | 35.46 | 50.29 | 258.17 | 413.86 | 549.08 | 251.90 | 68.85 | 37.52 | 31.97 |
| 25.59 | 21.93 | 21.81 | 38.66 | 50.04 | 286.29 | 435.96 | 435.58 | 243.47 | 69.10 | 37.35 | 31.60 |
| 25.36 | 21.73 | 21.58 | 41.47 | 51.37 | 263.68 | 458.38 | 340.51 | 246.89 | 66.70 | 37.29 | 31.29 |
| 25.39 | 21.77 | 21.35 | 39.42 | 53.80 | 255.38 | 484.54 | 344.44 | 227.64 | 63.78 | 37.27 | 31.25 |
| 25.16 | 21.69 | 21.35 | 40.87 | 57.25 | 306.24 | 475.42 | 351.02 | 210.41 | 62.72 | 37.41 | 31.08 |
| 24.85 | 22.06 | 21.08 | 41.25 | 59.79 | 336.08 | 416.77 | 319.04 | 200.66 | 60.72 | 37.40 | 31.04 |
| 25.11 | 21.53 | 21.08 | 45.53 | 64.73 | 381.36 | 424.81 | 287.56 | 197.05 | 59.61 | 36.92 | 30.87 |
| 24.87 | 21.22 | 21.34 | 45.62 | 74.87 | 436.47 | 465.48 | 271.91 | 202.11 | 57.95 | 36.60 | 30.83 |
| 24.67 | 21.37 | 21.34 | 45.28 | 82.66 | 418.35 | 546.93 | 277.80 | 201.42 | 56.52 | 36.58 | 30.66 |
| 24.72 | 21.52 | 21.64 | 43.11 | 88.93 | 436.78 | 617.81 | 304.79 | 189.95 | 55.36 | 36.38 | 30.62 |
| 24.40 | - | 21.23 | 41.44 | 92.22 | 436.15 | 714.46 | 338.17 | 184.19 | 54.39 | 36.12 | 30.59 |
| 23.98 | - | 21.31 | 41.13 | 97.16 | 462.82 | 782.87 | 352.16 | 178.49 | 53.62 | 36.07 | 30.42 |
| 23.92 | - | 20.71 | - | 105.02 | - | 819.60 | 354.95 | - | 52.37 | - | 30.52 |
| **25.89** | **22.83** | **21.90** | **29.76** | **48.14** | **294.30** | **499.04** | **580.94** | **279.64** | **88.07** | **40.92** | **32.60** |



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|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 30.62 | 30.52 | 29.21 | 24.20 | 75.31 | 98.24 | 181.53 | 396.50 | 175.64 | 123.32 | 59.16 | 38.96 |
| 30.86 | 30.33 | 28.93 | 24.39 | 78.41 | 98.56 | 142.51 | 350.33 | 182.29 | 121.55 | 56.40 | 38.68 |
| 31.11 | 30.13 | 28.78 | 24.52 | 77.34 | 104.38 | 130.73 | 293.26 | 189.19 | 119.20 | 55.40 | 38.24 |
| 31.63 | 29.93 | 28.77 | 24.53 | 76.26 | 110.46 | 138.84 | 181.66 | 196.29 | 116.67 | 54.61 | 37.97 |
| 31.75 | 29.88 | 28.50 | 24.67 | 75.18 | 121.67 | 155.81 | 141.82 | 203.57 | 114.26 | 53.69 | 37.53 |
| 32.14 | 29.96 | 28.35 | 25.28 | 74.17 | 133.64 | 185.20 | 179.82 | 210.98 | 111.79 | 51.44 | 37.26 |
| 32.39 | 29.91 | 28.07 | 25.96 | 72.02 | 152.01 | 233.28 | 210.22 | 218.58 | 109.45 | 50.80 | 36.83 |
| 32.64 | 29.99 | 27.80 | 26.64 | 71.00 | 170.70 | 298.33 | 246.89 | 221.12 | 107.04 | 49.30 | 36.55 |
| 32.45 | 29.79 | 27.66 | 27.19 | 69.99 | 183.68 | 339.56 | 309.22 | 218.46 | 104.76 | 48.16 | 36.13 |
| 32.12 | 29.88 | 27.25 | 27.84 | 63.85 | 163.54 | 336.71 | 376.17 | 215.86 | 102.48 | 47.19 | 35.86 |
| 31.79 | 29.68 | 26.98 | 29.22 | 58.01 | 164.93 | 333.92 | 465.60 | 218.39 | 100.20 | 45.88 | 35.71 |
| 31.75 | 29.77 | 26.72 | 30.87 | 53.36 | 176.15 | 331.77 | 493.28 | 220.17 | 97.99 | 45.11 | 35.72 |
| 31.57 | 29.63 | 26.53 | 32.26 | 48.78 | 176.46 | 396.88 | 483.46 | 214.85 | 95.77 | 44.75 | 35.56 |
| 31.53 | 29.63 | 26.46 | 33.62 | 44.46 | 152.08 | 464.15 | 447.68 | 213.13 | 95.70 | 44.38 | 35.57 |
| 31.35 | 29.49 | 26.27 | 34.38 | 42.30 | 143.15 | 493.79 | 379.53 | 213.07 | 95.45 | 43.84 | 35.58 |
| 31.31 | 29.63 | 25.32 | 35.48 | 43.34 | 152.39 | 523.05 | 386.24 | 213.01 | 93.80 | 43.32 | 35.43 |
| 30.99 | 29.78 | 25.25 | 37.57 | 43.68 | 164.24 | 535.28 | 410.25 | 212.94 | 88.55 | 42.72 | 35.00 |
| 30.95 | 30.05 | 25.32 | 37.10 | 44.75 | 195.02 | 552.25 | 426.08 | 200.47 | 79.05 | 41.89 | 34.68 |
| 31.49 | 30.05 | 25.25 | 38.27 | 44.73 | 208.51 | 579.80 | 466.87 | 183.94 | 80.57 | 41.51 | 34.70 |
| 32.63 | 29.91 | 25.32 | 39.41 | 45.45 | 226.37 | 608.94 | 499.05 | 190.46 | 79.24 | 41.00 | 34.56 |
| 32.59 | 29.91 | 25.25 | 40.63 | 59.54 | 222.00 | 651.76 | 512.79 | 196.86 | 77.08 | 40.67 | 34.58 |
| 31.38 | 29.78 | 25.32 | 41.85 | 58.21 | 226.88 | 585.44 | 490.88 | 189.32 | 75.75 | 40.17 | 34.45 |
| 31.18 | 29.78 | 25.25 | 45.13 | 56.99 | 207.12 | 481.50 | 537.37 | 174.56 | 73.79 | 39.84 | 34.47 |
| 31.26 | 29.92 | 25.06 | 46.74 | 63.16 | 193.82 | 425.32 | 499.11 | 170.25 | 71.32 | 39.51 | 34.34 |
| 31.06 | 30.06 | 25.00 | 48.62 | 76.45 | 216.05 | 467.76 | 473.58 | 157.65 | 69.48 | 39.18 | 34.35 |
| 31.15 | 29.23 | 24.82 | 51.34 | 87.28 | 256.52 | 508.74 | 323.85 | 154.17 | 68.03 | 40.89 | 34.22 |
| 30.95 | 29.22 | 24.75 | 57.10 | 101.72 | 302.63 | 551.93 | 325.31 | 155.37 | 67.14 | 40.49 | 34.24 |
| 31.04 | 29.35 | 24.45 | 57.06 | 105.65 | 324.04 | 596.52 | 250.44 | 154.42 | 66.25 | 40.14 | 34.11 |
| 30.69 | - | 24.39 | 66.95 | 102.61 | 299.91 | 608.75 | 192.99 | 151.00 | 64.86 | 39.69 | 34.13 |
| 30.78 | - | 24.57 | 70.56 | 94.69 | 236.32 | 537.24 | 173.36 | 147.90 | 62.40 | 39.28 | 34.05 |
| 30.58 | - | 24.51 | - | 94.75 | - | 494.99 | 168.80 | - | 61.10 | - | 34.01 |
| **31.48** | **29.83** | **26.33** | **37.65** | **67.85** | **186.05** | **415.23** | **357.82** | **192.13** | **90.13** | **45.35** | **35.60** |



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|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 33.13 | 28.62 | 28.39 | 25.16 | 56.38 | 225.93 | 747.40 | 505.57 | 390.04 | 145.93 | 68.15 | 46.38 |
| 31.88 | 28.61 | 28.09 | 25.36 | 58.99 | 239.67 | 754.36 | 512.60 | 388.08 | 143.08 | 67.77 | 45.89 |
| 31.12 | 28.76 | 27.79 | 25.77 | 59.35 | 253.86 | 760.07 | 493.73 | 423.10 | 140.68 | 66.51 | 45.79 |
| 31.15 | 28.90 | 27.63 | 25.98 | 60.41 | 254.62 | 748.66 | 552.57 | 467.12 | 137.38 | 65.43 | 45.51 |
| 30.40 | 28.90 | 27.48 | 25.85 | 62.90 | 255.38 | 748.03 | 600.07 | 509.31 | 134.28 | 64.61 | 45.22 |
| 30.12 | 29.04 | 27.19 | 25.84 | 63.97 | 270.14 | 701.79 | 632.18 | 515.96 | 131.17 | 63.53 | 44.93 |
| 30.16 | 29.03 | 27.17 | 25.98 | 66.57 | 285.40 | 727.13 | 642.89 | 550.98 | 128.20 | 63.22 | 44.84 |
| 29.88 | 29.18 | 27.17 | 26.48 | 68.15 | 301.11 | 798.07 | 635.29 | 570.05 | 125.16 | 61.47 | 44.55 |
| 29.76 | 29.17 | 27.31 | 26.98 | 69.61 | 317.39 | 846.84 | 633.39 | 557.51 | 122.24 | 60.21 | 44.65 |
| 29.64 | 29.17 | 27.30 | 27.55 | 72.08 | 343.99 | 801.87 | 603.94 | 562.64 | 119.33 | 59.45 | 44.06 |
| 29.51 | 29.17 | 27.43 | 28.06 | 75.06 | 361.60 | 833.54 | 585.76 | 538.89 | 116.48 | 56.41 | 43.48 |
| 29.39 | 29.31 | 27.39 | 28.36 | 79.30 | 376.23 | 883.58 | 590.38 | 502.72 | 113.63 | 55.97 | 42.90 |
| 29.12 | 29.31 | 27.34 | 28.65 | 83.92 | 387.70 | 935.51 | 602.29 | 458.95 | 104.51 | 55.52 | 42.32 |
| 28.84 | 29.45 | 27.15 | 29.17 | 88.61 | 402.26 | 870.27 | 607.10 | 400.87 | 110.21 | 55.30 | 41.93 |
| 28.43 | 29.45 | 26.96 | 30.16 | 93.49 | 441.15 | 888.01 | 603.94 | 299.40 | 109.83 | 55.08 | 41.37 |
| 28.46 | 29.60 | 26.91 | 30.71 | 136.43 | 456.86 | 856.34 | 577.27 | 254.69 | 109.77 | 54.86 | 40.99 |
| 28.34 | 29.59 | 26.72 | 31.26 | 142.70 | 490.62 | 797.44 | 546.74 | 259.37 | 109.01 | 54.21 | 40.44 |
| 28.22 | 29.59 | 26.68 | 31.79 | 149.16 | 512.35 | 775.27 | 541.04 | 253.61 | 109.39 | 53.55 | 39.88 |
| 28.25 | 29.66 | 26.49 | 32.28 | 155.75 | 534.64 | 776.53 | 520.01 | 240.31 | 109.13 | 53.12 | 39.51 |
| 27.98 | 29.57 | 26.44 | 32.91 | 162.59 | 548.77 | 703.69 | 511.33 | 241.76 | 108.37 | 52.48 | 38.97 |
| 27.86 | 29.65 | 26.26 | 34.30 | 178.30 | 554.28 | 705.59 | 500.69 | 242.02 | 107.61 | 52.12 | 38.60 |
| 27.89 | 29.57 | 26.36 | 37.48 | 185.65 | 577.65 | 715.73 | 457.24 | 243.85 | 100.01 | 50.99 | 38.24 |
| 27.63 | 29.48 | 26.30 | 39.37 | 193.18 | 594.24 | 716.99 | 448.63 | 222.57 | 93.11 | 50.43 | 37.71 |
| 27.77 | 29.25 | 26.41 | 41.31 | 200.85 | 626.04 | 665.69 | 423.55 | 213.96 | 86.27 | 49.39 | 36.83 |
| 27.76 | 28.87 | 26.36 | 43.31 | 208.76 | 651.12 | 625.28 | 389.22 | 198.95 | 80.82 | 48.78 | 36.24 |
| 27.91 | 28.71 | 26.15 | 49.28 | 216.87 | 661.26 | 606.60 | 380.73 | 171.39 | 77.27 | 48.27 | 35.55 |
| 28.19 | 28.71 | 25.79 | 47.49 | 225.11 | 676.46 | 567.45 | 383.71 | 157.52 | 74.55 | 47.76 | 34.89 |
| 28.34 | 28.55 | 25.44 | 49.64 | 233.53 | 696.73 | 570.18 | 372.50 | 148.15 | 69.80 | 47.47 | 34.05 |
| 28.33 | - | 25.09 | 51.87 | 242.14 | 713.83 | 535.53 | 363.75 | 152.84 | 69.48 | 46.97 | 33.42 |
| 28.33 | - | 24.75 | 54.17 | 256.46 | 742.96 | 496.32 | 367.68 | 151.51 | 68.91 | 46.67 | 32.93 |
| 28.47 | - | 24.96 | - | 238.28 | - | 473.01 | 385.29 | - | 68.53 | - | 32.44 |
| **29.10** | **29.17** | **26.74** | **33.75** | **134.99** | **458.48** | **730.09** | **515.20** | **342.94** | **107.23** | **55.86** | **40.47** |



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| 1999 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 32.57 | 27.95 | 26.67 | 24.46 | 44.53 | 165.25 | 453.95 | 809.47 | 377.69 | 196.03 | 49.15 | 36.23 |
| 32.11 | 28.01 | 27.52 | 24.81 | 46.61 | 179.63 | 489.48 | 844.31 | 323.09 | 188.94 | 48.85 | 36.40 |
| 31.81 | 27.93 | 27.08 | 24.89 | 48.61 | 190.97 | 513.30 | 879.14 | 272.17 | 161.45 | 48.61 | 36.58 |
| 31.51 | 28.00 | 27.25 | 25.09 | 50.70 | 201.86 | 565.87 | 898.78 | 281.79 | 133.71 | 48.02 | 36.58 |
| 31.22 | 27.96 | 27.43 | 26.16 | 52.85 | 215.10 | 644.16 | 969.72 | 269.57 | 110.91 | 47.81 | 36.72 |
| 31.08 | 28.13 | 27.60 | 27.51 | 55.04 | 239.42 | 675.82 | 1025.45 | 258.17 | 93.55 | 47.40 | 36.76 |
| 30.93 | 28.19 | 27.93 | 28.76 | 57.32 | 269.00 | 682.79 | 1029.89 | 253.04 | 87.53 | 46.79 | 36.86 |
| 30.77 | 27.62 | 28.69 | 31.63 | 58.92 | 300.23 | 697.36 | 1032.42 | 245.75 | 81.64 | 46.32 | 36.70 |
| 30.62 | 27.11 | 31.07 | 34.61 | 60.39 | 310.93 | 724.60 | 1005.82 | 231.69 | 73.09 | 45.28 | 36.53 |
| 30.46 | 26.77 | 31.84 | 36.01 | 62.05 | 339.94 | 746.76 | 989.99 | 202.62 | 70.05 | 45.17 | 36.54 |
| 30.16 | 26.71 | 32.67 | 37.43 | 64.48 | 338.04 | 713.19 | 974.15 | 187.10 | 69.36 | 44.43 | 36.60 |
| 29.85 | 26.77 | 33.19 | 37.53 | 66.95 | 369.52 | 782.87 | 945.65 | 190.71 | 70.05 | 43.54 | 36.55 |
| 29.69 | 26.70 | 27.81 | 37.81 | 69.48 | 319.29 | 743.60 | 875.34 | 195.72 | 68.91 | 42.82 | 36.48 |
| 29.39 | 26.76 | 27.34 | 38.08 | 72.08 | 316.82 | 678.36 | 768.93 | 187.29 | 67.58 | 42.21 | 36.44 |
| 29.24 | 26.76 | 26.60 | 38.10 | 74.74 | 333.23 | 570.81 | 725.86 | 176.15 | 66.38 | 42.04 | 36.50 |
| 29.09 | 26.75 | 26.17 | 38.33 | 77.46 | 367.49 | 567.01 | 709.39 | 206.10 | 64.35 | 40.64 | 36.50 |
| 28.79 | 27.97 | 26.00 | 37.57 | 78.86 | 373.19 | 538.63 | 704.33 | 221.18 | 62.26 | 39.92 | 36.45 |
| 28.64 | 27.67 | 25.95 | 37.61 | 80.38 | 393.84 | 594.62 | 654.29 | 232.83 | 59.49 | 39.19 | 36.39 |
| 28.50 | 27.22 | 25.84 | 36.73 | 83.23 | 409.49 | 541.86 | 663.79 | 236.25 | 57.07 | 38.51 | 36.34 |
| 28.34 | 27.21 | 25.73 | 35.97 | 85.19 | 399.86 | 677.72 | 643.52 | 237.01 | 55.06 | 37.79 | 36.36 |
| 28.20 | 26.91 | 25.75 | 36.00 | 85.89 | 380.86 | 732.20 | 636.55 | 242.78 | 53.10 | 37.68 | 36.36 |
| 28.05 | 26.75 | 25.79 | 36.36 | 119.14 | 369.77 | 648.59 | 624.33 | 250.44 | 48.74 | 37.55 | 36.33 |
| 27.91 | 26.46 | 25.67 | 36.90 | 119.65 | 361.03 | 595.64 | 579.23 | 254.94 | 48.30 | 37.33 | 36.30 |
| 27.76 | 26.16 | 25.70 | 37.81 | 122.18 | 348.68 | 586.71 | 562.45 | 252.66 | 49.64 | 36.87 | 36.19 |
| 27.62 | 26.43 | 25.27 | 37.83 | 125.16 | 329.36 | 626.23 | 552.00 | 215.54 | 49.82 | 36.47 | 36.02 |
| 27.62 | 26.42 | 24.93 | 38.03 | 128.96 | 355.84 | 657.46 | 540.47 | 214.78 | 49.83 | 36.32 | 36.13 |
| 27.62 | 26.55 | 24.82 | 38.41 | 134.66 | 372.12 | 654.92 | 528.56 | 211.36 | 49.60 | 35.96 | 36.26 |
| 27.68 | 26.54 | 25.12 | 39.41 | 138.52 | 378.01 | 704.96 | 533.69 | 204.01 | 49.82 | 36.05 | 36.20 |
| 27.65 | - | 25.01 | 40.73 | 148.15 | 401.57 | 723.96 | 511.14 | 203.25 | 49.61 | 36.11 | 36.32 |
| 28.10 | - | 24.90 | 42.60 | 152.08 | 433.81 | 751.83 | 465.41 | 201.04 | 49.40 | 36.23 | 36.10 |
| 28.02 | - | 24.80 | - | 158.41 | - | 775.90 | 430.07 | - | 49.30 | - | 36.05 |
| **29.39** | **27.16** | **27.04** | **34.77** | **87.83** | **325.47** | **647.13** | **745.62** | **234.56** | **76.92** | **41.70** | **36.41** |



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| 2000 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 35.94 | 26.01 | 23.04 | 24.27 | 45.08 | 264.31 | 408.35 | 784.13 | 430.45 | 94.94 | 65.94 | 36.45 |
| 35.77 | 25.90 | 23.02 | 23.89 | 52.51 | 231.44 | 395.55 | 667.59 | 410.56 | 96.84 | 66.06 | 35.09 |
| 35.41 | 25.80 | 23.01 | 23.00 | 57.72 | 219.79 | 359.70 | 625.79 | 390.99 | 95.26 | 64.86 | 35.62 |
| 35.24 | 25.61 | 23.07 | 22.73 | 66.32 | 214.97 | 343.30 | 606.79 | 371.42 | 94.12 | 64.99 | 35.58 |
| 35.01 | 25.48 | 23.12 | 22.40 | 100.90 | 201.73 | 329.55 | 586.77 | 353.11 | 93.23 | 63.72 | 34.78 |
| 34.70 | 25.38 | 23.04 | 22.76 | 116.99 | 188.43 | 339.24 | 568.02 | 334.68 | 92.16 | 62.53 | 33.53 |
| 34.54 | 25.26 | 23.04 | 23.11 | 158.73 | 195.78 | 334.37 | 549.97 | 317.90 | 90.95 | 60.18 | 31.94 |
| 34.38 | 24.76 | 23.02 | 23.25 | 181.28 | 193.56 | 329.17 | 531.92 | 319.04 | 88.99 | 57.75 | 32.11 |
| 33.96 | 24.53 | 22.94 | 23.70 | 222.76 | 214.78 | 453.25 | 513.42 | 314.98 | 87.09 | 58.03 | 32.28 |
| 33.62 | 24.39 | 22.90 | 26.04 | 218.58 | 246.39 | 470.42 | 503.86 | 313.34 | 80.06 | 55.86 | 32.11 |
| 33.09 | 24.18 | 22.87 | 26.68 | 241.89 | 296.93 | 526.92 | 486.25 | 262.92 | 76.70 | 53.76 | 32.28 |
| 31.97 | 24.09 | 22.93 | 26.94 | 251.83 | 296.68 | 575.62 | 485.94 | 264.38 | 70.05 | 51.75 | 32.11 |
| 30.85 | 24.16 | 22.85 | 27.86 | 248.79 | 296.68 | 589.81 | 515.83 | 288.57 | 67.27 | 50.89 | 32.28 |
| 28.55 | 24.22 | 22.77 | 29.27 | 243.28 | 326.89 | 558.58 | 547.75 | 305.93 | 64.10 | 50.02 | 32.45 |
| 28.43 | 24.13 | 22.42 | 31.75 | 236.13 | 382.76 | 550.60 | 502.91 | 315.11 | 65.05 | 49.07 | 31.94 |
| 28.35 | 24.20 | 22.39 | 34.27 | 232.52 | 433.93 | 568.02 | 542.69 | 366.92 | 64.86 | 48.20 | 32.11 |
| 28.14 | 24.18 | 22.23 | 34.63 | 252.28 | 504.11 | 534.96 | 541.74 | 380.35 | 65.30 | 48.47 | 33.32 |
| 27.94 | 24.17 | 22.21 | 34.96 | 263.81 | 506.14 | 381.17 | 492.08 | 413.54 | 67.20 | 48.73 | 33.49 |
| 27.60 | 24.23 | 22.18 | 34.83 | 264.06 | 539.27 | 386.37 | 444.83 | 395.36 | 66.95 | 48.99 | 33.66 |
| 27.44 | 24.30 | 22.16 | 43.55 | 264.19 | 604.57 | 373.83 | 459.02 | 379.15 | 68.03 | 48.12 | 32.46 |
| 27.19 | 24.21 | 22.00 | 48.76 | 268.30 | 497.65 | 476.12 | 360.27 | 352.29 | 67.65 | 48.38 | 32.66 |
| 27.06 | 24.12 | 21.97 | 49.77 | 273.43 | 397.13 | 438.05 | 350.20 | 251.26 | 68.47 | 46.45 | 31.95 |
| 27.19 | 23.94 | 22.28 | 53.15 | 277.93 | 384.34 | 513.04 | 305.61 | 207.88 | 68.47 | 45.99 | 32.16 |
| 27.15 | 23.30 | 22.81 | 54.11 | 283.38 | 340.95 | 598.93 | 294.40 | 163.54 | 67.96 | 43.45 | 31.50 |
| 27.12 | 23.09 | 23.24 | 55.16 | 277.17 | 365.53 | 615.34 | 306.50 | 139.22 | 66.51 | 42.99 | 31.71 |
| 27.08 | 23.08 | 23.43 | 56.33 | 275.27 | 419.68 | 673.92 | 347.67 | 125.66 | 66.51 | 41.49 | 31.06 |
| 26.68 | 23.00 | 23.54 | 56.85 | 282.17 | 478.08 | 664.42 | 372.31 | 110.91 | 64.10 | 41.04 | 31.26 |
| 26.46 | 23.06 | 23.66 | 56.95 | 285.09 | 530.53 | 747.40 | 394.16 | 100.20 | 64.04 | 40.23 | 31.47 |
| 26.36 | - | 23.84 | 49.47 | 281.16 | 545.60 | 799.34 | 467.82 | 94.82 | 64.29 | 39.19 | 31.67 |
| 26.17 | - | 24.01 | 47.06 | 275.84 | 485.05 | 856.97 | 473.14 | 93.55 | 64.29 | 37.82 | 31.02 |
| 26.03 | - | 24.05 | - | 273.81 | - | 886.74 | 451.67 | - | 65.75 | - | 31.22 |
| **30.17** | **24.38** | **22.90** | **36.25** | **218.49** | **360.12** | **518.68** | **486.48** | **285.60** | **74.75** | **51.50** | **32.69** |



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| 2001 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 31.46 | 28.19 | 25.72 | 27.15 | 80.19 | 329.11 | 768.93 | 405.87 | 484.41 | 125.85 | 60.14 | 34.32 |
| 31.63 | 28.17 | 25.73 | 27.91 | 87.03 | 353.49 | 865.84 | 435.26 | 517.35 | 125.47 | 60.13 | 34.34 |
| 31.50 | 28.16 | 25.75 | 29.43 | 91.97 | 343.36 | 905.11 | 502.28 | 521.09 | 125.73 | 61.28 | 33.57 |
| 31.67 | 27.88 | 25.23 | 29.97 | 94.12 | 361.22 | 998.85 | 581.83 | 406.19 | 125.35 | 61.27 | 33.59 |
| 31.83 | 27.86 | 25.24 | 31.40 | 101.15 | 379.59 | 907.64 | 616.48 | 349.88 | 125.60 | 58.87 | 33.30 |
| 30.47 | 27.85 | 24.99 | 33.19 | 111.67 | 387.51 | 819.60 | 648.59 | 322.39 | 125.60 | 56.71 | 32.87 |
| 30.19 | 27.44 | 25.00 | 36.89 | 124.78 | 406.76 | 912.71 | 748.03 | 316.57 | 125.54 | 54.55 | 32.89 |
| 30.35 | 27.47 | 24.75 | 40.44 | 142.77 | 435.71 | 959.58 | 736.63 | 317.33 | 123.70 | 52.32 | 32.90 |
| 30.52 | 27.51 | 24.77 | 44.23 | 135.73 | 454.96 | 1031.79 | 703.06 | 337.34 | 125.41 | 50.31 | 32.17 |
| 30.19 | 27.14 | 24.78 | 46.21 | 131.74 | 491.57 | 948.18 | 660.62 | 335.76 | 123.57 | 48.26 | 31.89 |
| 30.31 | 27.17 | 24.79 | 45.55 | 149.42 | 505.63 | 986.18 | 681.53 | 335.13 | 116.35 | 46.28 | 31.90 |
| 30.45 | 26.94 | 24.81 | 48.00 | 175.26 | 631.49 | 1000.12 | 691.66 | 331.52 | 102.93 | 44.32 | 31.92 |
| 30.07 | 26.98 | 25.09 | 50.60 | 198.57 | 740.43 | 970.35 | 649.86 | 282.30 | 90.51 | 43.41 | 31.97 |
| 29.90 | 27.01 | 25.11 | 52.29 | 226.75 | 684.69 | 979.22 | 738.53 | 240.18 | 86.14 | 42.86 | 31.56 |
| 29.88 | 27.05 | 24.78 | 57.32 | 240.18 | 697.36 | 971.62 | 647.32 | 195.78 | 81.90 | 42.47 | 31.61 |
| 29.86 | 27.08 | 24.46 | 61.46 | 245.50 | 640.36 | 943.11 | 683.43 | 174.31 | 81.90 | 42.44 | 30.86 |
| 29.55 | 27.12 | 24.41 | 61.95 | 233.72 | 563.08 | 635.29 | 710.66 | 159.11 | 81.33 | 40.54 | 30.91 |
| 29.54 | 26.88 | 24.37 | 59.65 | 241.57 | 483.02 | 497.21 | 773.37 | 144.16 | 80.50 | 39.61 | 30.95 |
| 29.23 | 26.92 | 24.56 | 54.41 | 234.23 | 492.21 | 531.03 | 689.13 | 138.71 | 79.11 | 38.74 | 31.00 |
| 29.16 | 26.96 | 25.05 | 52.00 | 243.54 | 435.96 | 637.82 | 717.63 | 138.84 | 78.54 | 38.71 | 31.04 |
| 29.20 | 26.72 | 25.26 | 48.66 | 270.46 | 445.71 | 771.47 | 740.43 | 134.97 | 77.72 | 38.69 | 30.80 |
| 29.19 | 26.74 | 25.21 | 47.24 | 276.41 | 442.67 | 952.62 | 677.09 | 121.23 | 76.39 | 37.78 | 30.84 |
| 29.17 | 26.75 | 24.89 | 47.92 | 272.80 | 456.61 | 1050.79 | 678.99 | 119.65 | 72.46 | 37.76 | 30.88 |
| 28.91 | 25.91 | 24.83 | 50.70 | 259.94 | 425.89 | 1000.75 | 519.50 | 118.32 | 69.93 | 36.90 | 30.93 |
| 28.81 | 25.93 | 25.04 | 53.26 | 257.66 | 403.34 | 932.35 | 606.91 | 119.33 | 68.60 | 36.05 | 30.53 |
| 28.80 | 25.94 | 25.53 | 55.86 | 240.81 | 402.52 | 766.40 | 571.57 | 120.34 | 67.33 | 36.03 | 30.12 |
| 28.79 | 25.96 | 25.74 | 54.17 | 255.70 | 389.03 | 632.88 | 548.89 | 119.84 | 64.92 | 36.00 | 30.12 |
| 28.77 | 25.98 | 26.00 | 55.69 | 270.77 | 425.19 | 657.46 | 526.60 | 118.89 | 63.72 | 35.15 | 29.82 |
| 28.22 | - | 25.77 | 61.79 | 286.35 | 466.62 | 672.66 | 529.01 | 120.66 | 62.51 | 35.17 | 29.07 |
| 28.21 | - | 25.99 | 69.61 | 301.11 | 582.84 | 563.40 | 515.07 | 122.37 | 62.50 | 34.30 | 29.06 |
| 28.20 | - | 26.39 | - | 316.88 | - | 459.02 | 505.63 | - | 61.32 | - | 28.33 |
| **29.81** | **27.06** | **25.16** | **47.83** | **203.19** | **475.26** | **830.00** | **627.14** | **242.13** | **92.85** | **44.90** | **31.49** |



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|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 28.31 | 27.45 | 26.23 | 24.97 | 37.76 | 204.96 | 416.39 | 371.48 | 429.75 | 135.48 | 59.46 | 36.71 |
| 27.57 | 26.89 | 26.26 | 24.98 | 37.72 | 232.20 | 458.32 | 351.97 | 408.92 | 134.02 | 58.37 | 36.74 |
| 27.57 | 26.34 | 25.85 | 24.99 | 40.42 | 291.30 | 463.51 | 392.00 | 402.07 | 132.88 | 57.30 | 36.76 |
| 27.58 | 25.80 | 25.87 | 25.01 | 44.01 | 304.98 | 509.75 | 401.38 | 386.75 | 131.36 | 55.14 | 35.92 |
| 27.58 | 25.98 | 25.90 | 25.72 | 50.21 | 332.66 | 475.99 | 489.04 | 375.28 | 129.91 | 54.09 | 35.09 |
| 27.59 | 26.16 | 27.10 | 25.75 | 58.71 | 331.01 | 528.31 | 541.61 | 371.10 | 128.45 | 53.05 | 35.12 |
| 27.60 | 26.34 | 27.13 | 26.49 | 59.70 | 322.14 | 494.11 | 594.50 | 340.95 | 126.99 | 52.03 | 34.29 |
| 27.61 | 25.80 | 27.15 | 26.51 | 58.58 | 333.23 | 469.66 | 673.92 | 332.47 | 121.74 | 51.01 | 34.32 |
| 27.62 | 25.98 | 25.72 | 25.79 | 63.17 | 353.68 | 445.14 | 691.03 | 316.44 | 120.79 | 50.00 | 33.51 |
| 27.64 | 26.17 | 25.74 | 26.54 | 71.64 | 361.66 | 466.43 | 754.36 | 310.42 | 118.82 | 49.01 | 34.37 |
| 27.67 | 26.35 | 25.77 | 28.05 | 83.04 | 367.17 | 405.11 | 787.93 | 285.59 | 113.76 | 48.02 | 34.39 |
| 27.70 | 26.53 | 25.08 | 29.15 | 88.61 | 361.28 | 374.65 | 839.87 | 268.30 | 111.86 | 47.05 | 34.41 |
| 28.48 | 26.72 | 25.10 | 31.69 | 100.14 | 384.21 | 378.77 | 749.93 | 258.87 | 106.92 | 46.09 | 35.29 |
| 28.51 | 26.73 | 24.99 | 32.37 | 109.26 | 420.13 | 370.66 | 669.49 | 250.12 | 100.58 | 42.30 | 35.31 |
| 28.24 | 26.74 | 24.16 | 32.40 | 115.47 | 408.28 | 354.25 | 538.06 | 246.96 | 97.35 | 41.41 | 34.49 |
| 28.26 | 26.76 | 24.05 | 33.75 | 118.57 | 421.39 | 377.56 | 465.98 | 254.24 | 95.58 | 40.54 | 33.67 |
| 28.29 | 26.77 | 24.64 | 35.46 | 130.16 | 428.42 | 420.38 | 397.96 | 248.73 | 93.87 | 40.59 | 33.37 |
| 27.86 | 26.79 | 24.52 | 37.22 | 145.49 | 364.77 | 470.29 | 411.89 | 245.69 | 92.16 | 40.64 | 32.89 |
| 27.89 | 26.80 | 24.69 | 39.04 | 124.71 | 306.56 | 484.92 | 431.15 | 237.33 | 90.51 | 39.78 | 32.92 |
| 27.17 | 26.82 | 25.00 | 42.00 | 130.67 | 291.23 | 530.72 | 442.10 | 212.69 | 88.80 | 39.83 | 32.45 |
| 27.20 | 26.75 | 24.60 | 47.24 | 136.18 | 281.48 | 534.33 | 462.88 | 192.04 | 87.09 | 39.88 | 32.15 |
| 26.49 | 26.11 | 23.37 | 52.82 | 141.75 | 309.03 | 541.93 | 518.11 | 202.37 | 82.78 | 39.92 | 32.17 |
| 26.51 | 26.12 | 23.26 | 54.98 | 147.39 | 352.23 | 442.93 | 541.29 | 196.79 | 81.26 | 39.07 | 32.20 |
| 26.70 | 26.14 | 24.54 | 57.20 | 153.09 | 383.20 | 384.72 | 587.34 | 184.70 | 79.93 | 39.12 | 32.22 |
| 26.89 | 26.15 | 25.85 | 57.17 | 159.74 | 375.47 | 398.78 | 617.24 | 171.20 | 76.07 | 38.27 | 31.92 |
| 27.07 | 26.17 | 27.20 | 48.69 | 165.69 | 378.39 | 435.52 | 640.99 | 153.34 | 74.87 | 37.97 | 32.01 |
| 27.26 | 26.18 | 27.08 | 44.71 | 163.16 | 373.19 | 398.91 | 573.72 | 146.63 | 72.33 | 38.02 | 32.09 |
| 27.44 | 26.20 | 27.39 | 42.77 | 172.03 | 411.77 | 394.54 | 542.94 | 132.76 | 73.66 | 37.51 | 31.69 |
| 27.63 | - | 26.37 | 39.97 | 180.39 | 459.33 | 407.90 | 562.64 | 128.89 | 71.19 | 37.53 | 31.78 |
| 27.82 | - | 25.65 | 37.26 | 186.98 | 431.21 | 406.95 | 571.44 | 120.47 | 69.99 | 36.69 | 31.54 |
| 28.01 | - | 24.96 | - | 195.72 | - | 404.54 | 573.34 | - | 66.38 | - | 31.30 |
| **27.61** | **26.42** | **25.52** | **36.02** | **111.94** | **352.55** | **440.19** | **554.44** | **260.40** | **100.24** | **44.99** | **33.65** |



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|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 29.71 | 29.03 | 23.55 | 22.24 | 65.24 | 133.96 | 584.62 | 732.83 | 452.30 | 120.15 | 70.94 | 42.73 |
| 28.97 | 28.68 | 23.56 | 22.17 | 62.01 | 141.63 | 615.53 | 773.37 | 461.04 | 112.87 | 71.07 | 43.05 |
| 29.07 | 28.33 | 22.80 | 22.68 | 58.95 | 227.07 | 656.19 | 819.60 | 493.16 | 109.32 | 71.70 | 42.15 |
| 29.18 | 27.58 | 22.81 | 22.61 | 47.16 | 260.01 | 701.16 | 753.10 | 517.60 | 105.97 | 71.70 | 41.56 |
| 29.28 | 27.57 | 22.66 | 22.54 | 43.56 | 282.62 | 744.86 | 649.22 | 499.24 | 106.47 | 70.18 | 41.18 |
| 29.39 | 27.57 | 22.24 | 22.77 | 38.55 | 293.83 | 760.07 | 582.21 | 481.44 | 107.30 | 68.22 | 40.79 |
| 29.83 | 27.27 | 22.25 | 23.32 | 38.19 | 316.69 | 713.83 | 577.14 | 460.22 | 108.88 | 67.52 | 40.82 |
| 29.85 | 27.28 | 22.83 | 23.85 | 41.22 | 332.97 | 661.89 | 541.23 | 383.01 | 105.14 | 65.56 | 40.44 |
| 29.74 | 27.29 | 22.84 | 25.77 | 47.72 | 326.51 | 627.43 | 538.32 | 357.93 | 98.94 | 64.86 | 40.46 |
| 29.65 | 27.29 | 22.54 | 28.18 | 51.48 | 286.61 | 615.27 | 531.98 | 337.98 | 96.08 | 62.85 | 40.90 |
| 29.67 | 27.30 | 22.55 | 30.28 | 53.26 | 282.93 | 595.38 | 448.06 | 332.66 | 90.13 | 62.19 | 40.92 |
| 29.69 | 26.55 | 22.42 | 32.16 | 49.06 | 276.60 | 615.97 | 420.19 | 326.32 | 84.24 | 61.53 | 40.54 |
| 29.55 | 26.55 | 22.28 | 34.54 | 46.62 | 256.90 | 601.15 | 427.73 | 331.07 | 80.19 | 60.46 | 39.68 |
| 29.57 | 26.56 | 21.88 | 37.41 | 45.25 | 263.17 | 622.18 | 408.03 | 339.81 | 79.05 | 59.56 | 39.32 |
| 29.60 | 25.04 | 21.75 | 38.73 | 45.52 | 292.88 | 649.86 | 385.92 | 336.58 | 77.91 | 58.04 | 38.97 |
| 29.62 | 25.04 | 21.21 | 44.31 | 47.70 | 330.95 | 716.36 | 387.70 | 311.94 | 79.68 | 57.67 | 38.99 |
| 30.49 | 25.05 | 21.07 | 40.37 | 57.23 | 350.58 | 684.69 | 445.84 | 297.50 | 77.21 | 56.85 | 38.64 |
| 30.52 | 25.06 | 20.62 | 38.75 | 65.11 | 384.21 | 663.79 | 508.04 | 326.19 | 76.07 | 55.78 | 37.92 |
| 30.54 | 25.83 | 20.50 | 38.01 | 77.84 | 372.05 | 737.90 | 551.62 | 350.83 | 74.99 | 54.24 | 37.19 |
| 30.05 | 25.84 | 20.68 | 36.89 | 84.49 | 408.66 | 838.61 | 531.60 | 340.32 | 73.85 | 52.69 | 36.47 |
| 30.08 | 25.08 | 20.55 | 35.79 | 97.42 | 448.38 | 895.61 | 440.65 | 329.87 | 72.84 | 52.37 | 36.50 |
| 29.93 | 24.27 | 20.83 | 34.05 | 111.79 | 474.79 | 932.35 | 374.46 | 335.25 | 71.70 | 50.94 | 36.08 |
| 29.95 | 24.28 | 20.69 | 34.68 | 117.87 | 455.91 | 1026.72 | 369.52 | 333.16 | 69.29 | 49.51 | 36.11 |
| 30.15 | 24.28 | 20.57 | 39.04 | 122.37 | 465.03 | 1015.32 | 381.24 | 309.79 | 69.67 | 48.08 | 36.94 |
| 28.98 | 23.52 | 20.43 | 42.96 | 132.50 | 502.72 | 934.88 | 412.53 | 255.19 | 68.66 | 47.76 | 36.86 |
| 29.01 | 23.83 | 20.98 | 54.88 | 141.31 | 568.21 | 896.24 | 454.84 | 218.90 | 68.91 | 46.33 | 36.41 |
| 29.03 | 23.84 | 21.87 | 51.25 | 140.11 | 623.57 | 848.11 | 464.15 | 188.18 | 67.96 | 44.95 | 35.89 |
| 29.91 | 23.85 | 22.09 | 48.75 | 136.94 | 547.56 | 806.30 | 484.48 | 153.53 | 68.22 | 43.63 | 35.44 |
| 29.59 | - | 23.38 | 49.87 | 134.59 | 551.55 | 785.40 | 488.09 | 141.12 | 68.53 | 43.33 | 34.99 |
| 29.57 | - | 24.23 | 57.76 | 130.48 | 557.32 | 738.53 | 489.99 | 129.72 | 69.61 | 43.03 | 34.91 |
| 29.05 | - | 25.08 | - | 128.77 | - | 735.36 | 477.64 | - | 70.24 | - | 35.58 |
| **29.65** | **26.06** | **22.06** | **35.22** | **79.37** | **367.20** | **742.63** | **511.33** | **337.73** | **84.84** | **57.78** | **38.66** |



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| 2004 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 55.45 | 49.37 | 45.38 | 53.48 | 85.86 | 167.10 | 545.40 | 738.80 | 553.10 | 233.10 | 96.99 | 69.22 |
| 54.74 | 48.16 | 45.35 | 56.24 | 81.31 | 155.30 | 619.60 | 724.40 | 508.00 | 231.80 | 94.80 | 68.55 |
| 54.02 | 48.19 | 45.31 | 57.43 | 74.97 | 169.80 | 651.90 | 611.50 | 494.80 | 218.20 | 93.37 | 66.91 |
| 53.90 | 47.78 | 45.28 | 59.21 | 70.71 | 190.40 | 683.80 | 492.40 | 483.90 | 211.00 | 92.32 | 65.60 |
| 53.18 | 48.00 | 44.97 | 61.38 | 64.88 | 213.40 | 722.60 | 570.50 | 520.70 | 201.00 | 90.89 | 65.57 |
| 53.06 | 48.22 | 44.94 | 70.74 | 65.59 | 236.50 | 764.30 | 712.60 | 525.80 | 188.00 | 89.84 | 64.15 |
| 53.52 | 47.90 | 44.64 | 79.53 | 68.03 | 254.30 | 807.20 | 822.50 | 564.50 | 186.00 | 88.41 | 63.48 |
| 52.51 | 48.11 | 44.60 | 76.97 | 73.73 | 286.80 | 857.20 | 882.90 | 608.50 | 183.40 | 87.23 | 63.45 |
| 52.68 | 48.87 | 45.10 | 7.63 | 87.16 | 313.90 | 837.10 | 953.20 | 617.10 | 168.50 | 86.93 | 63.43 |
| 52.01 | 48.55 | 47.30 | 74.54 | 93.79 | 342.30 | 684.60 | 802.50 | 633.80 | 154.60 | 85.50 | 62.44 |
| 51.90 | 48.76 | 46.73 | 72.50 | 108.80 | 364.10 | 650.40 | 794.90 | 614.40 | 146.00 | 84.72 | 62.41 |
| 51.79 | 48.17 | 45.63 | 70.57 | 131.80 | 382.70 | 678.40 | 691.60 | 598.90 | 137.80 | 84.00 | 62.38 |
| 52.21 | 48.39 | 46.13 | 67.25 | 149.90 | 440.80 | 737.90 | 672.60 | 618.80 | 134.50 | 82.92 | 62.36 |
| 52.10 | 48.07 | 46.63 | 61.44 | 172.10 | 486.10 | 738.60 | 705.20 | 628.10 | 133.50 | 81.14 | 62.34 |
| 51.81 | 47.48 | 47.13 | 61.31 | 201.70 | 533.50 | 768.70 | 797.30 | 611.20 | 130.40 | 80.06 | 61.72 |
| 52.05 | 47.70 | 47.09 | 61.47 | 226.80 | 583.60 | 774.20 | 889.60 | 592.80 | 124.80 | 78.17 | 61.83 |
| 51.23 | 47.92 | 48.13 | 61.93 | 254.50 | 636.80 | 707.40 | 1029.00 | 526.50 | 121.70 | 78.14 | 61.93 |
| 51.48 | 48.13 | 49.17 | 62.49 | 288.80 | 693.80 | 651.00 | 917.00 | 453.90 | 120.90 | 77.41 | 60.56 |
| 51.19 | 47.62 | 49.14 | 62.99 | 320.90 | 752.40 | 548.80 | 800.50 | 412.40 | 117.90 | 76.69 | 60.67 |
| 51.44 | 47.65 | 48.83 | 69.40 | 337.60 | 800.10 | 525.20 | 719.90 | 375.20 | 114.70 | 75.61 | 60.19 |
| 51.15 | 46.87 | 48.26 | 69.90 | 331.10 | 720.10 | 545.50 | 701.10 | 337.10 | 109.70 | 75.58 | 59.70 |
| 51.93 | 46.90 | 47.43 | 70.40 | 340.20 | 648.40 | 533.90 | 654.70 | 293.40 | 108.80 | 74.50 | 59.81 |
| 52.18 | 46.93 | 46.85 | 68.64 | 362.30 | 568.30 | 508.20 | 626.20 | 253.80 | 106.00 | 74.47 | 58.04 |
| 51.89 | 46.96 | 48.70 | 72.36 | 344.40 | 550.20 | 505.00 | 661.70 | 233.50 | 107.20 | 73.75 | 58.74 |
| 50.98 | 46.72 | 48.44 | 74.59 | 282.80 | 452.10 | 591.80 | 686.50 | 227.10 | 106.40 | 72.38 | 56.78 |
| 50.69 | 46.68 | 48.98 | 78.75 | 260.30 | 422.50 | 644.20 | 674.20 | 226.30 | 106.90 | 70.96 | 55.41 |
| 50.40 | 46.11 | 48.72 | 88.80 | 236.20 | 386.60 | 764.90 | 651.00 | 233.70 | 108.20 | 70.93 | 55.52 |
| 50.11 | 46.08 | 48.99 | 104.60 | 227.70 | 402.40 | 810.10 | 600.30 | 239.30 | 105.30 | 70.26 | 57.10 |
| 49.79 | 45.42 | 49.35 | 114.40 | 221.20 | 422.70 | 882.30 | 652.50 | 248.00 | 104.10 | 69.27 | 57.79 |
| 49.47 | - | 49.63 | 126.40 | 228.80 | 501.50 | 854.80 | 602.50 | 239.80 | 101.80 | 69.25 | 58.78 |
| 49.15 | - | 51.51 | - | 230.40 | - | 812.80 | 575.00 | - | 99.44 | - | 58.89 |
| **51.94** | **47.65** | **47.24** | **70.58** | **194.33** | **435.95** | **690.57** | **723.05** | **449.15** | **142.63** | **80.88** | **61.48** |



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|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 55.23 | 50.42 | 43.73 | 33.52 | 109.15 | 102.79 | 1520.83 | 736.93 | 350.56 | 135.02 | 61.52 | 52.35 |
| 55.10 | 50.29 | 42.93 | 33.53 | 130.65 | 118.05 | 1244.42 | 702.10 | 346.75 | 129.82 | 60.18 | 52.69 |
| 54.96 | 50.39 | 42.33 | 36.02 | 154.92 | 142.15 | 1156.52 | 715.92 | 337.74 | 124.68 | 59.27 | 52.82 |
| 54.83 | 50.49 | 41.53 | 35.20 | 184.72 | 190.08 | 1072.49 | 743.56 | 333.92 | 122.47 | 57.70 | 52.50 |
| 54.69 | 50.37 | 40.54 | 34.45 | 211.81 | 212.14 | 846.39 | 693.26 | 325.91 | 119.65 | 56.13 | 52.19 |
| 54.56 | 50.24 | 39.64 | 38.12 | 234.03 | 277.98 | 749.09 | 669.49 | 323.37 | 117.00 | 54.37 | 51.87 |
| 54.42 | 50.34 | 39.10 | 40.08 | 253.49 | 269.02 | 691.05 | 614.20 | 330.72 | 113.68 | 52.95 | 51.78 |
| 54.29 | 50.44 | 38.56 | 41.45 | 272.67 | 241.16 | 681.10 | 583.80 | 340.39 | 111.25 | 52.27 | 51.47 |
| 54.15 | 50.32 | 37.86 | 41.73 | 284.34 | 242.71 | 740.80 | 556.49 | 345.81 | 108.82 | 51.70 | 50.86 |
| 54.03 | 50.42 | 37.33 | 43.18 | 263.72 | 255.59 | 850.26 | 527.63 | 350.79 | 106.94 | 51.36 | 50.54 |
| 54.13 | 50.16 | 36.62 | 43.78 | 228.89 | 238.51 | 1105.11 | 428.46 | 359.74 | 104.39 | 51.31 | 50.23 |
| 54.01 | 49.90 | 36.08 | 45.10 | 237.57 | 255.87 | 1381.52 | 446.31 | 349.29 | 102.07 | 51.48 | 50.14 |
| 54.10 | 49.86 | 35.55 | 46.11 | 234.75 | 269.24 | 1427.96 | 433.54 | 340.95 | 99.03 | 51.43 | 50.05 |
| 53.98 | 49.53 | 35.51 | 45.95 | 231.43 | 282.68 | 1559.53 | 420.88 | 327.24 | 97.04 | 51.38 | 49.73 |
| 53.86 | 49.49 | 35.29 | 47.93 | 232.65 | 312.97 | 1602.10 | 413.09 | 322.65 | 96.05 | 51.33 | 49.64 |
| 53.52 | 49.23 | 35.25 | 49.97 | 235.85 | 367.65 | 1641.35 | 401.92 | 305.79 | 94.83 | 51.28 | 48.83 |
| 53.40 | 49.19 | 35.21 | 52.24 | 237.73 | 426.36 | 1661.25 | 408.22 | 279.91 | 93.39 | 51.46 | 48.02 |
| 53.50 | 48.93 | 34.94 | 56.01 | 240.55 | 507.34 | 1361.07 | 402.92 | 263.05 | 92.84 | 51.19 | 47.15 |
| 53.38 | 48.89 | 34.90 | 58.69 | 231.49 | 500.54 | 1080.79 | 404.52 | 253.10 | 91.90 | 51.14 | 46.20 |
| 53.26 | 48.63 | 34.69 | 60.74 | 217.72 | 504.03 | 1114.51 | 409.00 | 237.57 | 91.07 | 51.09 | 45.48 |
| 53.14 | 48.38 | 34.64 | 63.29 | 211.14 | 617.52 | 1157.63 | 404.63 | 220.54 | 89.74 | 51.04 | 44.56 |
| 53.01 | 48.12 | 34.45 | 65.42 | 207.77 | 845.28 | 1182.50 | 400.87 | 201.19 | 88.97 | 51.00 | 43.84 |
| 52.38 | 47.86 | 34.41 | 69.68 | 205.45 | 945.90 | 1198.54 | 394.57 | 167.97 | 87.15 | 51.16 | 42.99 |
| 52.04 | 47.60 | 34.37 | 73.38 | 198.10 | 1047.06 | 1129.43 | 386.88 | 145.25 | 84.93 | 51.04 | 41.93 |
| 51.92 | 46.72 | 34.19 | 76.42 | 189.86 | 1170.34 | 1093.50 | 380.75 | 130.60 | 82.17 | 51.38 | 41.07 |
| 51.80 | 45.93 | 34.15 | 81.89 | 170.35 | 1299.15 | 1037.11 | 380.69 | 132.26 | 79.46 | 51.51 | 40.06 |
| 51.68 | 45.32 | 33.81 | 89.91 | 149.84 | 1453.94 | 993.99 | 377.21 | 135.30 | 76.92 | 51.63 | 39.29 |
| 51.34 | 44.72 | 33.77 | 92.07 | 129.82 | 1581.64 | 966.35 | 372.01 | 139.28 | 72.55 | 51.98 | 38.36 |
| 51.22 | - | 33.58 | 95.55 | 114.68 | 1582.75 | 908.31 | 367.76 | 144.80 | 70.39 | 52.10 | 37.42 |
| 50.87 | - | 33.55 | 99.86 | 102.40 | 1611.49 | 853.02 | 359.19 | 142.32 | 67.47 | 52.22 | 37.39 |
| 50.54 | - | 33.36 | - | 92.12 | - | 776.18 | 356.81 | - | 63.05 | - | 37.18 |
| **53.33** | **49.01** | **36.51** | **56.38** | **199.99** | **595.73** | **1122.09** | **480.44** | **266.16** | **97.25** | **52.85** | **46.73** |



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|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 37.15 | 34.98 | 34.84 | 31.28 | 76.81 | 265.93 | 501.10 | 615.31 | 304.24 | 127.34 | 73.27 | 64.26 |
| 36.92 | 34.99 | 35.01 | 31.03 | 58.28 | 255.65 | 488.83 | 608.12 | 301.03 | 124.90 | 72.88 | 64.09 |
| 36.89 | 34.99 | 34.99 | 31.13 | 60.94 | 252.88 | 501.87 | 621.39 | 293.96 | 121.70 | 72.39 | 63.71 |
| 36.67 | 35.20 | 34.96 | 31.24 | 68.46 | 261.56 | 474.78 | 633.55 | 273.72 | 120.70 | 71.94 | 63.57 |
| 36.65 | 35.20 | 34.94 | 31.53 | 82.78 | 241.49 | 440.51 | 671.15 | 254.10 | 119.37 | 71.72 | 63.18 |
| 36.51 | 35.21 | 34.72 | 31.64 | 95.11 | 224.41 | 470.64 | 657.32 | 240.88 | 116.61 | 71.61 | 62.42 |
| 36.39 | 35.22 | 34.69 | 31.83 | 112.63 | 216.23 | 479.70 | 633.00 | 238.34 | 113.85 | 71.39 | 61.79 |
| 36.45 | 35.22 | 34.48 | 32.03 | 127.22 | 203.24 | 492.36 | 554.33 | 227.95 | 111.14 | 71.28 | 61.32 |
| 36.32 | 35.24 | 34.45 | 32.23 | 155.47 | 193.29 | 501.04 | 489.60 | 220.98 | 109.48 | 70.78 | 60.89 |
| 36.39 | 35.19 | 34.40 | 32.24 | 167.25 | 187.10 | 513.87 | 478.65 | 216.06 | 107.82 | 70.34 | 59.97 |
| 36.46 | 35.15 | 34.35 | 32.44 | 191.02 | 190.36 | 522.27 | 488.11 | 208.93 | 106.49 | 69.90 | 59.25 |
| 36.33 | 35.10 | 34.30 | 32.45 | 229.33 | 184.77 | 533.44 | 479.15 | 201.47 | 101.91 | 69.73 | 58.54 |
| 36.40 | 35.06 | 34.25 | 32.10 | 260.45 | 175.98 | 552.45 | 496.62 | 192.90 | 99.31 | 69.57 | 57.72 |
| 36.47 | 35.01 | 34.20 | 32.09 | 297.33 | 181.07 | 513.92 | 481.64 | 186.27 | 96.99 | 69.40 | 57.30 |
| 36.34 | 34.96 | 34.35 | 32.07 | 334.98 | 225.30 | 479.81 | 469.03 | 181.46 | 94.72 | 69.12 | 57.00 |
| 36.21 | 34.73 | 34.30 | 32.06 | 360.13 | 233.53 | 451.62 | 459.25 | 176.48 | 91.84 | 68.90 | 56.70 |
| 36.27 | 34.71 | 34.12 | 31.68 | 352.06 | 263.99 | 391.25 | 442.72 | 172.56 | 90.19 | 68.68 | 56.40 |
| 36.15 | 34.69 | 33.75 | 31.66 | 354.60 | 272.78 | 342.16 | 419.17 | 166.97 | 88.03 | 68.52 | 56.10 |
| 36.02 | 34.68 | 33.38 | 31.65 | 290.58 | 281.08 | 287.65 | 456.87 | 163.43 | 86.26 | 68.24 | 55.80 |
| 35.97 | 34.66 | 33.02 | 31.64 | 300.59 | 302.86 | 257.97 | 481.53 | 159.12 | 85.76 | 67.85 | 55.50 |
| 35.93 | 34.64 | 32.66 | 31.91 | 312.97 | 318.34 | 263.00 | 471.47 | 154.92 | 85.27 | 67.69 | 55.20 |
| 35.88 | 34.63 | 32.31 | 32.37 | 338.07 | 332.32 | 285.50 | 462.90 | 160.23 | 84.93 | 67.47 | 55.15 |
| 35.84 | 34.61 | 31.95 | 36.48 | 344.37 | 375.72 | 325.58 | 451.90 | 165.31 | 83.83 | 67.02 | 54.86 |
| 35.79 | 34.58 | 31.85 | 42.68 | 348.46 | 411.21 | 406.23 | 455.38 | 151.99 | 82.11 | 66.69 | 54.32 |
| 35.75 | 34.75 | 31.75 | 49.24 | 321.54 | 446.31 | 429.56 | 437.47 | 135.74 | 80.62 | 66.25 | 54.02 |
| 35.71 | 34.73 | 31.83 | 54.42 | 326.85 | 470.47 | 519.84 | 439.73 | 133.69 | 79.24 | 65.70 | 53.73 |
| 35.52 | 34.70 | 31.73 | 62.47 | 331.22 | 498.44 | 574.95 | 443.11 | 131.15 | 77.86 | 65.36 | 53.44 |
| 35.52 | 34.87 | 31.63 | 69.84 | 312.53 | 523.38 | 626.92 | 397.89 | 131.54 | 76.81 | 65.03 | 53.39 |
| 35.34 | - | 31.71 | 80.90 | 296.00 | 519.17 | 586.01 | 363.22 | 129.77 | 75.26 | 64.70 | 53.10 |
| 35.15 | - | 31.79 | 83.50 | 298.93 | 509.11 | 652.35 | 333.32 | 127.67 | 74.54 | 64.65 | 52.81 |
| 34.97 | - | 31.54 | - | 281.08 | - | 605.91 | 311.92 | - | 74.04 | - | 52.52 |
| **36.14** | **34.92** | **33.49** | **39.33** | **241.55** | **300.60** | **466.87** | **490.48** | **193.43** | **96.42** | **68.94** | **57.68** |



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|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 57.31 | 42.73 | 30.04 | 34.94 | 40.42 | 274.94 | 322.87 | 348.41 | 208.88 | 134.14 | 62.51 | 50.02 |
| 56.07 | 42.30 | 30.29 | 34.83 | 50.42 | 284.61 | 337.35 | 348.52 | 207.61 | 131.59 | 60.98 | 49.47 |
| 54.70 | 41.33 | 30.70 | 34.92 | 63.76 | 323.14 | 353.88 | 350.12 | 204.68 | 128.55 | 59.68 | 48.69 |
| 53.93 | 40.66 | 31.11 | 34.96 | 69.95 | 333.70 | 374.83 | 350.56 | 203.40 | 125.68 | 58.93 | 47.91 |
| 53.87 | 39.96 | 31.97 | 35.19 | 74.21 | 350.56 | 395.73 | 362.06 | 199.64 | 123.24 | 57.19 | 47.67 |
| 52.63 | 39.11 | 32.65 | 35.48 | 78.02 | 374.83 | 425.47 | 373.89 | 196.60 | 120.43 | 55.92 | 47.42 |
| 51.59 | 38.37 | 32.84 | 35.52 | 84.55 | 406.68 | 483.41 | 387.11 | 200.20 | 117.94 | 55.17 | 47.18 |
| 50.55 | 37.89 | 32.95 | 35.75 | 89.36 | 430.06 | 425.86 | 336.36 | 204.07 | 115.12 | 54.48 | 46.93 |
| 50.63 | 37.62 | 33.28 | 35.98 | 97.43 | 446.53 | 403.30 | 357.09 | 208.88 | 112.74 | 54.24 | 46.92 |
| 50.26 | 37.55 | 33.56 | 36.02 | 110.75 | 462.34 | 431.61 | 358.14 | 207.38 | 110.09 | 54.00 | 46.91 |
| 49.91 | 36.98 | 33.57 | 36.19 | 119.10 | 479.98 | 415.69 | 342.44 | 204.34 | 107.71 | 54.00 | 46.66 |
| 49.91 | 36.56 | 34.06 | 36.18 | 133.08 | 516.19 | 432.99 | 400.87 | 203.62 | 105.39 | 53.78 | 46.76 |
| 49.63 | 36.17 | 33.51 | 36.36 | 152.71 | 529.90 | 439.79 | 386.22 | 200.20 | 102.74 | 53.55 | 46.63 |
| 49.43 | 35.93 | 34.01 | 36.34 | 172.94 | 565.00 | 432.27 | 385.01 | 201.19 | 100.52 | 54.02 | 46.20 |
| 49.10 | 35.68 | 34.12 | 36.32 | 199.48 | 609.78 | 419.45 | 381.80 | 199.87 | 97.93 | 53.80 | 46.30 |
| 48.82 | 35.55 | 34.23 | 36.50 | 222.81 | 572.74 | 407.56 | 358.30 | 196.27 | 95.77 | 53.27 | 45.96 |
| 48.49 | 35.52 | 34.15 | 36.48 | 256.47 | 539.13 | 422.65 | 336.52 | 193.45 | 93.56 | 52.81 | 45.84 |
| 48.63 | 35.44 | 34.26 | 36.60 | 284.50 | 541.18 | 417.35 | 310.15 | 189.36 | 90.96 | 52.36 | 45.72 |
| 47.99 | 35.41 | 34.19 | 36.51 | 311.65 | 551.85 | 431.17 | 297.94 | 181.68 | 88.91 | 52.60 | 45.25 |
| 47.44 | 35.36 | 34.30 | 36.62 | 322.76 | 554.78 | 437.80 | 289.98 | 173.61 | 86.81 | 52.61 | 44.36 |
| 46.87 | 35.19 | 34.32 | 36.54 | 346.75 | 534.27 | 451.79 | 289.09 | 169.24 | 84.49 | 52.53 | 43.68 |
| 46.12 | 34.40 | 34.54 | 36.46 | 361.23 | 512.93 | 438.35 | 284.23 | 163.27 | 82.28 | 52.45 | 43.22 |
| 45.63 | 33.07 | 34.58 | 36.57 | 387.27 | 476.88 | 425.47 | 277.70 | 157.08 | 80.01 | 52.30 | 42.32 |
| 46.00 | 32.39 | 34.61 | 36.48 | 367.59 | 457.92 | 411.65 | 264.71 | 150.00 | 78.08 | 52.22 | 41.64 |
| 45.71 | 32.07 | 34.83 | 35.99 | 344.82 | 463.34 | 398.60 | 256.31 | 147.46 | 76.14 | 52.14 | 41.18 |
| 45.12 | 31.41 | 34.85 | 35.30 | 258.30 | 448.52 | 361.29 | 246.97 | 145.36 | 73.82 | 51.83 | 40.71 |
| 44.73 | 30.92 | 35.08 | 35.19 | 213.52 | 453.67 | 335.25 | 238.51 | 143.59 | 71.83 | 51.98 | 40.48 |
| 44.36 | 30.43 | 34.97 | 34.99 | 199.64 | 470.97 | 319.05 | 230.99 | 141.43 | 69.73 | 51.20 | 40.46 |
| 44.09 | - | 35.06 | 35.00 | 216.34 | 414.08 | 333.43 | 226.40 | 139.66 | 67.69 | 50.89 | 40.23 |
| 44.03 | - | 34.95 | 35.71 | 235.47 | 307.94 | 333.32 | 225.13 | 137.18 | 65.75 | 50.57 | 40.21 |
| 43.69 | - | 34.85 | - | 259.57 | - | 349.24 | 219.71 | - | 64.20 | - | 39.98 |
| **48.94** | **36.29** | **33.63** | **35.86** | **197.58** | **456.28** | **398.98** | **316.81** | **182.64** | **96.90** | **54.13** | **44.93** |



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|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 42.40 | 41.28 | 41.66 | 44.84 | 70.08 | 249.53 | 678.11 | 753.90 | 302.56 | 126.36 | 76.62 | - |
| 42.38 | 41.23 | 41.61 | 45.08 | 72.04 | 299.59 | 617.28 | 784.90 | 339.15 | 97.22 | 75.92 | - |
| 42.11 | 41.18 | 41.55 | 45.16 | 73.91 | 298.60 | 543.76 | 875.85 | 356.52 | 95.52 | 79.78 | - |
| 41.98 | 41.14 | 41.49 | 45.84 | 75.93 | 333.98 | 621.51 | 884.65 | 364.84 | 93.84 | 78.10 | - |
| 41.64 | 41.09 | 41.44 | 46.47 | 78.05 | 361.36 | 667.93 | 943.66 | 340.94 | 90.59 | 73.34 | - |
| 41.30 | 41.24 | 41.58 | 47.01 | 79.94 | 405.08 | 754.55 | 803.71 | 304.98 | 88.42 | 72.86 | - |
| 41.37 | 41.23 | 41.53 | 47.62 | 82.11 | 435.22 | 788.33 | 721.24 | 283.68 | 86.30 | 75.72 | - |
| 41.04 | 41.22 | 41.47 | 47.78 | 83.86 | 465.79 | 826.61 | 748.81 | 278.78 | 83.95 | 75.51 | - |
| 40.70 | 41.20 | 42.76 | 47.52 | 85.82 | 482.35 | 711.14 | 743.21 | 272.57 | 82.32 | 75.03 | - |
| 39.12 | 41.19 | 42.59 | 48.18 | 87.88 | 496.30 | 702.23 | 727.94 | 258.41 | 80.05 | 74.26 | - |
| 39.14 | 41.18 | 42.53 | 48.43 | 89.83 | 550.34 | 793.74 | 770.18 | 252.46 | 79.32 | 73.54 | - |
| 39.15 | 41.16 | 42.68 | 49.52 | 91.94 | 590.46 | 929.73 | 682.09 | 245.59 | 78.02 | 69.64 | - |
| 39.56 | 41.35 | 42.87 | 49.74 | 93.93 | 640.90 | 907.11 | 677.27 | 236.92 | 77.24 | 69.36 | - |
| 39.57 | 41.34 | 43.28 | 50.87 | 97.77 | 644.79 | 895.77 | 688.42 | 231.30 | 75.92 | 69.76 | - |
| 39.99 | 41.33 | 43.48 | 51.71 | 99.53 | 650.48 | 822.35 | 632.62 | 236.49 | 76.21 | 69.81 | - |
| 40.00 | 41.31 | 43.68 | 52.14 | 102.73 | 713.78 | 714.44 | 624.45 | 230.25 | 76.17 | 68.69 | - |
| 40.01 | 41.50 | 44.09 | 53.17 | 104.39 | 767.56 | 793.46 | 617.21 | 220.93 | 75.28 | 68.03 | - |
| 40.16 | 41.49 | 44.62 | 53.95 | 106.29 | 715.27 | 896.64 | 609.07 | 218.90 | 74.67 | 67.37 | - |
| 40.38 | 41.48 | 44.70 | 53.38 | 116.16 | 649.74 | 848.75 | 527.74 | 229.13 | 74.63 | 62.87 | - |
| 40.46 | 41.53 | 45.14 | 54.56 | 119.08 | 638.97 | 828.49 | 514.48 | 225.66 | 73.04 | 62.89 | - |
| 40.67 | 41.65 | 45.53 | 54.77 | 134.81 | 593.80 | 708.43 | 478.31 | 253.81 | 72.87 | 61.28 | - |
| 40.69 | 41.64 | 45.74 | 55.37 | 137.48 | 566.71 | 598.94 | 503.03 | 251.44 | 71.73 | 58.54 | - |
| 40.70 | 41.63 | 45.72 | 56.23 | 234.62 | 614.90 | 524.78 | 473.45 | 247.91 | 71.06 | 58.40 | - |
| 40.86 | 41.61 | 44.65 | 56.79 | 279.57 | 632.44 | 552.20 | 424.27 | 245.22 | 74.60 | 58.34 | - |
| 40.81 | 41.60 | 43.58 | 57.78 | 277.96 | 665.56 | 514.61 | 463.90 | 264.51 | 76.06 | 58.88 | - |
| 40.76 | 41.59 | 43.57 | 59.42 | 228.72 | 704.57 | 505.58 | 455.69 | 256.47 | 75.05 | 59.17 | - |
| 41.12 | 41.73 | 43.98 | 60.41 | 225.75 | 783.12 | 493.31 | 442.15 | 251.06 | 71.79 | 57.22 | - |
| 41.07 | 41.52 | 43.92 | 63.19 | 136.46 | 795.39 | 510.68 | 355.41 | 232.35 | 70.54 | 56.26 | - |
| 41.02 | - | 43.88 | 64.27 | 230.50 | 702.50 | 546.67 | 299.72 | 228.23 | 69.67 | 54.52 | - |
| 40.97 | - | 43.84 | 68.08 | 234.99 | 666.14 | 641.69 | 281.48 | 222.14 | 68.49 | 52.73 | - |
| 40.92 | - | 44.43 | - | 239.88 | - | 709.93 | 270.28 | - | 72.70 | - | - |
| **40.71** | **41.38** | **43.34** | **52.64** | **134.58** | **570.51** | **698.35** | **605.78** | **262.77** | **79.99** | **67.15** | **-** |



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|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 40.93 | 39.47 | 38.59 | 38.36 | 49.36 | 293.64 | 480.23 | 759.43 | 418.92 | 206.42 | 115.85 | - |
| 41.25 | 39.81 | 38.97 | 37.95 | 49.50 | 302.19 | 497.84 | 777.80 | 412.97 | 201.29 | 116.10 | - |
| 40.71 | 39.31 | 38.54 | 37.74 | 48.97 | 315.05 | 492.59 | 791.10 | 409.36 | 196.10 | 115.72 | - |
| 41.03 | 39.65 | 38.93 | 37.72 | 48.66 | 331.58 | 485.81 | 807.57 | 396.88 | 197.87 | 116.61 | - |
| 40.50 | 39.23 | 38.49 | 37.32 | 48.36 | 319.92 | 479.09 | 780.33 | 382.88 | 201.99 | 113.95 | - |
| 40.82 | 39.64 | 38.88 | 36.90 | 48.06 | 310.30 | 464.97 | 751.20 | 365.84 | 197.05 | 112.49 | - |
| 40.28 | 39.22 | 38.45 | 37.55 | 48.19 | 278.37 | 482.39 | 772.10 | 356.60 | 192.68 | 110.97 | - |
| 40.71 | 39.64 | 38.83 | 37.91 | 48.11 | 270.58 | 498.54 | 785.40 | 346.15 | 187.04 | 109.51 | - |
| 40.28 | 39.21 | 38.40 | 38.54 | 48.68 | 248.29 | 509.18 | 745.50 | 338.93 | 186.03 | 107.99 | - |
| 40.71 | 39.63 | 38.79 | 38.94 | 49.49 | 245.69 | 529.45 | 763.87 | 321.19 | 179.19 | 106.54 | - |
| 40.29 | 39.21 | 38.35 | 39.71 | 50.07 | 285.66 | 550.10 | 746.76 | 308.52 | 174.75 | 105.59 | - |
| 40.72 | 39.57 | 38.60 | 40.12 | 52.03 | 283.69 | 526.60 | 728.40 | 296.30 | 168.42 | 105.21 | - |
| 40.30 | 39.11 | 38.03 | 40.07 | 53.79 | 270.52 | 543.13 | 748.66 | 280.91 | 166.77 | 104.76 | - |
| 40.73 | 39.47 | 38.28 | 40.51 | 55.87 | 279.83 | 559.98 | 689.76 | 272.86 | 161.32 | 104.83 | - |
| 40.22 | 38.99 | 39.10 | 39.72 | 63.47 | 266.72 | 536.23 | 708.76 | 256.46 | 158.79 | 103.88 | - |
| 40.56 | 39.36 | 38.55 | 39.95 | 68.91 | 253.42 | 520.96 | 660.62 | 239.99 | 157.21 | 103.56 | - |
| 40.06 | 38.89 | 38.10 | 40.18 | 73.79 | 251.07 | 498.16 | 679.63 | 227.07 | 154.67 | 102.80 | - |
| 40.40 | 39.25 | 37.72 | 40.56 | 80.50 | 253.04 | 522.16 | 649.86 | 216.94 | 150.81 | 102.55 | - |
| 39.90 | 38.81 | 37.43 | 41.31 | 86.65 | 255.51 | 546.87 | 599.37 | 207.69 | 148.78 | 100.46 | - |
| 40.25 | 39.21 | 37.22 | 42.73 | 93.04 | 256.97 | 572.14 | 586.26 | 199.83 | 147.26 | 99.25 | - |
| 39.75 | 38.76 | 37.12 | 41.54 | 99.70 | 258.93 | 606.53 | 556.05 | 196.16 | 144.79 | 97.80 | - |
| 40.17 | 39.16 | 37.76 | 42.23 | 106.60 | 262.03 | 642.26 | 533.25 | 196.48 | 141.69 | 95.39 | - |
| 39.76 | 38.72 | 37.68 | 41.67 | 113.76 | 267.92 | 659.99 | 517.67 | 199.39 | 147.77 | 93.74 | - |
| 40.18 | 39.11 | 37.53 | 41.70 | 125.54 | 285.15 | 651.12 | 503.29 | 195.08 | 145.74 | 92.03 | - |
| 39.77 | 38.67 | 37.33 | 41.61 | 130.67 | 302.82 | 642.89 | 480.42 | 197.17 | 143.46 | 90.83 | - |
| 40.19 | 39.07 | 37.31 | 42.18 | 143.34 | 333.42 | 634.02 | 455.66 | 196.79 | 146.38 | 87.85 | - |
| 39.78 | 38.63 | 37.03 | 43.53 | 148.85 | 365.53 | 625.60 | 436.21 | 201.10 | 146.19 | 84.81 | - |
| 40.21 | 39.02 | 36.80 | 44.89 | 161.45 | 392.45 | 670.12 | 436.02 | 200.15 | 146.38 | 82.59 | - |
| 39.71 | - | 37.83 | 45.56 | 188.05 | 415.38 | 713.83 | 435.52 | 199.58 | 141.69 | 79.68 | - |
| 40.05 | - | 38.40 | 47.50 | 211.93 | 457.69 | 723.33 | 430.89 | 201.92 | 135.23 | 77.08 | - |
| 39.55 | - | 38.78 | - | 237.33 | - | 736.63 | 424.88 | - | 125.16 | - | - |
| **40.31** | **39.21** | **38.12** | **40.54** | **91.38** | **297.11** | **567.83** | **636.85** | **274.67** | **164.48** | **101.35** | **-** |



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|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 42.09 | 19.19 | 15.26 | 18.30 | 42.35 | 109.01 | 449.39 | 766.40 | 501.07 | 133.01 | 77.72 | 57.64 |
| 41.84 | 18.54 | 15.34 | 19.32 | 41.65 | 115.15 | 413.48 | 733.46 | 477.57 | 132.19 | 80.38 | 55.29 |
| 41.93 | 17.96 | 14.83 | 19.74 | 39.99 | 121.55 | 397.01 | 708.76 | 458.07 | 131.36 | 82.66 | 52.99 |
| 42.06 | 17.44 | 14.50 | 19.46 | 39.49 | 124.02 | 426.08 | 543.38 | 434.50 | 130.22 | 81.90 | 51.14 |
| 20.80 | 16.70 | 14.43 | 17.92 | 39.41 | 126.55 | 431.84 | 454.90 | 413.67 | 129.40 | 81.45 | 49.33 |
| 20.22 | 17.11 | 13.93 | 18.53 | 40.75 | 129.08 | 408.54 | 662.52 | 405.24 | 128.58 | 80.95 | 49.47 |
| 20.22 | 17.29 | 13.90 | 19.05 | 41.02 | 115.09 | 404.16 | 855.07 | 393.14 | 126.99 | 79.11 | 49.62 |
| 20.33 | 16.84 | 13.94 | 19.67 | 41.67 | 108.12 | 497.15 | 1056.49 | 394.54 | 125.03 | 77.27 | 48.42 |
| 20.44 | 16.70 | 14.01 | 20.12 | 41.60 | 117.43 | 498.10 | 1221.17 | 384.91 | 123.45 | 75.56 | 47.85 |
| 20.22 | 16.81 | 13.88 | 20.33 | 41.14 | 87.34 | 635.29 | 1212.30 | 372.43 | 121.55 | 73.60 | 45.67 |
| 19.90 | 16.31 | 13.36 | 20.46 | 41.89 | 149.23 | 549.84 | 1094.49 | 369.90 | 119.96 | 73.35 | 44.15 |
| 20.98 | 16.25 | 12.36 | 20.64 | 41.90 | 194.01 | 571.57 | 1065.36 | 368.12 | 118.44 | 72.97 | 43.37 |
| 20.72 | 15.97 | 11.95 | 22.52 | 45.47 | 219.41 | 583.98 | 1024.82 | 349.12 | 116.92 | 72.59 | 42.96 |
| 20.75 | 16.05 | 13.76 | 24.09 | 51.30 | 231.12 | 613.75 | 983.02 | 335.51 | 114.52 | 72.52 | 42.26 |
| 20.50 | 16.21 | 14.88 | 24.98 | 55.11 | 226.63 | 613.44 | 958.95 | 328.60 | 112.49 | 72.14 | 44.35 |
| 19.06 | 15.58 | 15.28 | 25.89 | 59.44 | 208.00 | 602.61 | 927.91 | 327.71 | 110.15 | 72.02 | 43.83 |
| 18.69 | 15.14 | 14.23 | 28.22 | 64.16 | 179.69 | 691.03 | 887.38 | 320.56 | 107.87 | 71.64 | 43.55 |
| 18.22 | 15.25 | 15.45 | 29.91 | 80.82 | 201.23 | 777.80 | 881.68 | 284.01 | 105.59 | 71.32 | 41.51 |
| 18.79 | 15.15 | 15.50 | 31.06 | 86.08 | 248.73 | 853.17 | 848.11 | 256.52 | 103.37 | 70.94 | 41.07 |
| 18.88 | 14.87 | 15.30 | 32.69 | 70.69 | 318.85 | 860.77 | 826.57 | 235.87 | 101.03 | 70.81 | 41.87 |
| 16.08 | 14.73 | 15.40 | 37.10 | 71.19 | 391.88 | 841.77 | 756.27 | 225.17 | 98.75 | 70.56 | 41.28 |
| 14.56 | 14.81 | 14.90 | 44.31 | 72.78 | 445.14 | 730.93 | 773.37 | 214.91 | 96.40 | 69.36 | 40.70 |
| 14.65 | 14.72 | 14.90 | 40.94 | 73.03 | 498.54 | 708.76 | 704.96 | 201.86 | 94.06 | 67.96 | 40.12 |
| 14.68 | 14.91 | 14.11 | 43.04 | 73.03 | 496.26 | 598.55 | 703.06 | 189.13 | 91.46 | 66.76 | 39.54 |
| 14.69 | 14.83 | 14.43 | 40.93 | 79.24 | 512.92 | 619.52 | 677.09 | 176.53 | 88.93 | 65.49 | 39.14 |
| 13.95 | 14.61 | 15.11 | 38.83 | 83.23 | 501.90 | 604.38 | 588.04 | 164.87 | 86.20 | 64.04 | 38.91 |
| 14.09 | 14.59 | 16.10 | 40.39 | 95.64 | 491.26 | 684.69 | 532.74 | 154.23 | 83.73 | 62.50 | 33.90 |
| 15.58 | 15.08 | 16.34 | 42.79 | 97.99 | 472.25 | 780.97 | 485.87 | 144.10 | 80.00 | 60.46 | 32.86 |
| 14.26 | - | 16.31 | 49.61 | 100.39 | 481.56 | 834.81 | 468.52 | 134.66 | 76.39 | 59.04 | 33.55 |
| 14.11 | - | 16.97 | 51.64 | 103.24 | 505.70 | 879.78 | 447.11 | 133.83 | 73.47 | 56.85 | 30.11 |
| 17.73 | - | 17.61 | - | 106.09 | - | 900.04 | 464.84 | - | 76.13 | - | 27.91 |
| **21.00** | **16.06** | **14.78** | **29.42** | **63.28** | **270.92** | **627.84** | **784.34** | **305.01** | **107.67** | **71.80** | **43.04** |



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|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 48.42 | 53.12 | 32.63 | 61.67 | 80.82 | 203.70 | 589.75 | 557.32 | 312.32 | 180.45 | 101.60 | 76.13 |
| 47.64 | 52.12 | 32.16 | 61.10 | 81.58 | 228.21 | 525.08 | 482.32 | 332.21 | 176.97 | 96.02 | 74.61 |
| 46.59 | 51.12 | 31.57 | 60.89 | 81.71 | 231.25 | 533.88 | 494.49 | 352.86 | 174.43 | 94.69 | 73.22 |
| 45.71 | 50.15 | 31.11 | 60.68 | 81.83 | 233.21 | 525.33 | 515.83 | 373.70 | 171.84 | 93.49 | 72.46 |
| 44.47 | 49.01 | 30.52 | 60.46 | 83.54 | 235.81 | 517.60 | 516.27 | 395.93 | 169.30 | 93.04 | 71.76 |
| 40.75 | 48.06 | 30.08 | 60.25 | 87.53 | 242.71 | 514.18 | 543.89 | 417.91 | 166.83 | 91.97 | 70.88 |
| 41.33 | 46.95 | 29.51 | 58.76 | 90.07 | 288.70 | 508.74 | 598.42 | 456.42 | 164.30 | 92.35 | 69.93 |
| 41.70 | 46.03 | 28.95 | 57.11 | 92.41 | 319.73 | 495.63 | 618.57 | 473.27 | 161.89 | 92.60 | 69.04 |
| 42.34 | 44.95 | 28.51 | 56.03 | 93.87 | 331.33 | 486.89 | 632.06 | 464.78 | 159.42 | 92.60 | 67.96 |
| 42.73 | 43.89 | 28.65 | 54.43 | 94.94 | 345.64 | 473.46 | 650.49 | 455.91 | 156.32 | 92.41 | 67.08 |
| 43.43 | 43.27 | 28.99 | 53.02 | 96.40 | 371.36 | 455.47 | 615.02 | 438.24 | 153.22 | 91.33 | 66.70 |
| 44.29 | 42.13 | 29.41 | 51.47 | 95.32 | 386.75 | 411.39 | 581.07 | 435.14 | 146.88 | 90.64 | 66.06 |
| 43.32 | 41.58 | 29.55 | 49.42 | 97.10 | 390.48 | 454.27 | 546.30 | 419.94 | 140.68 | 88.99 | 65.37 |
| 42.54 | 40.87 | 29.82 | 47.78 | 98.56 | 401.31 | 466.93 | 538.44 | 397.58 | 134.59 | 87.28 | 64.48 |
| 42.05 | 40.32 | 30.34 | 47.76 | 99.32 | 407.78 | 475.10 | 484.92 | 392.26 | 128.70 | 87.53 | 64.23 |
| 41.27 | 39.62 | 30.48 | 49.01 | 101.09 | 440.14 | 542.18 | 464.08 | 391.18 | 123.00 | 87.28 | 63.97 |
| 40.34 | 39.08 | 33.52 | 48.55 | 104.13 | 446.60 | 502.15 | 451.92 | 370.03 | 117.43 | 88.23 | 63.59 |
| 39.50 | 38.54 | 37.03 | 46.73 | 107.23 | 452.81 | 480.87 | 445.78 | 318.40 | 114.01 | 89.18 | 63.14 |
| 39.37 | 38.01 | 40.75 | 48.78 | 114.07 | 495.88 | 459.97 | 426.14 | 283.38 | 113.12 | 85.25 | 62.34 |
| 38.50 | 37.48 | 385.48 | 49.67 | 118.19 | 518.36 | 455.98 | 420.89 | 257.16 | 112.62 | 81.01 | 60.73 |
| 39.73 | 36.95 | 198.76 | 51.92 | 123.51 | 572.01 | 453.44 | 414.24 | 251.14 | 112.05 | 80.50 | 60.03 |
| 39.88 | 36.86 | 164.74 | 54.59 | 131.17 | 589.24 | 404.04 | 399.29 | 244.23 | 111.79 | 79.05 | 58.73 |
| 39.80 | 37.28 | 120.85 | 56.97 | 151.44 | 596.97 | 414.05 | 395.99 | 235.75 | 110.65 | 78.10 | 57.61 |
| 39.70 | 36.49 | 87.34 | 60.18 | 158.41 | 624.33 | 469.47 | 383.77 | 227.45 | 109.58 | 78.73 | 56.57 |
| 39.61 | 35.19 | 70.31 | 63.53 | 162.78 | 638.45 | 484.48 | 377.56 | 219.34 | 108.50 | 78.86 | 55.81 |
| 39.52 | 35.30 | 58.22 | 67.33 | 166.07 | 654.92 | 585.19 | 354.76 | 211.42 | 107.93 | 78.35 | 55.20 |
| 178.43 | 33.71 | 55.36 | 70.50 | 169.24 | 702.43 | 718.90 | 344.37 | 203.70 | 107.68 | 79.81 | 54.43 |
| 140.74 | 33.23 | 54.38 | 72.84 | 186.34 | 703.06 | 830.37 | 338.04 | 196.10 | 107.11 | 77.97 | 53.51 |
| 112.17 | - | 58.62 | 77.91 | 191.73 | 656.19 | 712.56 | 332.72 | 189.45 | 106.85 | 76.83 | 52.94 |
| 81.58 | - | 57.92 | 80.82 | 195.53 | 621.73 | 579.36 | 327.46 | 182.99 | 108.18 | 74.99 | 52.37 |
| 61.25 | - | 60.11 | - | 199.07 | - | 566.31 | 320.62 | - | 108.37 | - | 50.92 |
| **53.83** | **41.83** | **63.41** | **58.00** | **120.48** | **444.37** | **519.13** | **470.10** | **330.01** | **134.35** | **86.69** | **63.28** |



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|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 50.80 | 39.41 | 63.09 | 35.53 | 63.72 | 127.44 | 446.79 | 651.12 | 527.30 | 151.89 | 62.56 | 41.47 |
| 49.40 | 38.85 | 50.13 | 35.18 | 65.37 | 130.67 | 461.23 | 684.69 | 511.84 | 142.64 | 62.26 | 40.70 |
| 47.99 | 38.33 | 49.26 | 34.94 | 67.01 | 134.78 | 474.98 | 715.73 | 503.86 | 133.64 | 61.96 | 40.20 |
| 47.01 | 38.07 | 48.46 | 35.87 | 68.79 | 137.89 | 489.42 | 749.93 | 496.83 | 128.39 | 61.60 | 39.84 |
| 48.94 | 37.83 | 48.09 | 36.46 | 69.86 | 144.86 | 504.30 | 706.86 | 485.87 | 106.66 | 61.04 | 39.35 |
| 49.81 | 37.44 | 47.71 | 37.17 | 72.90 | 149.10 | 514.94 | 670.12 | 478.59 | 102.10 | 60.46 | 39.31 |
| 50.39 | 35.88 | 47.60 | 37.96 | 74.36 | 152.65 | 535.66 | 629.71 | 467.69 | 94.94 | 60.11 | 39.01 |
| 48.31 | 35.32 | 45.93 | 38.87 | 77.15 | 159.74 | 555.48 | 607.86 | 455.03 | 91.59 | 59.69 | 38.73 |
| 47.51 | 35.06 | 44.69 | 39.65 | 79.24 | 165.19 | 571.44 | 580.94 | 443.05 | 87.98 | 59.37 | 38.71 |
| 46.36 | 35.03 | 43.28 | 41.08 | 83.16 | 178.17 | 583.35 | 557.13 | 437.04 | 83.67 | 58.62 | 38.43 |
| 45.20 | 34.29 | 41.89 | 42.41 | 86.90 | 184.95 | 593.86 | 542.24 | 423.86 | 82.85 | 58.04 | 38.28 |
| 44.84 | 34.19 | 40.64 | 43.67 | 91.27 | 191.54 | 607.80 | 514.82 | 412.21 | 82.59 | 57.37 | 38.20 |
| 44.47 | 33.75 | 38.41 | 44.27 | 95.20 | 199.83 | 619.33 | 504.11 | 396.44 | 81.39 | 57.07 | 38.17 |
| 43.91 | 33.29 | 36.88 | 44.86 | 99.82 | 215.92 | 628.89 | 497.46 | 385.99 | 81.20 | 56.94 | 38.02 |
| 42.96 | 33.11 | 36.35 | 45.69 | 264.95 | 235.94 | 636.55 | 484.03 | 372.88 | 80.76 | 55.46 | 38.00 |
| 42.44 | 32.87 | 35.86 | 46.26 | 327.21 | 252.85 | 604.51 | 471.56 | 358.62 | 80.00 | 54.07 | 37.84 |
| 41.58 | 32.66 | 35.64 | 47.11 | 220.17 | 271.41 | 611.28 | 461.49 | 340.64 | 77.08 | 52.92 | 37.83 |
| 40.37 | 32.28 | 35.34 | 47.85 | 183.37 | 286.29 | 622.24 | 471.81 | 323.66 | 75.94 | 50.28 | 37.67 |
| 39.28 | 32.01 | 35.20 | 49.29 | 145.49 | 300.42 | 599.82 | 479.60 | 309.35 | 74.99 | 48.17 | 37.65 |
| 39.97 | 31.70 | 34.95 | 50.52 | 128.70 | 314.79 | 591.84 | 523.88 | 297.06 | 73.92 | 46.93 | 37.49 |
| 40.45 | 31.64 | 35.61 | 50.92 | 109.13 | 341.14 | 580.82 | 542.43 | 279.39 | 72.78 | 46.02 | 37.34 |
| 40.52 | 31.57 | 35.21 | 52.10 | 100.46 | 364.58 | 562.51 | 569.80 | 258.30 | 72.08 | 45.50 | 37.33 |
| 40.03 | 28.84 | 34.91 | 53.86 | 93.42 | 373.13 | 557.32 | 603.30 | 237.08 | 71.51 | 45.18 | 37.19 |
| 39.66 | 26.50 | 34.73 | 56.27 | 96.40 | 383.20 | 550.98 | 637.19 | 221.31 | 70.24 | 44.73 | 37.05 |
| 39.74 | 24.03 | 34.37 | 58.23 | 99.63 | 395.99 | 542.62 | 649.22 | 200.28 | 68.15 | 44.25 | 37.03 |
| 41.21 | 21.81 | 34.20 | 59.33 | 102.99 | 408.73 | 531.79 | 635.29 | 193.56 | 65.81 | 43.91 | 36.94 |
| 42.41 | 174.12 | 34.03 | 60.19 | 106.73 | 424.62 | 539.08 | 612.61 | 185.96 | 65.05 | 43.44 | 36.91 |
| 42.61 | 419.43 | 33.79 | 61.12 | 110.65 | 437.80 | 545.03 | 585.19 | 178.68 | 64.23 | 43.11 | 36.88 |
| 42.90 | 128.70 | 33.49 | 62.15 | 116.42 | 425.51 | 553.39 | 570.37 | 166.58 | 63.78 | 42.62 | 36.85 |
| 42.06 | - | 33.24 | 62.49 | 120.79 | 436.02 | 571.25 | 556.94 | 160.63 | 63.47 | 42.15 | 36.83 |
| 41.68 | - | 35.67 | - | 122.62 | - | 628.89 | 543.70 | - | 62.86 | - | 36.74 |
| **44.03** | **54.76** | **39.96** | **47.04** | **114.32** | **264.17** | **561.85** | **581.00** | **350.32** | **85.62** | **52.86** | **38.13** |



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| 2013 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 36.30 | 29.31 | 25.44 | 37.24 | 67.08 | 226.37 | 434.00 | 793.63 | 487.84 | 200.02 | 74.80 | 50.15 |
| 35.90 | 28.50 | 24.39 | 36.65 | 69.55 | 234.73 | 465.73 | 806.30 | 477.26 | 189.70 | 76.96 | 49.57 |
| 35.51 | 27.60 | 22.80 | 37.92 | 72.02 | 247.59 | 423.74 | 819.60 | 470.86 | 182.80 | 85.00 | 49.51 |
| 35.12 | 52.08 | 21.38 | 38.37 | 72.59 | 317.83 | 441.41 | 832.27 | 457.43 | 176.02 | 80.50 | 49.23 |
| 34.73 | 43.37 | 20.34 | 40.75 | 75.88 | 371.23 | 458.32 | 767.03 | 452.49 | 169.56 | 76.20 | 48.75 |
| 41.68 | 36.77 | 49.99 | 41.57 | 76.77 | 404.10 | 469.85 | 711.93 | 448.31 | 163.03 | 72.08 | 47.77 |
| 64.67 | 35.41 | 47.34 | 42.19 | 78.35 | 436.40 | 492.40 | 684.06 | 446.10 | 155.24 | 72.21 | 46.90 |
| 57.50 | 34.42 | 44.82 | 42.44 | 82.34 | 494.68 | 526.92 | 665.06 | 437.10 | 150.24 | 72.52 | 46.75 |
| 54.39 | 33.15 | 42.73 | 42.97 | 85.95 | 529.26 | 553.33 | 642.89 | 425.70 | 144.67 | 72.59 | 46.17 |
| 52.51 | 31.97 | 40.78 | 43.98 | 89.37 | 565.36 | 580.12 | 631.17 | 416.52 | 140.55 | 72.59 | 45.76 |
| 51.62 | 31.35 | 39.11 | 45.05 | 92.98 | 618.31 | 580.94 | 637.19 | 411.01 | 136.56 | 70.75 | 45.53 |
| 50.53 | 30.65 | 37.59 | 45.77 | 96.27 | 658.09 | 566.95 | 617.93 | 399.03 | 132.57 | 69.86 | 44.93 |
| 49.30 | 30.04 | 36.00 | 46.03 | 100.01 | 629.02 | 554.85 | 608.31 | 389.53 | 128.70 | 68.91 | 44.91 |
| 47.44 | 30.33 | 34.88 | 46.30 | 104.38 | 599.94 | 549.65 | 590.95 | 379.46 | 125.60 | 66.06 | 44.58 |
| 45.88 | 30.47 | 34.00 | 47.17 | 107.93 | 565.87 | 574.74 | 564.16 | 372.12 | 123.89 | 65.68 | 44.19 |
| 44.72 | 30.00 | 33.17 | 48.14 | 109.39 | 575.69 | 600.58 | 544.40 | 363.44 | 122.37 | 65.05 | 43.93 |
| 42.68 | 29.18 | 31.94 | 49.29 | 113.50 | 532.55 | 635.29 | 535.85 | 352.67 | 121.23 | 64.35 | 43.34 |
| 41.87 | 28.95 | 31.24 | 49.85 | 116.48 | 492.27 | 656.19 | 526.54 | 342.35 | 119.33 | 63.16 | 42.81 |
| 41.21 | 28.71 | 30.02 | 51.05 | 119.58 | 459.08 | 677.09 | 521.40 | 333.67 | 118.19 | 60.94 | 42.11 |
| 40.59 | 28.78 | 28.87 | 52.03 | 136.62 | 467.57 | 702.43 | 516.84 | 325.75 | 116.48 | 59.12 | 41.11 |
| 39.69 | 28.83 | 52.58 | 52.86 | 152.58 | 488.72 | 761.97 | 509.31 | 314.67 | 115.28 | 58.70 | 41.05 |
| 38.67 | 28.35 | 51.47 | 53.91 | 179.31 | 511.14 | 784.77 | 490.94 | 306.56 | 114.01 | 58.29 | 40.89 |
| 37.91 | 27.88 | 49.65 | 55.14 | 206.80 | 534.20 | 810.74 | 478.33 | 297.00 | 112.74 | 57.87 | 40.73 |
| 37.13 | 27.90 | 46.15 | 55.80 | 237.20 | 579.99 | 763.23 | 492.21 | 286.04 | 108.44 | 57.52 | 40.63 |
| 36.40 | 27.51 | 43.36 | 57.32 | 265.39 | 611.16 | 747.40 | 504.11 | 272.61 | 104.57 | 57.06 | 40.47 |
| 35.72 | 27.63 | 42.73 | 58.50 | 252.53 | 654.29 | 725.86 | 507.03 | 259.37 | 100.71 | 56.64 | 39.55 |
| 35.01 | 27.61 | 41.73 | 60.43 | 240.05 | 721.43 | 746.13 | 511.52 | 246.77 | 97.35 | 56.24 | 38.94 |
| 34.11 | 26.63 | 40.59 | 62.35 | 223.97 | 600.13 | 760.07 | 513.61 | 234.35 | 93.87 | 54.97 | 38.68 |
| 33.23 | - | 39.87 | 63.78 | 206.23 | 494.99 | 777.80 | 523.11 | 222.51 | 90.51 | 53.81 | 38.29 |
| 32.07 | - | 38.30 | 65.81 | 208.26 | 460.28 | 789.83 | 525.33 | 210.66 | 85.70 | 50.27 | 37.91 |
| 30.32 | - | 37.55 | - | 218.20 | - | 784.77 | 504.30 | - | 79.93 | - | 37.65 |
| **41.75** | **31.19** | **37.45** | **49.02** | **137.34** | **502.74** | **625.71** | **599.27** | **361.31** | **129.67** | **65.69** | **43.64** |



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| 2014 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 36.08 | 32.01 | 26.58 | 26.59 | 53.61 | 153.91 | 437.10 | 562.89 | 348.81 | 144.60 | 70.75 | 48.64 |
| 35.97 | 31.73 | 26.39 | 25.59 | 58.28 | 150.87 | 513.93 | 526.47 | 334.49 | 139.66 | 70.81 | 47.91 |
| 35.82 | 31.31 | 27.51 | 24.87 | 60.86 | 152.90 | 558.46 | 523.30 | 320.49 | 134.97 | 69.55 | 46.87 |
| 34.03 | 31.49 | 26.89 | 25.81 | 59.93 | 152.84 | 565.24 | 560.17 | 308.90 | 129.91 | 68.47 | 46.45 |
| 34.66 | 32.55 | 28.29 | 25.47 | 59.91 | 146.31 | 530.72 | 565.30 | 303.90 | 124.14 | 67.27 | 46.03 |
| 37.53 | 34.86 | 28.88 | 25.25 | 60.99 | 150.68 | 500.76 | 603.56 | 287.18 | 119.84 | 66.70 | 45.99 |
| 38.71 | 34.93 | 29.50 | 23.79 | 62.38 | 154.55 | 396.75 | 619.58 | 266.66 | 115.47 | 66.00 | 45.72 |
| 37.72 | 34.65 | 29.26 | 27.88 | 63.91 | 157.08 | 343.11 | 601.72 | 252.34 | 111.92 | 64.42 | 45.43 |
| 37.24 | 35.84 | 29.22 | 28.14 | 66.25 | 160.82 | 296.62 | 574.42 | 246.83 | 109.58 | 64.04 | 45.01 |
| 36.95 | 34.48 | 29.12 | 27.60 | 66.76 | 162.59 | 320.62 | 556.11 | 242.46 | 109.39 | 63.01 | 44.60 |
| 36.81 | 36.26 | 29.09 | 26.67 | 67.33 | 165.69 | 357.10 | 540.53 | 236.89 | 107.55 | 62.58 | 43.70 |
| 35.55 | 36.74 | 28.93 | 26.42 | 68.91 | 190.52 | 392.13 | 534.83 | 226.88 | 106.03 | 61.94 | 42.71 |
| 36.85 | 37.33 | 28.90 | 27.43 | 69.61 | 204.65 | 441.41 | 529.20 | 223.65 | 105.65 | 61.37 | 42.11 |
| 36.71 | 37.33 | 28.70 | 28.27 | 70.88 | 243.85 | 446.67 | 605.84 | 220.42 | 105.14 | 60.80 | 41.66 |
| 36.39 | 34.93 | 28.57 | 29.45 | 72.65 | 254.81 | 532.05 | 593.29 | 217.19 | 104.45 | 60.30 | 41.22 |
| 35.84 | 34.39 | 28.69 | 30.69 | 74.17 | 263.17 | 535.97 | 581.89 | 212.31 | 104.19 | 60.31 | 40.63 |
| 35.63 | 33.40 | 28.45 | 31.54 | 75.69 | 282.05 | 533.82 | 570.49 | 207.50 | 104.32 | 60.25 | 40.04 |
| 35.26 | 32.96 | 28.14 | 31.70 | 77.97 | 343.17 | 545.16 | 562.26 | 205.09 | 104.26 | 60.11 | 39.61 |
| 35.20 | 32.96 | 27.75 | 31.89 | 80.06 | 366.60 | 554.97 | 547.31 | 200.34 | 103.05 | 59.69 | 39.11 |
| 34.98 | 32.25 | 27.81 | 30.61 | 82.78 | 309.54 | 565.81 | 540.91 | 191.28 | 102.04 | 58.49 | 38.60 |
| 34.61 | 31.56 | 28.17 | 31.09 | 84.94 | 262.92 | 575.88 | 534.77 | 187.10 | 98.49 | 57.23 | 38.03 |
| 34.19 | 31.01 | 28.40 | 32.31 | 87.60 | 258.87 | 585.25 | 527.49 | 183.24 | 94.75 | 56.12 | 37.62 |
| 34.07 | 30.47 | 28.47 | 32.50 | 91.08 | 258.11 | 530.53 | 441.53 | 178.81 | 90.07 | 54.24 | 37.05 |
| 33.83 | 30.02 | 28.17 | 32.70 | 93.80 | 233.15 | 543.13 | 432.98 | 175.70 | 86.20 | 53.53 | 36.50 |
| 33.42 | 30.28 | 28.15 | 32.89 | 104.26 | 240.43 | 559.98 | 427.79 | 172.66 | 83.92 | 52.60 | 35.82 |
| 32.95 | 28.91 | 27.86 | 33.79 | 117.87 | 259.56 | 586.77 | 439.38 | 166.77 | 81.52 | 51.34 | 35.36 |
| 32.78 | 26.56 | 27.97 | 38.07 | 133.07 | 282.24 | 620.97 | 437.04 | 165.06 | 79.36 | 50.76 | 34.71 |
| 32.39 | 26.97 | 28.09 | 42.68 | 141.75 | 305.99 | 634.02 | 409.23 | 160.75 | 78.10 | 50.32 | 34.17 |
| 32.00 | - | 27.93 | 52.29 | 154.04 | 334.37 | 589.49 | 380.79 | 157.84 | 75.94 | 49.78 | 33.58 |
| 31.62 | - | 27.43 | 71.70 | 155.81 | 367.24 | 564.67 | 375.92 | 151.32 | 74.30 | 49.35 | 32.71 |
| 31.37 | - | 27.51 | - | 156.70 | - | 563.91 | 360.90 | - | 73.09 | - | 31.78 |
| **35.07** | **32.79** | **28.22** | **31.86** | **86.25** | **232.32** | **507.19** | **518.32** | **225.10** | **103.29** | **60.07** | **40.62** |



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|---|---|---|---|---|---|---|---|---|---|---|---|
| **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| 31.35 | 26.41 | 22.00 | 30.82 | 54.97 | 176.02 | 205.03 | 829.10 | 267.54 | 112.11 | 88.80 | 52.20 |
| 31.06 | 26.54 | 21.90 | 31.61 | 55.78 | 183.37 | 213.20 | 897.51 | 255.13 | 111.35 | 86.84 | 50.72 |
| 30.71 | 26.58 | 22.58 | 33.41 | 58.23 | 191.85 | 222.00 | 857.61 | 247.21 | 112.43 | 84.81 | 49.26 |
| 30.43 | 26.68 | 23.15 | 33.73 | 59.31 | 197.05 | 237.14 | 863.31 | 246.32 | 108.56 | 82.78 | 47.88 |
| 30.33 | 26.65 | 23.43 | 33.94 | 60.91 | 202.94 | 245.82 | 872.81 | 240.43 | 109.64 | 80.63 | 46.92 |
| 30.32 | 26.67 | 24.01 | 34.19 | 62.63 | 206.04 | 350.96 | 856.97 | 235.11 | 110.72 | 78.48 | 46.05 |
| 30.31 | 26.61 | 24.21 | 34.06 | 65.81 | 212.75 | 402.52 | 843.04 | 229.41 | 105.14 | 76.39 | 45.01 |
| 30.04 | 26.63 | 24.37 | 34.06 | 67.96 | 214.59 | 462.18 | 817.70 | 220.42 | 112.93 | 74.04 | 44.22 |
| 29.98 | 26.53 | 24.62 | 34.84 | 70.56 | 215.99 | 509.12 | 792.37 | 217.95 | 108.06 | 72.78 | 42.93 |
| 29.83 | 26.59 | 25.01 | 35.62 | 75.50 | 217.82 | 537.56 | 767.67 | 214.28 | 107.49 | 71.13 | 41.67 |
| 29.67 | 26.52 | 25.47 | 36.47 | 78.16 | 219.53 | 534.71 | 761.97 | 211.87 | 109.89 | 69.93 | 40.21 |
| 29.63 | 26.46 | 25.72 | 37.22 | 79.81 | 221.31 | 566.76 | 748.03 | 210.73 | 113.44 | 68.22 | 39.38 |
| 29.56 | 26.28 | 25.89 | 38.14 | 86.52 | 223.71 | 591.01 | 720.16 | 208.70 | 112.49 | 67.52 | 38.52 |
| 29.34 | 26.25 | 26.15 | 39.57 | 92.22 | 223.59 | 589.49 | 691.66 | 204.14 | 114.58 | 64.10 | 38.23 |
| 29.22 | 26.10 | 26.32 | 40.11 | 99.06 | 228.65 | 597.41 | 676.46 | 195.84 | 114.33 | 62.46 | 37.93 |
| 29.14 | 26.02 | 26.58 | 40.76 | 105.40 | 236.44 | 613.37 | 634.02 | 191.98 | 111.86 | 60.72 | 37.75 |
| 29.03 | 25.85 | 26.75 | 41.31 | 112.30 | 241.07 | 652.39 | 632.63 | 187.23 | 109.83 | 56.66 | 37.45 |
| 28.84 | 25.91 | 27.01 | 41.98 | 119.90 | 243.60 | 703.06 | 614.77 | 182.80 | 108.12 | 59.90 | 37.26 |
| 28.65 | 25.84 | 27.19 | 42.54 | 124.52 | 247.27 | 678.36 | 604.13 | 177.41 | 106.66 | 59.32 | 36.91 |
| 28.53 | 25.63 | 27.40 | 43.16 | 129.08 | 248.10 | 678.99 | 578.16 | 172.15 | 105.08 | 58.96 | 36.81 |
| 28.34 | 25.55 | 27.62 | 43.67 | 136.56 | 248.73 | 690.39 | 554.47 | 166.96 | 103.94 | 58.38 | 36.42 |
| 27.98 | 25.29 | 27.80 | 44.15 | 147.33 | 258.30 | 705.59 | 536.42 | 161.83 | 105.02 | 58.02 | 36.12 |
| 28.09 | 25.31 | 28.07 | 45.19 | 160.75 | 269.95 | 678.99 | 521.15 | 158.41 | 102.86 | 57.45 | 35.65 |
| 28.07 | 25.22 | 28.24 | 46.67 | 178.49 | 234.23 | 732.83 | 502.97 | 154.99 | 100.84 | 56.19 | 34.56 |
| 28.01 | 25.25 | 28.52 | 48.06 | 149.23 | 228.97 | 771.47 | 484.73 | 153.66 | 98.81 | 55.78 | 33.83 |
| 27.78 | 24.48 | 28.79 | 49.48 | 152.08 | 215.16 | 775.27 | 471.24 | 149.04 | 98.11 | 55.28 | 33.58 |
| 27.69 | 23.79 | 28.96 | 51.05 | 157.02 | 206.42 | 756.90 | 455.03 | 143.65 | 96.97 | 54.88 | 33.17 |
| 27.64 | 22.87 | 29.24 | 52.56 | 160.82 | 200.09 | 721.43 | 439.51 | 141.18 | 94.69 | 54.38 | 32.80 |
| 27.47 | - | 29.66 | 53.38 | 164.93 | 196.86 | 742.33 | 421.65 | 138.71 | 93.68 | 53.99 | 32.40 |
| 27.14 | - | 29.74 | 54.17 | 167.40 | 218.08 | 754.36 | 399.73 | 135.61 | 92.47 | 53.50 | 32.27 |
| 26.96 | - | 29.88 | - | 185.33 | - | 768.93 | 378.77 | - | 90.95 | - | 31.95 |
| **29.07** | **25.88** | **26.33** | **40.86** | **110.28** | **220.95** | **570.63** | **652.44** | **194.02** | **105.90** | **66.08** | **39.36** |



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# APPENDIX – IV:

# 4 POWER AND ENERGY POTENTIAL



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| 1966 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 38.06 | 60.00 | 27.68 | 104.36 | 101.05 | 54.83 | 24.49 | 7.09 |
| | 10 | 37.66 | 60.00 | 27.20 | 104.36 | 101.10 | 54.83 | 24.07 | 7.01 |
| | 11 | 34.78 | 60.00 | 23.73 | 104.27 | 100.99 | 54.78 | 20.99 | 7.03 |
| Feb | 10 | 32.72 | 60.00 | 21.26 | 104.36 | 101.64 | 54.83 | 18.93 | 5.98 |
| | 10 | 34.54 | 60.00 | 23.45 | 104.36 | 101.45 | 54.83 | 20.83 | 6.36 |
| | 9 | 32.11 | 60.00 | 20.53 | 104.34 | 101.98 | 54.82 | 18.34 | 5.27 |
| Mar | 10 | 27.13 | 60.00 | 14.55 | 104.36 | 102.28 | 54.83 | 13.03 | 4.80 |
| | 10 | 24.37 | 60.00 | 11.24 | 104.36 | 102.58 | 54.83 | 10.10 | 4.21 |
| | 11 | 22.43 | 60.00 | 8.92 | 104.27 | 102.51 | 54.78 | 8.00 | 4.17 |
| Apr | 10 | 24.21 | 60.00 | 11.06 | 104.36 | 102.60 | 54.83 | 9.93 | 4.18 |
| | 10 | 31.82 | 60.00 | 20.18 | 104.36 | 101.75 | 54.83 | 17.98 | 5.79 |
| | 10 | 42.53 | 60.00 | 33.03 | 104.36 | 100.55 | 54.83 | 29.08 | 8.01 |
| May | 10 | 59.69 | 60.00 | 53.63 | 104.36 | 98.57 | 54.83 | 46.29 | 11.45 |
| | 10 | 69.16 | 60.00 | 60.00 | 104.35 | 97.94 | 54.82 | 51.46 | 12.48 |
| | 11 | 88.07 | 60.00 | 60.00 | 104.18 | 97.14 | 54.73 | 51.04 | 13.64 |
| Jun | 10 | 120.10 | 60.00 | 60.00 | 104.16 | 97.94 | 54.72 | 51.46 | 12.48 |
| | 10 | 496.45 | 60.00 | 60.00 | 102.94 | 97.94 | 54.08 | 51.46 | 12.45 |
| | 10 | 955.93 | 60.00 | 60.00 | 101.85 | 97.94 | 53.51 | 51.46 | 12.43 |
| Jul | 10 | 614.56 | 60.00 | 60.00 | 102.63 | 97.94 | 53.92 | 51.46 | 12.45 |
| | 10 | 749.80 | 60.00 | 60.00 | 102.30 | 97.94 | 53.74 | 51.46 | 12.44 |
| | 11 | 1008.18 | 60.00 | 60.00 | 101.65 | 97.14 | 53.41 | 51.04 | 13.58 |
| Aug | 10 | 1096.74 | 60.00 | 60.00 | 101.59 | 97.94 | 53.37 | 51.46 | 12.43 |
| | 10 | 842.72 | 60.00 | 60.00 | 102.09 | 97.94 | 53.63 | 51.46 | 12.44 |
| | 11 | 726.22 | 60.00 | 60.00 | 102.25 | 97.14 | 53.72 | 51.04 | 13.59 |
| Sep | 10 | 648.85 | 60.00 | 60.00 | 102.54 | 97.94 | 53.87 | 51.46 | 12.45 |
| | 10 | 411.30 | 60.00 | 60.00 | 103.19 | 97.94 | 54.21 | 51.46 | 12.46 |
| | 10 | 204.50 | 60.00 | 60.00 | 103.86 | 97.94 | 54.56 | 51.46 | 12.47 |
| Oct | 10 | 171.78 | 60.00 | 60.00 | 103.97 | 97.94 | 54.62 | 51.46 | 12.48 |
| | 10 | 98.93 | 60.00 | 60.00 | 104.24 | 97.94 | 54.76 | 51.46 | 12.48 |
| | 11 | 68.93 | 60.00 | 60.00 | 104.25 | 97.14 | 54.77 | 51.04 | 13.64 |
| Nov | 10 | 57.59 | 60.00 | 51.10 | 102.64 | 96.90 | 53.92 | 43.36 | 10.83 |
| | 10 | 51.44 | 60.00 | 43.72 | 102.40 | 97.37 | 53.80 | 37.28 | 9.61 |
| | 10 | 44.21 | 60.00 | 35.06 | 101.93 | 97.72 | 53.55 | 30.00 | 8.14 |
| Dec | 10 | 42.18 | 60.00 | 32.62 | 102.56 | 98.63 | 53.88 | 28.17 | 7.79 |
| | 10 | 41.15 | 60.00 | 31.38 | 103.38 | 99.64 | 54.31 | 27.38 | 7.65 |
| | 11 | 41.57 | 60.00 | 31.88 | 104.27 | 100.15 | 54.78 | 27.96 | 8.56 |



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| 1967 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 36.79 | 60.00 | 26.14 | 95.55 | 91.83 | 48.24 | 21.02 | 6.13 |
| | 10 | 36.41 | 60.00 | 25.69 | 96.64 | 93.03 | 48.87 | 20.93 | 6.14 |
| | 11 | 34.34 | 60.00 | 23.21 | 97.98 | 94.37 | 49.58 | 19.17 | 6.40 |
| Feb | 10 | 35.08 | 60.00 | 24.10 | 98.73 | 95.42 | 50.13 | 20.13 | 6.03 |
| | 10 | 35.08 | 60.00 | 24.10 | 99.84 | 96.59 | 50.75 | 20.38 | 6.11 |
| | 8 | 34.82 | 60.00 | 23.78 | 99.57 | 97.03 | 50.98 | 20.20 | 4.86 |
| Mar | 10 | 34.36 | 60.00 | 23.24 | 101.64 | 98.57 | 51.79 | 20.06 | 6.08 |
| | 10 | 34.79 | 60.00 | 23.75 | 102.79 | 99.74 | 52.40 | 20.74 | 6.24 |
| | 11 | 34.09 | 60.00 | 22.91 | 104.26 | 101.07 | 53.10 | 20.28 | 6.80 |
| Apr | 10 | 33.93 | 60.00 | 22.72 | 104.36 | 101.52 | 53.33 | 20.20 | 6.17 |
| | 10 | 35.76 | 60.00 | 24.92 | 104.36 | 101.31 | 53.23 | 22.10 | 6.55 |
| | 10 | 63.92 | 60.00 | 58.71 | 104.36 | 98.07 | 51.52 | 50.41 | 12.14 |
| May | 10 | 57.73 | 60.00 | 51.28 | 104.13 | 98.53 | 51.76 | 44.24 | 10.92 |
| | 10 | 59.33 | 60.00 | 53.20 | 104.36 | 98.61 | 51.81 | 45.93 | 11.26 |
| | 11 | 88.76 | 60.00 | 60.00 | 104.18 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 230.67 | 60.00 | 60.00 | 103.77 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 347.77 | 60.00 | 60.00 | 103.39 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 597.61 | 60.00 | 60.00 | 102.67 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 763.70 | 60.00 | 60.00 | 102.26 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 931.39 | 60.00 | 60.00 | 101.90 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 1081.19 | 60.00 | 60.00 | 101.52 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 1003.67 | 60.00 | 60.00 | 101.76 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 972.11 | 60.00 | 60.00 | 101.82 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 631.98 | 60.00 | 60.00 | 102.48 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 426.51 | 60.00 | 60.00 | 103.15 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 514.21 | 60.00 | 60.00 | 102.89 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 248.69 | 60.00 | 60.00 | 103.71 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 130.48 | 60.00 | 60.00 | 104.12 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 80.91 | 60.00 | 60.00 | 104.30 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 61.78 | 60.00 | 56.14 | 104.27 | 97.56 | 51.26 | 47.96 | 12.81 |
| Nov | 10 | 52.08 | 60.00 | 44.50 | 102.23 | 97.11 | 51.02 | 37.84 | 9.61 |
| | 10 | 44.73 | 60.00 | 35.68 | 101.73 | 97.44 | 51.19 | 30.44 | 8.14 |
| | 10 | 40.93 | 60.00 | 31.11 | 101.98 | 98.17 | 51.57 | 26.75 | 7.41 |
| Dec | 10 | 35.51 | 60.00 | 24.61 | 101.89 | 98.71 | 51.86 | 21.28 | 6.33 |
| | 10 | 32.88 | 60.00 | 21.45 | 102.39 | 99.55 | 52.30 | 18.70 | 5.83 |
| | 11 | 30.98 | 60.00 | 19.18 | 103.58 | 100.73 | 52.92 | 16.91 | 6.05 |



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| 1968 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 27.33 | 60.00 | 14.80 | 97.48 | 95.06 | 49.94 | 12.32 | 4.46 |
| | 10 | 26.45 | 60.00 | 13.75 | 98.41 | 96.14 | 50.51 | 11.57 | 4.33 |
| | 11 | 26.28 | 60.00 | 13.54 | 99.96 | 97.53 | 51.24 | 11.56 | 4.80 |
| Feb | 10 | 25.56 | 60.00 | 12.67 | 100.54 | 98.46 | 51.73 | 10.92 | 4.25 |
| | 10 | 23.73 | 60.00 | 10.47 | 101.23 | 99.39 | 52.22 | 9.12 | 3.91 |
| | 8 | 25.45 | 60.00 | 12.54 | 101.79 | 100.22 | 52.65 | 11.00 | 3.44 |
| Mar | 10 | 26.06 | 60.00 | 13.27 | 103.61 | 101.60 | 53.38 | 11.81 | 4.50 |
| | 10 | 24.03 | 60.00 | 10.84 | 104.21 | 102.46 | 53.83 | 9.73 | 4.10 |
| | 11 | 19.08 | 60.00 | 4.89 | 104.27 | 102.91 | 54.07 | 4.41 | 3.35 |
| Apr | 10 | 18.90 | 60.00 | 4.68 | 104.36 | 103.18 | 54.21 | 4.23 | 3.01 |
| | 10 | 21.65 | 60.00 | 7.98 | 104.36 | 102.88 | 54.05 | 7.19 | 3.60 |
| | 10 | 46.15 | 60.00 | 37.38 | 104.36 | 100.13 | 52.61 | 32.77 | 8.66 |
| May | 10 | 47.10 | 60.00 | 38.52 | 104.36 | 100.02 | 52.55 | 33.74 | 8.85 |
| | 10 | 58.81 | 60.00 | 52.57 | 104.36 | 98.67 | 51.84 | 45.42 | 11.16 |
| | 11 | 127.80 | 60.00 | 60.00 | 104.03 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 273.70 | 60.00 | 60.00 | 103.62 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 493.05 | 60.00 | 60.00 | 102.95 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 652.50 | 60.00 | 60.00 | 102.53 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 900.18 | 60.00 | 60.00 | 101.97 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 1054.61 | 60.00 | 60.00 | 101.67 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 814.60 | 60.00 | 60.00 | 102.05 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 1239.70 | 60.00 | 60.00 | 101.35 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 1166.17 | 60.00 | 60.00 | 101.47 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 525.84 | 60.00 | 60.00 | 102.76 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 325.53 | 60.00 | 60.00 | 103.46 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 320.51 | 60.00 | 60.00 | 103.47 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 219.39 | 60.00 | 60.00 | 103.81 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 130.48 | 60.00 | 60.00 | 104.12 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 70.63 | 60.00 | 60.00 | 104.34 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 58.55 | 60.00 | 52.26 | 104.27 | 97.98 | 51.48 | 44.84 | 12.13 |
| Nov | 10 | 49.84 | 60.00 | 41.81 | 102.50 | 97.67 | 51.31 | 35.76 | 9.20 |
| | 10 | 47.22 | 60.00 | 38.67 | 103.00 | 98.52 | 51.76 | 33.36 | 8.74 |
| | 10 | 39.87 | 60.00 | 29.84 | 102.51 | 98.85 | 51.94 | 25.83 | 7.24 |
| Dec | 10 | 37.79 | 60.00 | 27.35 | 103.12 | 99.75 | 52.40 | 23.89 | 6.87 |
| | 10 | 36.52 | 60.00 | 25.82 | 103.89 | 100.71 | 52.91 | 22.77 | 6.67 |
| | 11 | 33.60 | 60.00 | 22.33 | 104.27 | 101.14 | 53.13 | 19.77 | 6.69 |



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| 1969 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 30.33 | 60.00 | 18.39 | 97.59 | 94.81 | 49.81 | 15.27 | 5.05 |
| | 10 | 27.15 | 60.00 | 14.59 | 98.00 | 95.63 | 50.24 | 12.21 | 4.45 |
| | 11 | 26.76 | 60.00 | 14.11 | 99.52 | 97.01 | 50.97 | 11.98 | 4.88 |
| Feb | 10 | 27.03 | 60.00 | 14.43 | 100.31 | 98.06 | 51.52 | 12.39 | 4.54 |
| | 10 | 27.14 | 60.00 | 14.56 | 101.42 | 99.19 | 52.11 | 12.65 | 4.61 |
| | 8 | 24.98 | 60.00 | 11.97 | 101.17 | 99.63 | 52.34 | 10.44 | 3.35 |
| Mar | 10 | 23.82 | 60.00 | 10.58 | 102.63 | 100.83 | 52.97 | 9.34 | 3.99 |
| | 10 | 28.48 | 60.00 | 16.18 | 104.36 | 102.13 | 53.65 | 14.47 | 5.04 |
| | 11 | 26.92 | 60.00 | 14.30 | 104.27 | 101.96 | 53.57 | 12.77 | 5.17 |
| Apr | 10 | 33.74 | 60.00 | 22.48 | 104.36 | 101.54 | 53.35 | 19.99 | 6.13 |
| | 10 | 52.50 | 60.00 | 45.00 | 104.36 | 99.40 | 52.22 | 39.16 | 9.92 |
| | 10 | 31.21 | 60.00 | 19.45 | 100.96 | 98.24 | 51.61 | 16.73 | 5.41 |
| May | 10 | 43.64 | 60.00 | 34.36 | 104.36 | 100.42 | 52.76 | 30.22 | 8.15 |
| | 10 | 74.65 | 60.00 | 60.00 | 104.33 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 155.83 | 60.00 | 60.00 | 103.93 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 250.02 | 60.00 | 60.00 | 103.70 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 351.36 | 60.00 | 60.00 | 103.37 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 488.38 | 60.00 | 60.00 | 102.97 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 733.03 | 60.00 | 60.00 | 102.34 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 878.66 | 60.00 | 60.00 | 102.01 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 1111.03 | 60.00 | 60.00 | 101.47 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 1230.92 | 60.00 | 60.00 | 101.36 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 1179.80 | 60.00 | 60.00 | 101.45 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 546.71 | 60.00 | 60.00 | 102.71 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 426.51 | 60.00 | 60.00 | 103.15 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 265.45 | 60.00 | 60.00 | 103.65 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 172.45 | 60.00 | 60.00 | 103.97 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 161.24 | 60.00 | 60.00 | 104.01 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 127.83 | 60.00 | 60.00 | 104.13 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 71.30 | 60.00 | 60.00 | 104.24 | 97.14 | 51.04 | 51.04 | 13.47 |
| Nov | 10 | 55.30 | 60.00 | 48.35 | 102.16 | 96.64 | 50.77 | 40.92 | 10.21 |
| | 10 | 51.83 | 60.00 | 44.20 | 102.48 | 97.41 | 51.18 | 37.70 | 9.59 |
| | 10 | 48.86 | 60.00 | 40.63 | 102.91 | 98.23 | 51.61 | 34.94 | 9.05 |
| Dec | 10 | 45.29 | 60.00 | 36.34 | 103.21 | 98.97 | 51.99 | 31.50 | 8.38 |
| | 10 | 44.70 | 60.00 | 35.63 | 104.10 | 100.01 | 52.54 | 31.21 | 8.34 |
| | 11 | 36.87 | 60.00 | 26.24 | 104.18 | 100.64 | 52.87 | 23.12 | 7.41 |



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| 1970 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 35.64 | 60.00 | 24.77 | 96.66 | 93.15 | 48.94 | 20.20 | 6.00 |
| | 10 | 33.79 | 60.00 | 22.55 | 97.39 | 94.16 | 49.47 | 18.59 | 5.70 |
| | 11 | 33.31 | 60.00 | 21.97 | 99.05 | 95.64 | 50.25 | 18.40 | 6.26 |
| Feb | 10 | 30.87 | 60.00 | 19.04 | 99.10 | 96.33 | 50.61 | 16.06 | 5.24 |
| | 10 | 29.18 | 60.00 | 17.02 | 99.83 | 97.30 | 51.12 | 14.50 | 4.94 |
| | 8 | 27.87 | 60.00 | 15.44 | 99.64 | 97.78 | 51.37 | 13.22 | 3.76 |
| Mar | 10 | 27.46 | 60.00 | 14.95 | 101.41 | 99.15 | 52.09 | 12.98 | 4.68 |
| | 10 | 26.72 | 60.00 | 14.07 | 102.32 | 100.18 | 52.63 | 12.34 | 4.57 |
| | 11 | 26.98 | 60.00 | 14.38 | 103.87 | 101.53 | 53.34 | 12.79 | 5.16 |
| Apr | 10 | 31.67 | 60.00 | 20.01 | 104.36 | 101.77 | 53.47 | 17.83 | 5.70 |
| | 10 | 46.78 | 60.00 | 38.13 | 104.36 | 100.06 | 52.57 | 33.41 | 8.78 |
| | 10 | 68.01 | 60.00 | 60.00 | 104.35 | 97.94 | 51.46 | 51.46 | 12.35 |
| May | 10 | 50.76 | 60.00 | 42.91 | 102.47 | 97.52 | 51.24 | 36.64 | 9.38 |
| | 10 | 94.91 | 60.00 | 60.00 | 104.25 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 225.99 | 60.00 | 60.00 | 103.68 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 343.47 | 60.00 | 60.00 | 103.40 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 377.90 | 60.00 | 60.00 | 103.29 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 721.91 | 60.00 | 60.00 | 102.36 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 907.90 | 60.00 | 60.00 | 101.95 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 673.84 | 60.00 | 60.00 | 102.48 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 674.21 | 60.00 | 60.00 | 102.38 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 1036.50 | 60.00 | 60.00 | 101.70 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 908.08 | 60.00 | 60.00 | 101.95 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 983.68 | 60.00 | 60.00 | 101.70 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 928.34 | 60.00 | 60.00 | 101.91 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 568.20 | 60.00 | 60.00 | 102.75 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 200.52 | 60.00 | 60.00 | 103.87 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 206.65 | 60.00 | 60.00 | 103.85 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 140.83 | 60.00 | 60.00 | 104.08 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 81.74 | 60.00 | 60.00 | 104.20 | 97.14 | 51.04 | 51.04 | 13.47 |
| Nov | 10 | 55.58 | 60.00 | 48.70 | 102.22 | 96.67 | 50.79 | 41.22 | 10.28 |
| | 10 | 48.44 | 60.00 | 40.13 | 101.76 | 97.04 | 50.98 | 34.10 | 8.86 |
| | 10 | 41.41 | 60.00 | 31.70 | 101.33 | 97.41 | 51.18 | 27.04 | 7.45 |
| Dec | 10 | 37.68 | 60.00 | 27.22 | 101.60 | 98.15 | 51.56 | 23.39 | 6.74 |
| | 10 | 34.81 | 60.00 | 23.78 | 102.05 | 98.96 | 51.99 | 20.60 | 6.20 |
| | 11 | 32.22 | 60.00 | 20.66 | 103.13 | 100.10 | 52.59 | 18.11 | 6.30 |



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| 1971 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 30.49 | 60.00 | 18.59 | 96.66 | 93.81 | 49.28 | 15.27 | 5.03 |
| | 10 | 29.58 | 60.00 | 17.49 | 97.60 | 94.91 | 49.86 | 14.54 | 4.90 |
| | 11 | 29.17 | 60.00 | 17.00 | 99.18 | 96.34 | 50.61 | 14.34 | 5.38 |
| Feb | 10 | 29.02 | 60.00 | 16.82 | 99.83 | 97.31 | 51.13 | 14.34 | 4.91 |
| | 10 | 28.28 | 60.00 | 15.94 | 100.76 | 98.37 | 51.68 | 13.73 | 4.81 |
| | 8 | 27.33 | 60.00 | 14.80 | 100.67 | 98.89 | 51.96 | 12.81 | 3.71 |
| Mar | 10 | 26.45 | 60.00 | 13.75 | 102.30 | 100.18 | 52.63 | 12.06 | 4.52 |
| | 10 | 26.80 | 60.00 | 14.15 | 103.42 | 101.31 | 53.22 | 12.56 | 4.64 |
| | 11 | 27.57 | 60.00 | 15.09 | 104.27 | 101.88 | 53.52 | 13.46 | 5.32 |
| Apr | 10 | 30.71 | 60.00 | 18.85 | 104.36 | 101.88 | 53.52 | 16.81 | 5.50 |
| | 10 | 40.16 | 60.00 | 30.19 | 104.36 | 100.82 | 52.97 | 26.65 | 7.45 |
| | 10 | 58.24 | 60.00 | 51.88 | 104.36 | 98.74 | 51.87 | 44.86 | 11.05 |
| May | 10 | 69.97 | 60.00 | 60.00 | 104.35 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 123.56 | 60.00 | 60.00 | 104.15 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 271.80 | 60.00 | 60.00 | 103.53 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 682.63 | 60.00 | 60.00 | 102.46 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 773.92 | 60.00 | 60.00 | 102.24 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 949.69 | 60.00 | 60.00 | 101.87 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 675.45 | 60.00 | 60.00 | 102.47 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 968.34 | 60.00 | 60.00 | 101.83 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 897.92 | 60.00 | 60.00 | 101.87 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 1197.74 | 60.00 | 60.00 | 101.42 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 524.44 | 60.00 | 60.00 | 102.87 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 798.46 | 60.00 | 60.00 | 102.09 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 490.72 | 60.00 | 60.00 | 102.96 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 207.91 | 60.00 | 60.00 | 103.85 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 201.00 | 60.00 | 60.00 | 103.87 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 108.83 | 60.00 | 60.00 | 104.20 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 103.33 | 60.00 | 60.00 | 104.22 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 72.31 | 60.00 | 60.00 | 104.24 | 97.14 | 51.04 | 51.04 | 13.47 |
| Nov | 10 | 53.97 | 60.00 | 46.76 | 101.87 | 96.49 | 50.70 | 39.51 | 9.93 |
| | 10 | 48.46 | 60.00 | 40.15 | 101.77 | 97.04 | 50.98 | 34.12 | 8.86 |
| | 10 | 46.44 | 60.00 | 37.72 | 102.40 | 97.96 | 51.47 | 32.36 | 8.53 |
| Dec | 10 | 45.59 | 60.00 | 36.71 | 103.27 | 99.00 | 52.01 | 31.82 | 8.45 |
| | 10 | 43.05 | 60.00 | 33.65 | 103.77 | 99.84 | 52.45 | 29.42 | 7.98 |
| | 11 | 32.48 | 60.00 | 20.98 | 103.19 | 100.13 | 52.60 | 18.39 | 6.36 |



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| 1972 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 30.62 | 60.00 | 18.74 | 96.66 | 93.79 | 49.28 | 15.39 | 5.05 |
| | 10 | 31.15 | 60.00 | 19.38 | 97.93 | 95.06 | 49.94 | 16.14 | 5.22 |
| | 11 | 29.97 | 60.00 | 17.96 | 99.35 | 96.41 | 50.65 | 15.16 | 5.56 |
| Feb | 10 | 27.64 | 60.00 | 15.17 | 99.50 | 97.13 | 51.03 | 12.90 | 4.62 |
| | 10 | 25.11 | 60.00 | 12.13 | 100.04 | 98.00 | 51.49 | 10.41 | 4.14 |
| | 8 | 23.90 | 60.00 | 10.68 | 100.04 | 98.57 | 51.79 | 9.22 | 3.13 |
| Mar | 10 | 24.41 | 60.00 | 11.29 | 101.84 | 99.94 | 52.51 | 9.88 | 4.08 |
| | 10 | 25.25 | 60.00 | 12.30 | 103.07 | 101.12 | 53.13 | 10.89 | 4.30 |
| | 11 | 25.48 | 60.00 | 12.58 | 104.27 | 102.13 | 53.66 | 11.25 | 4.84 |
| Apr | 10 | 26.01 | 60.00 | 13.21 | 104.36 | 102.40 | 53.80 | 11.84 | 4.52 |
| | 10 | 28.52 | 60.00 | 16.22 | 104.36 | 102.12 | 53.65 | 14.50 | 5.05 |
| | 10 | 36.91 | 60.00 | 26.29 | 104.36 | 101.18 | 53.16 | 23.30 | 6.79 |
| May | 10 | 45.77 | 60.00 | 36.93 | 104.36 | 100.18 | 52.63 | 32.39 | 8.58 |
| | 10 | 76.44 | 60.00 | 60.00 | 104.32 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 117.22 | 60.00 | 60.00 | 104.07 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 138.18 | 60.00 | 60.00 | 104.09 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 325.53 | 60.00 | 60.00 | 103.46 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 475.29 | 60.00 | 60.00 | 103.00 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 427.58 | 60.00 | 60.00 | 103.14 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 487.31 | 60.00 | 60.00 | 102.97 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 413.98 | 60.00 | 60.00 | 103.08 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 731.59 | 60.00 | 60.00 | 102.34 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 469.55 | 60.00 | 60.00 | 103.02 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 402.57 | 60.00 | 60.00 | 103.12 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 546.14 | 60.00 | 60.00 | 102.81 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 368.75 | 60.00 | 60.00 | 103.32 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 130.86 | 60.00 | 60.00 | 104.12 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 151.97 | 60.00 | 60.00 | 104.04 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 104.80 | 60.00 | 60.00 | 104.21 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 64.57 | 60.00 | 59.48 | 104.27 | 97.20 | 51.07 | 50.62 | 13.38 |
| Nov | 10 | 55.03 | 60.00 | 48.03 | 102.20 | 96.72 | 50.82 | 40.68 | 10.17 |
| | 10 | 46.72 | 60.00 | 38.07 | 101.50 | 96.96 | 50.94 | 32.32 | 8.50 |
| | 10 | 41.59 | 60.00 | 31.91 | 101.47 | 97.54 | 51.25 | 27.26 | 7.50 |
| Dec | 10 | 37.16 | 60.00 | 26.59 | 101.59 | 98.20 | 51.59 | 22.87 | 6.64 |
| | 10 | 34.97 | 60.00 | 23.97 | 102.19 | 99.09 | 52.06 | 20.80 | 6.24 |
| | 11 | 33.07 | 60.00 | 21.68 | 103.42 | 100.30 | 52.70 | 19.04 | 6.51 |



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| 1973 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 31.08 | 60.00 | 19.30 | 96.77 | 93.85 | 49.31 | 15.86 | 5.14 |
| | 10 | 30.33 | 60.00 | 18.39 | 97.75 | 94.97 | 49.89 | 15.30 | 5.06 |
| | 11 | 29.98 | 60.00 | 17.98 | 99.35 | 96.41 | 50.65 | 15.18 | 5.57 |
| Feb | 10 | 28.52 | 60.00 | 16.22 | 99.69 | 97.23 | 51.08 | 13.81 | 4.81 |
| | 10 | 27.14 | 60.00 | 14.56 | 100.49 | 98.22 | 51.60 | 12.53 | 4.57 |
| | 8 | 25.42 | 60.00 | 12.51 | 100.31 | 98.71 | 51.86 | 10.81 | 3.39 |
| Mar | 10 | 24.50 | 60.00 | 11.40 | 101.86 | 99.95 | 52.51 | 9.98 | 4.10 |
| | 10 | 24.05 | 60.00 | 10.86 | 102.82 | 101.00 | 53.06 | 9.61 | 4.04 |
| | 11 | 25.32 | 60.00 | 12.39 | 104.27 | 102.15 | 53.67 | 11.08 | 4.80 |
| Apr | 10 | 33.86 | 60.00 | 22.63 | 104.36 | 101.52 | 53.34 | 20.12 | 6.16 |
| | 10 | 38.58 | 60.00 | 28.30 | 104.36 | 100.99 | 53.06 | 25.02 | 7.13 |
| | 10 | 57.23 | 60.00 | 50.68 | 104.36 | 98.85 | 51.93 | 43.87 | 10.85 |
| May | 10 | 88.58 | 60.00 | 60.00 | 104.28 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 95.88 | 60.00 | 60.00 | 104.25 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 187.61 | 60.00 | 60.00 | 103.82 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 380.95 | 60.00 | 60.00 | 103.28 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 687.47 | 60.00 | 60.00 | 102.44 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 905.92 | 60.00 | 60.00 | 101.95 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 996.32 | 60.00 | 60.00 | 101.78 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 1321.85 | 60.00 | 60.00 | 101.22 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 1103.53 | 60.00 | 60.00 | 101.48 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 1039.36 | 60.00 | 60.00 | 101.69 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 871.31 | 60.00 | 60.00 | 102.03 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 1018.09 | 60.00 | 60.00 | 101.63 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 554.03 | 60.00 | 60.00 | 102.79 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 519.95 | 60.00 | 60.00 | 102.88 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 317.10 | 60.00 | 60.00 | 103.48 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 133.01 | 60.00 | 60.00 | 104.11 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 117.91 | 60.00 | 60.00 | 104.17 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 91.72 | 60.00 | 60.00 | 104.16 | 97.14 | 51.04 | 51.04 | 13.47 |
| Nov | 10 | 67.38 | 60.00 | 60.00 | 104.36 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 51.98 | 60.00 | 44.37 | 102.72 | 97.66 | 51.31 | 37.94 | 9.64 |
| | 10 | 46.47 | 60.00 | 37.77 | 102.62 | 98.19 | 51.59 | 32.47 | 8.56 |
| Dec | 10 | 41.11 | 60.00 | 31.33 | 102.54 | 98.74 | 51.88 | 27.09 | 7.49 |
| | 10 | 37.93 | 60.00 | 27.52 | 102.92 | 99.52 | 52.28 | 23.98 | 6.89 |
| | 11 | 34.58 | 60.00 | 23.50 | 103.87 | 100.59 | 52.85 | 20.70 | 6.88 |



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| 1974 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 33.22 | 60.00 | 21.86 | 96.89 | 93.71 | 49.23 | 17.94 | 5.56 |
| | 10 | 33.56 | 60.00 | 22.27 | 98.11 | 94.96 | 49.89 | 18.52 | 5.70 |
| | 11 | 32.32 | 60.00 | 20.78 | 99.56 | 96.32 | 50.60 | 17.53 | 6.08 |
| Feb | 10 | 31.39 | 60.00 | 19.66 | 99.97 | 97.18 | 51.05 | 16.73 | 5.39 |
| | 10 | 30.76 | 60.00 | 18.91 | 100.92 | 98.25 | 51.62 | 16.27 | 5.32 |
| | 8 | 30.15 | 60.00 | 18.18 | 100.79 | 98.75 | 51.88 | 15.72 | 4.18 |
| Mar | 10 | 30.49 | 60.00 | 18.59 | 102.78 | 100.23 | 52.66 | 16.31 | 5.37 |
| | 10 | 30.13 | 60.00 | 18.16 | 103.75 | 101.28 | 53.21 | 16.10 | 5.35 |
| | 11 | 31.52 | 60.00 | 19.82 | 104.27 | 101.40 | 53.27 | 17.60 | 6.22 |
| Apr | 10 | 34.45 | 60.00 | 23.35 | 104.36 | 101.46 | 53.30 | 20.74 | 6.28 |
| | 10 | 28.86 | 60.00 | 16.63 | 104.25 | 101.96 | 53.57 | 14.85 | 5.11 |
| | 10 | 51.19 | 60.00 | 43.43 | 104.36 | 99.55 | 52.30 | 37.85 | 9.66 |
| May | 10 | 66.54 | 60.00 | 60.00 | 104.36 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 78.43 | 60.00 | 60.00 | 104.31 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 146.03 | 60.00 | 60.00 | 103.97 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 206.78 | 60.00 | 60.00 | 103.85 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 324.81 | 60.00 | 60.00 | 103.46 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 319.61 | 60.00 | 60.00 | 103.47 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 412.88 | 60.00 | 60.00 | 103.19 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 793.47 | 60.00 | 60.00 | 102.20 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 712.53 | 60.00 | 60.00 | 102.29 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 637.25 | 60.00 | 60.00 | 102.57 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 691.24 | 60.00 | 60.00 | 102.44 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 496.49 | 60.00 | 60.00 | 102.85 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 299.52 | 60.00 | 60.00 | 103.54 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 198.33 | 60.00 | 60.00 | 103.88 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 186.74 | 60.00 | 60.00 | 103.92 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 114.11 | 60.00 | 60.00 | 104.18 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 95.04 | 60.00 | 60.00 | 104.25 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 75.17 | 60.00 | 60.00 | 104.23 | 97.14 | 51.04 | 51.04 | 13.47 |
| Nov | 10 | 61.39 | 60.00 | 55.67 | 103.43 | 97.32 | 51.13 | 47.44 | 11.53 |
| | 10 | 45.32 | 60.00 | 36.39 | 101.09 | 96.69 | 50.80 | 30.81 | 8.19 |
| | 10 | 37.05 | 60.00 | 26.47 | 100.38 | 96.93 | 50.93 | 22.46 | 6.53 |
| Dec | 10 | 35.08 | 60.00 | 24.10 | 101.04 | 97.86 | 51.41 | 20.65 | 6.19 |
| | 10 | 33.47 | 60.00 | 22.16 | 101.77 | 98.82 | 51.92 | 19.18 | 5.91 |
| | 11 | 31.88 | 60.00 | 20.25 | 103.05 | 100.06 | 52.57 | 17.74 | 6.22 |



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| 1975 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 29.38 | 60.00 | 17.25 | 96.66 | 93.95 | 49.36 | 14.19 | 4.81 |
| | 10 | 28.27 | 60.00 | 15.92 | 97.56 | 95.03 | 49.92 | 13.25 | 4.65 |
| | 11 | 27.90 | 60.00 | 15.48 | 99.12 | 96.44 | 50.67 | 13.07 | 5.10 |
| Feb | 10 | 27.26 | 60.00 | 14.71 | 99.69 | 97.38 | 51.16 | 12.55 | 4.56 |
| | 10 | 27.69 | 60.00 | 15.23 | 100.87 | 98.56 | 51.78 | 13.14 | 4.70 |
| | 8 | 27.37 | 60.00 | 14.85 | 100.92 | 99.15 | 52.09 | 12.89 | 3.73 |
| Mar | 10 | 26.58 | 60.00 | 13.90 | 102.56 | 100.44 | 52.77 | 12.22 | 4.56 |
| | 10 | 25.36 | 60.00 | 12.43 | 103.35 | 101.40 | 53.27 | 11.04 | 4.34 |
| | 11 | 24.16 | 60.00 | 11.00 | 104.27 | 102.29 | 53.74 | 9.85 | 4.53 |
| Apr | 10 | 24.93 | 60.00 | 11.92 | 104.36 | 102.52 | 53.86 | 10.70 | 4.29 |
| | 10 | 28.36 | 60.00 | 16.03 | 104.36 | 102.14 | 53.66 | 14.33 | 5.01 |
| | 10 | 46.27 | 60.00 | 37.53 | 104.36 | 100.12 | 52.60 | 32.90 | 8.68 |
| May | 10 | 70.83 | 60.00 | 60.00 | 104.34 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 81.01 | 60.00 | 60.00 | 104.30 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 111.31 | 60.00 | 60.00 | 104.09 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 187.12 | 60.00 | 60.00 | 103.92 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 325.35 | 60.00 | 60.00 | 103.46 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 370.01 | 60.00 | 60.00 | 103.32 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 397.63 | 60.00 | 60.00 | 103.23 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 769.26 | 60.00 | 60.00 | 102.25 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 617.63 | 60.00 | 60.00 | 102.52 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 815.71 | 60.00 | 60.00 | 102.15 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 978.92 | 60.00 | 60.00 | 101.81 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 615.68 | 60.00 | 60.00 | 102.52 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 467.40 | 60.00 | 60.00 | 103.03 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 359.07 | 60.00 | 60.00 | 103.35 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 201.77 | 60.00 | 60.00 | 103.87 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 127.20 | 60.00 | 60.00 | 104.13 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 108.81 | 60.00 | 60.00 | 104.20 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 72.20 | 60.00 | 60.00 | 104.24 | 97.14 | 51.04 | 51.04 | 13.47 |
| Nov | 10 | 54.27 | 60.00 | 47.13 | 101.94 | 96.53 | 50.71 | 39.83 | 10.00 |
| | 10 | 43.69 | 60.00 | 34.43 | 100.74 | 96.51 | 50.70 | 29.09 | 7.85 |
| | 10 | 39.15 | 60.00 | 28.98 | 100.84 | 97.16 | 51.05 | 24.66 | 6.97 |
| Dec | 10 | 33.41 | 60.00 | 22.10 | 100.68 | 97.68 | 51.32 | 18.90 | 5.83 |
| | 10 | 27.39 | 60.00 | 14.87 | 100.46 | 98.16 | 51.57 | 12.78 | 4.62 |
| | 11 | 24.05 | 60.00 | 10.86 | 101.23 | 99.14 | 52.09 | 9.43 | 4.37 |



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| 1976 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 22.51 | 60.00 | 9.01 | 96.66 | 94.81 | 49.81 | 7.48 | 3.49 |
| | 10 | 22.33 | 60.00 | 8.80 | 97.77 | 95.98 | 50.43 | 7.39 | 3.50 |
| | 11 | 22.16 | 60.00 | 8.59 | 99.24 | 97.33 | 51.13 | 7.32 | 3.86 |
| Feb | 10 | 22.19 | 60.00 | 8.62 | 100.08 | 98.39 | 51.69 | 7.43 | 3.55 |
| | 10 | 22.35 | 60.00 | 8.82 | 101.20 | 99.53 | 52.29 | 7.68 | 3.63 |
| | 8 | 22.53 | 60.00 | 9.04 | 101.56 | 100.26 | 52.67 | 7.93 | 2.96 |
| Mar | 10 | 23.05 | 60.00 | 9.66 | 103.26 | 101.56 | 53.36 | 8.59 | 3.85 |
| | 10 | 23.28 | 60.00 | 9.94 | 104.32 | 102.65 | 53.93 | 8.93 | 3.94 |
| | 11 | 23.22 | 60.00 | 9.86 | 104.27 | 102.41 | 53.80 | 8.84 | 4.31 |
| Apr | 10 | 22.99 | 60.00 | 9.59 | 104.36 | 102.73 | 53.97 | 8.63 | 3.88 |
| | 10 | 24.20 | 60.00 | 11.03 | 104.36 | 102.60 | 53.90 | 9.91 | 4.14 |
| | 10 | 39.82 | 60.00 | 29.78 | 104.36 | 100.85 | 52.99 | 26.30 | 7.38 |
| May | 10 | 50.42 | 60.00 | 42.50 | 104.36 | 99.64 | 52.35 | 37.08 | 9.51 |
| | 10 | 140.02 | 60.00 | 60.00 | 104.09 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 175.92 | 60.00 | 60.00 | 103.86 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 288.58 | 60.00 | 60.00 | 103.57 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 331.99 | 60.00 | 60.00 | 103.43 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 302.03 | 60.00 | 60.00 | 103.53 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 751.86 | 60.00 | 60.00 | 102.29 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 1150.21 | 60.00 | 60.00 | 101.50 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 977.00 | 60.00 | 60.00 | 101.71 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 515.65 | 60.00 | 60.00 | 102.89 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 708.10 | 60.00 | 60.00 | 102.39 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 489.64 | 60.00 | 60.00 | 102.86 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 404.45 | 60.00 | 60.00 | 103.21 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 230.65 | 60.00 | 60.00 | 103.77 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 158.62 | 60.00 | 60.00 | 104.02 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 119.97 | 60.00 | 60.00 | 104.16 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 71.65 | 60.00 | 60.00 | 104.34 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 55.36 | 60.00 | 48.43 | 104.27 | 98.39 | 51.69 | 41.72 | 11.45 |
| Nov | 10 | 45.61 | 60.00 | 36.73 | 102.35 | 98.01 | 51.49 | 31.52 | 8.36 |
| | 10 | 37.72 | 60.00 | 27.26 | 101.74 | 98.29 | 51.64 | 23.46 | 6.76 |
| | 10 | 35.21 | 60.00 | 24.25 | 102.27 | 99.14 | 52.09 | 21.05 | 6.29 |
| Dec | 10 | 33.58 | 60.00 | 22.29 | 102.97 | 100.08 | 52.58 | 19.53 | 6.01 |
| | 10 | 31.80 | 60.00 | 20.16 | 103.64 | 100.98 | 53.05 | 17.83 | 5.69 |
| | 11 | 30.43 | 60.00 | 18.51 | 104.27 | 101.53 | 53.34 | 16.46 | 5.97 |



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| 1977 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 29.81 | 60.00 | 17.77 | 98.38 | 95.70 | 50.28 | 14.89 | 4.99 |
| | 10 | 28.59 | 60.00 | 16.31 | 99.23 | 96.74 | 50.82 | 13.81 | 4.80 |
| | 11 | 27.23 | 60.00 | 14.68 | 100.52 | 97.99 | 51.48 | 12.59 | 5.04 |
| Feb | 10 | 27.50 | 60.00 | 14.99 | 101.29 | 99.01 | 52.02 | 13.00 | 4.68 |
| | 10 | 27.12 | 60.00 | 14.54 | 102.27 | 100.08 | 52.58 | 12.74 | 4.65 |
| | 8 | 25.72 | 60.00 | 12.86 | 102.16 | 100.58 | 52.84 | 11.32 | 3.50 |
| Mar | 10 | 24.93 | 60.00 | 11.92 | 103.69 | 101.81 | 53.49 | 10.62 | 4.26 |
| | 10 | 24.79 | 60.00 | 11.74 | 104.36 | 102.53 | 53.87 | 10.54 | 4.26 |
| | 11 | 25.62 | 60.00 | 12.74 | 104.27 | 102.12 | 53.65 | 11.39 | 4.87 |
| Apr | 10 | 30.47 | 60.00 | 18.57 | 104.36 | 101.90 | 53.54 | 16.57 | 5.45 |
| | 10 | 37.72 | 60.00 | 27.26 | 104.36 | 101.09 | 53.11 | 24.13 | 6.95 |
| | 10 | 46.54 | 60.00 | 37.85 | 104.36 | 100.09 | 52.58 | 33.17 | 8.74 |
| May | 10 | 60.64 | 60.00 | 54.77 | 104.36 | 98.45 | 51.73 | 47.21 | 11.51 |
| | 10 | 81.82 | 60.00 | 60.00 | 104.30 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 171.53 | 60.00 | 60.00 | 103.87 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 250.38 | 60.00 | 60.00 | 103.70 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 316.92 | 60.00 | 60.00 | 103.48 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 971.39 | 60.00 | 60.00 | 101.82 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 1290.10 | 60.00 | 60.00 | 101.27 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 1176.03 | 60.00 | 60.00 | 101.45 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 945.86 | 60.00 | 60.00 | 101.78 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 945.56 | 60.00 | 60.00 | 101.87 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 854.99 | 60.00 | 60.00 | 102.06 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 679.27 | 60.00 | 60.00 | 102.37 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 407.67 | 60.00 | 60.00 | 103.20 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 250.02 | 60.00 | 60.00 | 103.70 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 221.63 | 60.00 | 60.00 | 103.80 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 144.18 | 60.00 | 60.00 | 104.07 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 92.83 | 60.00 | 60.00 | 104.26 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 72.80 | 60.00 | 60.00 | 104.24 | 97.14 | 51.04 | 51.04 | 13.47 |
| Nov | 10 | 57.90 | 60.00 | 51.48 | 102.71 | 96.93 | 50.93 | 43.69 | 10.78 |
| | 10 | 44.34 | 60.00 | 35.20 | 100.88 | 96.58 | 50.74 | 29.77 | 7.98 |
| | 10 | 38.90 | 60.00 | 28.68 | 100.79 | 97.14 | 51.03 | 24.40 | 6.92 |
| Dec | 10 | 32.84 | 60.00 | 21.41 | 100.55 | 97.62 | 51.29 | 18.30 | 5.71 |
| | 10 | 29.54 | 60.00 | 17.45 | 100.92 | 98.39 | 51.69 | 15.03 | 5.07 |
| | 11 | 27.02 | 60.00 | 14.42 | 101.93 | 99.49 | 52.27 | 12.56 | 5.06 |



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| 1978 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 26.01 | 60.00 | 13.21 | 96.66 | 94.37 | 49.58 | 10.91 | 4.17 |
| | 10 | 25.00 | 60.00 | 12.00 | 97.58 | 95.46 | 50.15 | 10.03 | 4.01 |
| | 11 | 23.27 | 60.00 | 9.92 | 98.73 | 96.65 | 50.78 | 8.40 | 4.08 |
| Feb | 10 | 23.35 | 60.00 | 10.02 | 99.57 | 97.72 | 51.34 | 8.58 | 3.77 |
| | 10 | 24.84 | 60.00 | 11.81 | 100.99 | 99.01 | 52.02 | 10.24 | 4.13 |
| | 8 | 25.02 | 60.00 | 12.02 | 101.24 | 99.70 | 52.38 | 10.50 | 3.36 |
| Mar | 10 | 25.22 | 60.00 | 12.26 | 102.98 | 101.03 | 53.08 | 10.85 | 4.29 |
| | 10 | 24.80 | 60.00 | 11.77 | 103.92 | 102.07 | 53.62 | 10.52 | 4.25 |
| | 11 | 21.82 | 60.00 | 8.18 | 104.27 | 102.58 | 53.89 | 7.35 | 3.99 |
| Apr | 10 | 18.76 | 60.00 | 4.51 | 104.36 | 103.20 | 54.22 | 4.08 | 2.98 |
| | 10 | 33.61 | 60.00 | 22.33 | 104.36 | 101.55 | 53.35 | 19.86 | 6.11 |
| | 10 | 37.00 | 60.00 | 26.40 | 104.36 | 101.17 | 53.15 | 23.39 | 6.80 |
| May | 10 | 93.07 | 60.00 | 60.00 | 104.26 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 130.89 | 60.00 | 60.00 | 104.12 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 192.77 | 60.00 | 60.00 | 103.80 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 351.90 | 60.00 | 60.00 | 103.37 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 423.28 | 60.00 | 60.00 | 103.16 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 1029.32 | 60.00 | 60.00 | 101.71 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 1417.45 | 60.00 | 60.00 | 101.08 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 1089.94 | 60.00 | 60.00 | 101.60 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 1057.54 | 60.00 | 60.00 | 101.56 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 1268.22 | 60.00 | 60.00 | 101.30 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 1100.70 | 60.00 | 60.00 | 101.58 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 875.58 | 60.00 | 60.00 | 101.92 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 380.05 | 60.00 | 60.00 | 103.29 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 359.43 | 60.00 | 60.00 | 103.35 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 256.84 | 60.00 | 60.00 | 103.68 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 160.67 | 60.00 | 60.00 | 104.01 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 101.32 | 60.00 | 60.00 | 104.23 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 74.27 | 60.00 | 60.00 | 104.23 | 97.14 | 51.04 | 51.04 | 13.47 |
| Nov | 10 | 53.57 | 60.00 | 46.29 | 101.79 | 96.45 | 50.67 | 39.09 | 9.85 |
| | 10 | 41.56 | 60.00 | 31.87 | 100.27 | 96.27 | 50.58 | 26.86 | 7.40 |
| | 10 | 35.15 | 60.00 | 24.18 | 99.97 | 96.72 | 50.81 | 20.48 | 6.13 |
| Dec | 10 | 30.13 | 60.00 | 18.16 | 99.96 | 97.32 | 51.13 | 15.47 | 5.14 |
| | 10 | 28.28 | 60.00 | 15.94 | 100.65 | 98.26 | 51.62 | 13.72 | 4.81 |
| | 11 | 27.20 | 60.00 | 14.64 | 101.97 | 99.51 | 52.28 | 12.75 | 5.11 |



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| 1979 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 36.75 | 60.00 | 26.10 | 96.66 | 93.01 | 48.87 | 21.26 | 6.21 |
| | 10 | 35.15 | 60.00 | 24.18 | 97.44 | 94.05 | 49.41 | 19.92 | 5.96 |
| | 11 | 33.62 | 60.00 | 22.35 | 98.88 | 95.42 | 50.13 | 18.67 | 6.31 |
| Feb | 10 | 32.82 | 60.00 | 21.39 | 99.29 | 96.28 | 50.59 | 18.03 | 5.63 |
| | 10 | 31.33 | 60.00 | 19.60 | 100.06 | 97.28 | 51.11 | 16.70 | 5.38 |
| | 8 | 30.38 | 60.00 | 18.45 | 99.83 | 97.74 | 51.35 | 15.79 | 4.17 |
| Mar | 10 | 30.87 | 60.00 | 19.04 | 101.91 | 99.27 | 52.15 | 16.55 | 5.40 |
| | 10 | 29.31 | 60.00 | 17.17 | 102.63 | 100.21 | 52.65 | 15.06 | 5.12 |
| | 11 | 31.13 | 60.00 | 19.35 | 104.27 | 101.44 | 53.30 | 17.19 | 6.13 |
| Apr | 10 | 33.75 | 60.00 | 22.51 | 104.36 | 101.54 | 53.34 | 20.01 | 6.14 |
| | 10 | 48.21 | 60.00 | 39.85 | 104.36 | 99.90 | 52.48 | 34.86 | 9.07 |
| | 10 | 71.56 | 60.00 | 60.00 | 104.34 | 97.94 | 51.46 | 51.46 | 12.35 |
| May | 10 | 87.69 | 60.00 | 60.00 | 104.28 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 71.51 | 60.00 | 60.00 | 104.34 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 77.16 | 60.00 | 60.00 | 104.22 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 131.07 | 60.00 | 60.00 | 104.12 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 294.68 | 60.00 | 60.00 | 103.55 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 748.09 | 60.00 | 60.00 | 102.30 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 912.92 | 60.00 | 60.00 | 101.94 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 1351.44 | 60.00 | 60.00 | 101.18 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 1009.77 | 60.00 | 60.00 | 101.65 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 1285.44 | 60.00 | 60.00 | 101.28 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 1060.17 | 60.00 | 60.00 | 101.66 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 488.83 | 60.00 | 60.00 | 102.87 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 363.73 | 60.00 | 60.00 | 103.34 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 313.51 | 60.00 | 60.00 | 103.49 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 157.22 | 60.00 | 60.00 | 104.02 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 126.55 | 60.00 | 60.00 | 104.13 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 111.09 | 60.00 | 60.00 | 104.19 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 85.80 | 60.00 | 60.00 | 104.19 | 97.14 | 51.04 | 51.04 | 13.47 |
| Nov | 10 | 74.29 | 60.00 | 60.00 | 104.33 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 51.62 | 60.00 | 43.94 | 102.65 | 97.62 | 51.29 | 37.56 | 9.56 |
| | 10 | 43.69 | 60.00 | 34.43 | 102.03 | 97.89 | 51.43 | 29.51 | 7.96 |
| Dec | 10 | 39.46 | 60.00 | 29.35 | 102.19 | 98.56 | 51.78 | 25.33 | 7.14 |
| | 10 | 37.05 | 60.00 | 26.47 | 102.74 | 99.43 | 52.24 | 23.04 | 6.70 |
| | 11 | 36.98 | 60.00 | 26.37 | 104.27 | 100.72 | 52.92 | 23.26 | 7.45 |



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| 1980 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 36.98 | 60.00 | 26.38 | 96.74 | 93.06 | 48.89 | 21.50 | 6.25 |
| | 10 | 35.67 | 60.00 | 24.81 | 97.58 | 94.13 | 49.45 | 20.45 | 6.07 |
| | 11 | 33.59 | 60.00 | 22.31 | 98.89 | 95.43 | 50.14 | 18.64 | 6.31 |
| Feb | 10 | 32.07 | 60.00 | 20.48 | 99.14 | 96.22 | 50.55 | 17.26 | 5.47 |
| | 10 | 31.03 | 60.00 | 19.23 | 100.01 | 97.27 | 51.10 | 16.38 | 5.32 |
| | 8 | 30.38 | 60.00 | 18.45 | 99.86 | 97.76 | 51.36 | 15.80 | 4.17 |
| Mar | 10 | 33.31 | 60.00 | 21.97 | 102.44 | 99.55 | 52.30 | 19.15 | 5.92 |
| | 10 | 35.91 | 60.00 | 25.09 | 104.01 | 100.92 | 53.02 | 22.17 | 6.55 |
| | 11 | 37.24 | 60.00 | 26.69 | 104.27 | 100.69 | 52.90 | 23.53 | 7.50 |
| Apr | 10 | 37.74 | 60.00 | 27.28 | 104.36 | 101.09 | 53.11 | 24.15 | 6.95 |
| | 10 | 47.42 | 60.00 | 38.91 | 104.36 | 99.99 | 52.53 | 34.06 | 8.91 |
| | 10 | 55.82 | 60.00 | 48.98 | 104.36 | 99.02 | 52.02 | 42.47 | 10.57 |
| May | 10 | 98.93 | 60.00 | 60.00 | 104.24 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 105.05 | 60.00 | 60.00 | 104.21 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 150.56 | 60.00 | 60.00 | 103.95 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 264.19 | 60.00 | 60.00 | 103.65 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 410.37 | 60.00 | 60.00 | 103.19 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 606.04 | 60.00 | 60.00 | 102.65 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 602.10 | 60.00 | 60.00 | 102.66 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 785.76 | 60.00 | 60.00 | 102.21 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 788.67 | 60.00 | 60.00 | 102.11 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 906.82 | 60.00 | 60.00 | 101.95 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 390.10 | 60.00 | 60.00 | 103.25 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 525.51 | 60.00 | 60.00 | 102.76 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 396.20 | 60.00 | 60.00 | 103.24 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 289.30 | 60.00 | 60.00 | 103.57 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 187.39 | 60.00 | 60.00 | 103.92 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 152.58 | 60.00 | 60.00 | 104.04 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 97.19 | 60.00 | 60.00 | 104.24 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 77.09 | 60.00 | 60.00 | 104.22 | 97.14 | 51.04 | 51.04 | 13.47 |
| Nov | 10 | 58.04 | 60.00 | 51.65 | 102.74 | 96.95 | 50.93 | 43.84 | 10.81 |
| | 10 | 47.65 | 60.00 | 39.19 | 101.59 | 96.95 | 50.94 | 33.27 | 8.69 |
| | 10 | 42.85 | 60.00 | 33.42 | 101.63 | 97.57 | 51.26 | 28.55 | 7.76 |
| Dec | 10 | 39.28 | 60.00 | 29.13 | 101.94 | 98.32 | 51.65 | 25.08 | 7.08 |
| | 10 | 36.48 | 60.00 | 25.78 | 102.41 | 99.14 | 52.09 | 22.38 | 6.56 |
| | 11 | 33.64 | 60.00 | 22.36 | 103.46 | 100.26 | 52.68 | 19.63 | 6.64 |



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| 1981 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 32.77 | 60.00 | 21.32 | 96.66 | 93.52 | 49.13 | 17.46 | 5.46 |
| | 10 | 31.24 | 60.00 | 19.49 | 97.46 | 94.56 | 49.68 | 16.14 | 5.21 |
| | 11 | 29.74 | 60.00 | 17.69 | 98.81 | 95.87 | 50.37 | 14.85 | 5.48 |
| Feb | 10 | 28.14 | 60.00 | 15.77 | 99.13 | 96.69 | 50.80 | 13.35 | 4.70 |
| | 10 | 25.90 | 60.00 | 13.08 | 99.74 | 97.60 | 51.27 | 11.18 | 4.29 |
| | 8 | 23.18 | 60.00 | 9.82 | 99.44 | 98.02 | 51.50 | 8.43 | 3.00 |
| Mar | 10 | 23.23 | 60.00 | 9.87 | 101.12 | 99.34 | 52.19 | 8.59 | 3.80 |
| | 10 | 23.76 | 60.00 | 10.52 | 102.30 | 100.50 | 52.80 | 9.26 | 3.96 |
| | 11 | 26.63 | 60.00 | 13.95 | 104.27 | 101.99 | 53.59 | 12.46 | 5.10 |
| Apr | 10 | 33.74 | 60.00 | 22.48 | 104.36 | 101.54 | 53.35 | 19.99 | 6.13 |
| | 10 | 38.79 | 60.00 | 28.55 | 104.36 | 100.97 | 53.05 | 25.24 | 7.17 |
| | 10 | 52.44 | 60.00 | 44.93 | 104.36 | 99.41 | 52.23 | 39.11 | 9.91 |
| May | 10 | 142.12 | 60.00 | 60.00 | 104.08 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 190.15 | 60.00 | 60.00 | 103.91 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 274.12 | 60.00 | 60.00 | 103.52 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 217.11 | 60.00 | 60.00 | 103.81 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 204.50 | 60.00 | 60.00 | 103.86 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 518.34 | 60.00 | 60.00 | 102.88 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 615.19 | 60.00 | 60.00 | 102.63 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 834.18 | 60.00 | 60.00 | 102.11 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 889.93 | 60.00 | 60.00 | 101.89 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 815.35 | 60.00 | 60.00 | 102.15 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 736.61 | 60.00 | 60.00 | 102.33 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 378.77 | 60.00 | 60.00 | 103.19 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 230.13 | 60.00 | 60.00 | 103.77 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 158.10 | 60.00 | 60.00 | 104.02 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 191.30 | 60.00 | 60.00 | 103.90 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 115.50 | 60.00 | 60.00 | 104.18 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 73.34 | 60.00 | 60.00 | 104.33 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 54.54 | 60.00 | 47.45 | 104.26 | 98.50 | 51.75 | 40.92 | 11.28 |
| Nov | 10 | 47.17 | 60.00 | 38.60 | 102.87 | 98.38 | 51.69 | 33.26 | 8.72 |
| | 10 | 43.71 | 60.00 | 34.45 | 103.19 | 99.13 | 52.08 | 29.90 | 8.06 |
| | 10 | 38.69 | 60.00 | 28.42 | 103.18 | 99.71 | 52.38 | 24.82 | 7.06 |
| Dec | 10 | 35.23 | 60.00 | 24.27 | 103.50 | 100.44 | 52.77 | 21.35 | 6.38 |
| | 10 | 32.54 | 60.00 | 21.04 | 103.97 | 101.25 | 53.19 | 18.66 | 5.86 |
| | 11 | 30.26 | 60.00 | 18.31 | 104.27 | 101.55 | 53.35 | 16.29 | 5.93 |



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| 1982 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 30.01 | 60.00 | 18.01 | 98.42 | 95.72 | 50.29 | 15.09 | 5.03 |
| | 10 | 28.93 | 60.00 | 16.72 | 99.30 | 96.77 | 50.84 | 14.16 | 4.87 |
| | 11 | 27.60 | 60.00 | 15.13 | 100.60 | 98.03 | 51.50 | 12.98 | 5.12 |
| Feb | 10 | 27.26 | 60.00 | 14.71 | 101.23 | 98.98 | 52.00 | 12.75 | 4.63 |
| | 10 | 27.15 | 60.00 | 14.59 | 102.28 | 100.08 | 52.58 | 12.78 | 4.66 |
| | 8 | 26.32 | 60.00 | 13.58 | 102.26 | 100.62 | 52.86 | 11.97 | 3.61 |
| Mar | 10 | 28.28 | 60.00 | 15.94 | 104.36 | 102.14 | 53.66 | 14.26 | 5.00 |
| | 10 | 25.99 | 60.00 | 13.19 | 104.36 | 102.40 | 53.80 | 11.82 | 4.52 |
| | 11 | 21.15 | 60.00 | 7.38 | 104.27 | 102.66 | 53.93 | 6.63 | 3.83 |
| Apr | 10 | 20.31 | 60.00 | 6.37 | 104.36 | 103.03 | 54.13 | 5.75 | 3.32 |
| | 10 | 38.15 | 60.00 | 27.78 | 104.36 | 101.04 | 53.08 | 24.58 | 7.04 |
| | 10 | 58.88 | 60.00 | 52.66 | 104.36 | 98.66 | 51.83 | 45.49 | 11.17 |
| May | 10 | 111.97 | 60.00 | 60.00 | 104.19 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 99.38 | 60.00 | 60.00 | 104.24 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 187.28 | 60.00 | 60.00 | 103.82 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 225.34 | 60.00 | 60.00 | 103.79 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 373.78 | 60.00 | 60.00 | 103.30 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 312.80 | 60.00 | 60.00 | 103.50 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 354.05 | 60.00 | 60.00 | 103.37 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 360.86 | 60.00 | 60.00 | 103.34 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 752.97 | 60.00 | 60.00 | 102.19 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 1027.71 | 60.00 | 60.00 | 101.72 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 775.17 | 60.00 | 60.00 | 102.24 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 297.88 | 60.00 | 60.00 | 103.45 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 224.73 | 60.00 | 60.00 | 103.79 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 162.33 | 60.00 | 60.00 | 104.01 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 82.58 | 60.00 | 60.00 | 104.30 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 64.57 | 60.00 | 59.48 | 104.36 | 97.99 | 51.48 | 51.04 | 12.27 |
| | 10 | 58.81 | 60.00 | 52.57 | 104.21 | 98.50 | 51.75 | 45.34 | 11.14 |
| | 11 | 50.76 | 60.00 | 42.91 | 104.27 | 98.98 | 52.00 | 37.19 | 10.47 |
| Nov | 10 | 44.18 | 60.00 | 35.01 | 103.11 | 99.00 | 52.01 | 30.35 | 8.15 |
| | 10 | 38.79 | 60.00 | 28.55 | 103.03 | 99.54 | 52.29 | 24.89 | 7.07 |
| | 10 | 37.22 | 60.00 | 26.66 | 103.74 | 100.47 | 52.78 | 23.45 | 6.80 |
| Dec | 10 | 35.66 | 60.00 | 24.79 | 104.36 | 101.32 | 53.23 | 21.99 | 6.53 |
| | 10 | 35.35 | 60.00 | 24.42 | 104.36 | 101.36 | 53.25 | 21.67 | 6.46 |
| | 11 | 35.10 | 60.00 | 24.13 | 104.27 | 100.95 | 53.04 | 21.33 | 7.03 |



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| 1983 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 33.90 | 60.00 | 22.68 | 97.21 | 93.96 | 49.36 | 18.66 | 5.71 |
| | 10 | 33.25 | 60.00 | 21.90 | 98.20 | 95.09 | 49.96 | 18.24 | 5.65 |
| | 11 | 31.26 | 60.00 | 19.51 | 99.46 | 96.35 | 50.62 | 16.46 | 5.85 |
| Feb | 10 | 30.69 | 60.00 | 18.83 | 99.97 | 97.26 | 51.10 | 16.03 | 5.25 |
| | 10 | 29.67 | 60.00 | 17.60 | 100.84 | 98.29 | 51.64 | 15.15 | 5.09 |
| | 8 | 27.87 | 60.00 | 15.44 | 100.54 | 98.71 | 51.86 | 13.35 | 3.79 |
| Mar | 10 | 26.08 | 60.00 | 13.29 | 102.00 | 99.92 | 52.49 | 11.63 | 4.43 |
| | 10 | 23.76 | 60.00 | 10.52 | 102.57 | 100.77 | 52.94 | 9.28 | 3.97 |
| | 11 | 21.80 | 60.00 | 8.16 | 103.55 | 101.83 | 53.50 | 7.28 | 3.95 |
| Apr | 10 | 22.35 | 60.00 | 8.82 | 104.36 | 102.80 | 54.01 | 7.94 | 3.75 |
| | 10 | 26.31 | 60.00 | 13.57 | 104.36 | 102.37 | 53.78 | 12.17 | 4.58 |
| | 10 | 39.46 | 60.00 | 29.35 | 104.36 | 100.89 | 53.01 | 25.93 | 7.31 |
| May | 10 | 56.95 | 60.00 | 50.33 | 104.36 | 98.89 | 51.95 | 43.58 | 10.79 |
| | 10 | 158.05 | 60.00 | 60.00 | 104.02 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 162.40 | 60.00 | 60.00 | 103.91 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 146.80 | 60.00 | 60.00 | 104.06 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 238.47 | 60.00 | 60.00 | 103.74 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 395.30 | 60.00 | 60.00 | 103.24 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 487.49 | 60.00 | 60.00 | 102.97 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 383.46 | 60.00 | 60.00 | 103.27 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 794.06 | 60.00 | 60.00 | 102.10 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 980.36 | 60.00 | 60.00 | 101.81 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 736.07 | 60.00 | 60.00 | 102.33 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 823.57 | 60.00 | 60.00 | 102.03 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 752.40 | 60.00 | 60.00 | 102.29 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 410.90 | 60.00 | 60.00 | 103.19 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 169.54 | 60.00 | 60.00 | 103.98 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 108.96 | 60.00 | 60.00 | 104.20 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 79.10 | 60.00 | 60.00 | 104.31 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 61.47 | 60.00 | 55.76 | 104.27 | 97.60 | 51.28 | 47.66 | 12.74 |
| Nov | 10 | 51.13 | 60.00 | 43.36 | 102.10 | 97.08 | 51.00 | 36.86 | 9.41 |
| | 10 | 45.97 | 60.00 | 37.16 | 102.06 | 97.66 | 51.31 | 31.78 | 8.41 |
| | 10 | 36.10 | 60.00 | 25.33 | 101.02 | 97.72 | 51.34 | 21.67 | 6.39 |
| Dec | 10 | 30.65 | 60.00 | 18.78 | 100.92 | 98.26 | 51.62 | 16.16 | 5.30 |
| | 10 | 26.72 | 60.00 | 14.07 | 101.15 | 98.96 | 51.99 | 12.19 | 4.52 |
| | 11 | 25.48 | 60.00 | 12.58 | 102.39 | 100.17 | 52.63 | 11.04 | 4.74 |



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| 1984 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 25.67 | 60.00 | 12.80 | 97.55 | 95.35 | 50.09 | 10.69 | 4.14 |
| | 10 | 26.54 | 60.00 | 13.85 | 98.88 | 96.62 | 50.76 | 11.72 | 4.37 |
| | 11 | 25.29 | 60.00 | 12.35 | 100.16 | 97.87 | 51.42 | 10.58 | 4.59 |
| Feb | 10 | 24.55 | 60.00 | 11.46 | 100.76 | 98.81 | 51.91 | 9.92 | 4.06 |
| | 10 | 24.02 | 60.00 | 10.82 | 101.72 | 99.86 | 52.46 | 9.46 | 3.99 |
| | 8 | 23.43 | 60.00 | 10.11 | 101.87 | 100.49 | 52.80 | 8.90 | 3.11 |
| Mar | 10 | 22.76 | 60.00 | 9.31 | 103.35 | 101.69 | 53.43 | 8.29 | 3.80 |
| | 10 | 23.10 | 60.00 | 9.72 | 104.36 | 102.72 | 53.97 | 8.74 | 3.91 |
| | 11 | 25.03 | 60.00 | 12.03 | 104.27 | 102.19 | 53.69 | 10.77 | 4.73 |
| Apr | 10 | 24.03 | 60.00 | 10.84 | 104.36 | 102.62 | 53.91 | 9.74 | 4.10 |
| | 10 | 22.47 | 60.00 | 8.97 | 104.36 | 102.79 | 54.00 | 8.07 | 3.77 |
| | 10 | 36.82 | 60.00 | 26.19 | 104.36 | 101.19 | 53.16 | 23.20 | 6.77 |
| May | 10 | 41.22 | 60.00 | 31.46 | 104.36 | 100.70 | 52.90 | 27.74 | 7.66 |
| | 10 | 44.89 | 60.00 | 35.87 | 104.36 | 100.28 | 52.68 | 31.50 | 8.41 |
| | 11 | 56.73 | 60.00 | 50.07 | 104.27 | 98.22 | 51.60 | 43.06 | 11.74 |
| Jun | 10 | 228.46 | 60.00 | 60.00 | 103.77 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 349.74 | 60.00 | 60.00 | 103.38 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 606.40 | 60.00 | 60.00 | 102.65 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 607.66 | 60.00 | 60.00 | 102.64 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 680.65 | 60.00 | 60.00 | 102.46 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 809.87 | 60.00 | 60.00 | 102.06 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 999.19 | 60.00 | 60.00 | 101.77 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 1001.16 | 60.00 | 60.00 | 101.77 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 929.71 | 60.00 | 60.00 | 101.81 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 503.09 | 60.00 | 60.00 | 102.93 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 200.34 | 60.00 | 60.00 | 103.87 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 105.77 | 60.00 | 60.00 | 104.21 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 78.09 | 60.00 | 60.00 | 104.32 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 63.44 | 60.00 | 58.13 | 104.36 | 98.13 | 51.55 | 49.94 | 12.05 |
| | 11 | 57.25 | 60.00 | 50.70 | 104.27 | 98.15 | 51.57 | 43.57 | 11.85 |
| Nov | 10 | 51.96 | 60.00 | 44.35 | 103.25 | 98.23 | 51.61 | 38.15 | 9.69 |
| | 10 | 46.74 | 60.00 | 38.09 | 103.20 | 98.79 | 51.90 | 32.95 | 8.67 |
| | 10 | 41.77 | 60.00 | 32.13 | 103.21 | 99.38 | 52.21 | 27.96 | 7.68 |
| Dec | 10 | 38.04 | 60.00 | 27.65 | 103.47 | 100.09 | 52.58 | 24.23 | 6.95 |
| | 10 | 33.29 | 60.00 | 21.95 | 103.52 | 100.68 | 52.90 | 19.35 | 5.99 |
| | 11 | 30.28 | 60.00 | 18.33 | 104.27 | 101.55 | 53.35 | 16.30 | 5.93 |



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| 1985 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 29.34 | 60.00 | 17.21 | 98.42 | 95.80 | 50.33 | 14.44 | 4.90 |
| | 10 | 27.69 | 60.00 | 15.23 | 99.17 | 96.78 | 50.85 | 12.91 | 4.62 |
| | 11 | 25.66 | 60.00 | 12.80 | 100.28 | 97.95 | 51.46 | 10.98 | 4.68 |
| Feb | 10 | 26.29 | 60.00 | 13.55 | 101.16 | 99.02 | 52.02 | 11.75 | 4.43 |
| | 10 | 25.31 | 60.00 | 12.37 | 102.02 | 100.03 | 52.55 | 10.83 | 4.27 |
| | 8 | 24.44 | 60.00 | 11.32 | 102.07 | 100.61 | 52.86 | 9.98 | 3.29 |
| Mar | 10 | 25.52 | 60.00 | 12.63 | 103.94 | 102.00 | 53.59 | 11.28 | 4.40 |
| | 10 | 26.54 | 60.00 | 13.85 | 104.36 | 102.34 | 53.77 | 12.41 | 4.63 |
| | 11 | 24.42 | 60.00 | 11.31 | 104.27 | 102.26 | 53.73 | 10.13 | 4.59 |
| Apr | 10 | 27.51 | 60.00 | 15.02 | 104.36 | 102.23 | 53.71 | 13.44 | 4.84 |
| | 10 | 29.56 | 60.00 | 17.47 | 104.36 | 102.01 | 53.59 | 15.60 | 5.26 |
| | 10 | 41.57 | 60.00 | 31.89 | 104.36 | 100.65 | 52.88 | 28.11 | 7.74 |
| May | 10 | 47.62 | 60.00 | 39.14 | 104.36 | 99.96 | 52.52 | 34.26 | 8.95 |
| | 10 | 62.09 | 60.00 | 56.51 | 104.36 | 98.28 | 51.64 | 48.63 | 11.79 |
| | 11 | 111.82 | 60.00 | 60.00 | 104.09 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 194.65 | 60.00 | 60.00 | 103.89 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 281.59 | 60.00 | 60.00 | 103.60 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 326.96 | 60.00 | 60.00 | 103.45 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 566.94 | 60.00 | 60.00 | 102.75 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 853.91 | 60.00 | 60.00 | 102.06 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 958.08 | 60.00 | 60.00 | 101.75 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 799.93 | 60.00 | 60.00 | 102.18 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 801.54 | 60.00 | 60.00 | 102.18 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 639.32 | 60.00 | 60.00 | 102.46 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 455.38 | 60.00 | 60.00 | 103.06 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 253.25 | 60.00 | 60.00 | 103.69 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 219.44 | 60.00 | 60.00 | 103.81 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 156.43 | 60.00 | 60.00 | 104.03 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 81.86 | 60.00 | 60.00 | 104.30 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 57.62 | 60.00 | 51.15 | 104.27 | 98.10 | 51.54 | 43.93 | 11.93 |
| Nov | 10 | 47.12 | 60.00 | 38.54 | 102.14 | 97.61 | 51.28 | 32.94 | 8.64 |
| | 10 | 39.75 | 60.00 | 29.69 | 101.64 | 97.94 | 51.46 | 25.47 | 7.15 |
| | 10 | 34.76 | 60.00 | 23.71 | 101.64 | 98.53 | 51.77 | 20.46 | 6.16 |
| Dec | 10 | 33.13 | 60.00 | 21.75 | 102.36 | 99.48 | 52.26 | 18.95 | 5.88 |
| | 10 | 32.30 | 60.00 | 20.76 | 103.23 | 100.49 | 52.80 | 18.27 | 5.77 |
| | 11 | 29.85 | 60.00 | 17.83 | 104.26 | 101.59 | 53.37 | 15.86 | 5.84 |



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| 1986 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 27.69 | 60.00 | 15.23 | 98.51 | 96.10 | 50.49 | 12.82 | 4.58 |
| | 10 | 26.80 | 60.00 | 14.15 | 99.43 | 97.16 | 51.05 | 12.04 | 4.45 |
| | 11 | 26.20 | 60.00 | 13.44 | 100.86 | 98.48 | 51.74 | 11.59 | 4.83 |
| Feb | 10 | 25.41 | 60.00 | 12.50 | 101.42 | 99.39 | 52.22 | 10.88 | 4.26 |
| | 10 | 24.64 | 60.00 | 11.57 | 102.32 | 100.41 | 52.75 | 10.17 | 4.15 |
| | 8 | 24.50 | 60.00 | 11.41 | 102.52 | 101.06 | 53.10 | 10.09 | 3.31 |
| Mar | 10 | 24.45 | 60.00 | 11.34 | 104.14 | 102.33 | 53.76 | 10.16 | 4.18 |
| | 10 | 23.60 | 60.00 | 10.32 | 104.36 | 102.67 | 53.94 | 9.28 | 4.01 |
| | 11 | 22.66 | 60.00 | 9.20 | 104.27 | 102.48 | 53.84 | 8.25 | 4.18 |
| Apr | 10 | 23.15 | 60.00 | 9.79 | 104.36 | 102.71 | 53.96 | 8.80 | 3.92 |
| | 10 | 28.64 | 60.00 | 16.37 | 104.36 | 102.11 | 53.64 | 14.64 | 5.07 |
| | 10 | 42.81 | 60.00 | 33.37 | 104.36 | 100.51 | 52.81 | 29.37 | 7.99 |
| May | 10 | 49.05 | 60.00 | 40.86 | 104.36 | 99.80 | 52.43 | 35.71 | 9.24 |
| | 10 | 96.94 | 60.00 | 60.00 | 104.24 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 93.84 | 60.00 | 60.00 | 104.16 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 111.54 | 60.00 | 60.00 | 104.19 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 180.63 | 60.00 | 60.00 | 103.94 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 503.81 | 60.00 | 60.00 | 102.92 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 711.32 | 60.00 | 60.00 | 102.39 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 711.14 | 60.00 | 60.00 | 102.39 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 769.60 | 60.00 | 60.00 | 102.15 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 843.87 | 60.00 | 60.00 | 102.09 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 549.90 | 60.00 | 60.00 | 102.80 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 422.30 | 60.00 | 60.00 | 103.06 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 350.46 | 60.00 | 60.00 | 103.38 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 223.64 | 60.00 | 60.00 | 103.79 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 207.16 | 60.00 | 60.00 | 103.85 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 192.27 | 60.00 | 60.00 | 103.90 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 134.75 | 60.00 | 60.00 | 104.10 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 69.87 | 60.00 | 60.00 | 104.25 | 97.14 | 51.04 | 51.04 | 13.47 |
| Nov | 10 | 59.49 | 60.00 | 53.39 | 103.04 | 97.11 | 51.02 | 45.40 | 11.12 |
| | 10 | 50.27 | 60.00 | 42.33 | 102.15 | 97.24 | 51.09 | 36.04 | 9.25 |
| | 10 | 42.63 | 60.00 | 33.16 | 101.59 | 97.55 | 51.25 | 28.32 | 7.71 |
| Dec | 10 | 38.47 | 60.00 | 28.17 | 101.77 | 98.23 | 51.61 | 24.23 | 6.91 |
| | 10 | 34.22 | 60.00 | 23.07 | 101.93 | 98.90 | 51.96 | 19.97 | 6.07 |
| | 11 | 31.44 | 60.00 | 19.72 | 102.95 | 100.01 | 52.54 | 17.27 | 6.11 |



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| 1987 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 29.92 | 60.00 | 17.90 | 96.66 | 93.88 | 49.32 | 14.71 | 4.92 |
| | 10 | 29.04 | 60.00 | 16.85 | 97.61 | 94.99 | 49.90 | 14.01 | 4.80 |
| | 11 | 29.82 | 60.00 | 17.79 | 99.47 | 96.55 | 50.72 | 15.04 | 5.54 |
| Feb | 10 | 27.08 | 60.00 | 14.50 | 99.53 | 97.23 | 51.08 | 12.34 | 4.51 |
| | 10 | 26.78 | 60.00 | 14.13 | 100.56 | 98.34 | 51.67 | 12.17 | 4.50 |
| | 8 | 25.04 | 60.00 | 12.05 | 100.40 | 98.83 | 51.92 | 10.43 | 3.33 |
| Mar | 10 | 24.64 | 60.00 | 11.57 | 102.04 | 100.12 | 52.60 | 10.14 | 4.13 |
| | 10 | 24.23 | 60.00 | 11.08 | 103.00 | 101.17 | 53.15 | 9.81 | 4.09 |
| | 11 | 23.66 | 60.00 | 10.39 | 104.27 | 102.36 | 53.77 | 9.31 | 4.41 |
| Apr | 10 | 25.41 | 60.00 | 12.50 | 104.36 | 102.47 | 53.83 | 11.21 | 4.40 |
| | 10 | 25.45 | 60.00 | 12.54 | 104.36 | 102.46 | 53.83 | 11.25 | 4.40 |
| | 10 | 33.09 | 60.00 | 21.71 | 104.36 | 101.61 | 53.38 | 19.32 | 6.00 |
| May | 10 | 40.98 | 60.00 | 31.18 | 104.36 | 100.72 | 52.92 | 27.50 | 7.62 |
| | 10 | 53.07 | 60.00 | 45.69 | 104.36 | 99.34 | 52.19 | 39.74 | 10.04 |
| | 11 | 97.88 | 60.00 | 60.00 | 104.14 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 269.03 | 60.00 | 60.00 | 103.64 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 209.85 | 60.00 | 60.00 | 103.84 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 197.45 | 60.00 | 60.00 | 103.88 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 367.50 | 60.00 | 60.00 | 103.32 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 329.30 | 60.00 | 60.00 | 103.44 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 492.74 | 60.00 | 60.00 | 102.86 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 282.66 | 60.00 | 60.00 | 103.59 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 503.45 | 60.00 | 60.00 | 102.92 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 751.83 | 60.00 | 60.00 | 102.19 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 577.70 | 60.00 | 60.00 | 102.72 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 312.44 | 60.00 | 60.00 | 103.50 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 211.91 | 60.00 | 60.00 | 103.83 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 139.83 | 60.00 | 60.00 | 104.09 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 113.19 | 60.00 | 60.00 | 104.18 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 63.65 | 60.00 | 58.39 | 104.27 | 97.32 | 51.13 | 49.75 | 13.20 |
| Nov | 10 | 50.27 | 60.00 | 42.33 | 101.40 | 96.43 | 50.66 | 35.74 | 9.17 |
| | 10 | 47.35 | 60.00 | 38.82 | 101.84 | 97.26 | 51.10 | 33.06 | 8.66 |
| | 10 | 43.55 | 60.00 | 34.26 | 102.10 | 97.99 | 51.48 | 29.39 | 7.94 |
| Dec | 10 | 40.77 | 60.00 | 30.92 | 102.57 | 98.81 | 51.91 | 26.75 | 7.43 |
| | 10 | 39.75 | 60.00 | 29.69 | 103.40 | 99.82 | 52.44 | 25.95 | 7.29 |
| | 11 | 38.53 | 60.00 | 28.23 | 104.27 | 100.53 | 52.81 | 24.85 | 7.79 |



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| 1988 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 36.52 | 60.00 | 25.82 | 96.34 | 92.70 | 48.70 | 20.96 | 6.14 |
| | 10 | 31.78 | 60.00 | 20.14 | 96.40 | 93.37 | 49.05 | 16.46 | 5.26 |
| | 11 | 30.08 | 60.00 | 18.10 | 97.74 | 94.69 | 49.75 | 15.01 | 5.49 |
| Feb | 10 | 28.64 | 60.00 | 16.37 | 98.09 | 95.54 | 50.20 | 13.70 | 4.75 |
| | 10 | 27.67 | 60.00 | 15.21 | 99.00 | 96.61 | 50.75 | 12.87 | 4.60 |
| | 8 | 27.40 | 60.00 | 14.88 | 99.05 | 97.22 | 51.07 | 12.66 | 3.66 |
| Mar | 10 | 25.61 | 60.00 | 12.73 | 100.53 | 98.44 | 51.72 | 10.98 | 4.26 |
| | 10 | 24.66 | 60.00 | 11.59 | 101.40 | 99.46 | 52.25 | 10.10 | 4.11 |
| | 11 | 23.59 | 60.00 | 10.31 | 102.63 | 100.66 | 52.88 | 9.09 | 4.33 |
| Apr | 10 | 23.89 | 60.00 | 10.67 | 103.45 | 101.67 | 53.42 | 9.50 | 4.04 |
| | 10 | 38.90 | 60.00 | 28.68 | 104.36 | 100.96 | 53.04 | 25.36 | 7.19 |
| | 10 | 96.22 | 60.00 | 60.00 | 104.25 | 97.94 | 51.46 | 51.46 | 12.35 |
| May | 10 | 129.24 | 60.00 | 60.00 | 104.12 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 132.44 | 60.00 | 60.00 | 104.11 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 157.96 | 60.00 | 60.00 | 103.92 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 172.54 | 60.00 | 60.00 | 103.97 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 227.39 | 60.00 | 60.00 | 103.78 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 620.03 | 60.00 | 60.00 | 102.61 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 687.29 | 60.00 | 60.00 | 102.44 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 829.70 | 60.00 | 60.00 | 102.12 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 849.82 | 60.00 | 60.00 | 101.97 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 741.63 | 60.00 | 60.00 | 102.32 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 745.40 | 60.00 | 60.00 | 102.31 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 474.48 | 60.00 | 60.00 | 102.91 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 308.31 | 60.00 | 60.00 | 103.51 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 333.42 | 60.00 | 60.00 | 103.43 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 174.67 | 60.00 | 60.00 | 103.96 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 95.11 | 60.00 | 60.00 | 104.25 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 67.13 | 60.00 | 60.00 | 104.36 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 60.05 | 60.00 | 54.06 | 104.27 | 97.79 | 51.38 | 46.29 | 12.44 |
| Nov | 10 | 54.78 | 60.00 | 47.73 | 103.19 | 97.84 | 51.40 | 40.89 | 10.23 |
| | 10 | 51.39 | 60.00 | 43.66 | 103.52 | 98.60 | 51.80 | 37.70 | 9.61 |
| | 10 | 46.42 | 60.00 | 37.70 | 103.53 | 99.19 | 52.11 | 32.74 | 8.63 |
| Dec | 10 | 40.66 | 60.00 | 30.79 | 103.37 | 99.68 | 52.37 | 26.88 | 7.47 |
| | 10 | 39.26 | 60.00 | 29.11 | 104.11 | 100.63 | 52.87 | 25.65 | 7.25 |
| | 11 | 38.63 | 60.00 | 28.35 | 104.27 | 100.51 | 52.81 | 24.95 | 7.81 |



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| 1989 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 34.57 | 60.00 | 23.48 | 96.31 | 92.92 | 48.82 | 19.11 | 5.77 |
| | 10 | 30.34 | 60.00 | 18.41 | 96.49 | 93.65 | 49.20 | 15.09 | 4.99 |
| | 11 | 29.41 | 60.00 | 17.29 | 97.99 | 95.05 | 49.94 | 14.39 | 5.36 |
| Feb | 10 | 28.16 | 60.00 | 15.79 | 98.40 | 95.92 | 50.39 | 13.26 | 4.67 |
| | 10 | 27.11 | 60.00 | 14.54 | 99.28 | 96.97 | 50.95 | 12.34 | 4.51 |
| | 8 | 27.39 | 60.00 | 14.87 | 99.46 | 97.64 | 51.30 | 12.71 | 3.68 |
| Mar | 10 | 26.37 | 60.00 | 13.64 | 101.09 | 98.94 | 51.98 | 11.82 | 4.44 |
| | 10 | 25.99 | 60.00 | 13.19 | 102.08 | 100.01 | 52.54 | 11.55 | 4.41 |
| | 11 | 25.90 | 60.00 | 13.08 | 103.54 | 101.32 | 53.23 | 11.60 | 4.90 |
| Apr | 10 | 26.50 | 60.00 | 13.80 | 104.35 | 102.33 | 53.76 | 12.36 | 4.62 |
| | 10 | 27.21 | 60.00 | 14.65 | 104.36 | 102.27 | 53.73 | 13.12 | 4.77 |
| | 10 | 29.85 | 60.00 | 17.82 | 104.36 | 101.97 | 53.57 | 15.91 | 5.32 |
| May | 10 | 32.51 | 60.00 | 21.02 | 104.36 | 101.68 | 53.42 | 18.71 | 5.88 |
| | 10 | 41.51 | 60.00 | 31.81 | 104.36 | 100.66 | 52.88 | 28.04 | 7.72 |
| | 11 | 93.37 | 60.00 | 60.00 | 104.16 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 251.75 | 60.00 | 60.00 | 103.70 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 201.65 | 60.00 | 60.00 | 103.87 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 286.73 | 60.00 | 60.00 | 103.58 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 304.53 | 60.00 | 60.00 | 103.52 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 449.31 | 60.00 | 60.00 | 103.08 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 605.28 | 60.00 | 60.00 | 102.55 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 462.35 | 60.00 | 60.00 | 103.04 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 456.94 | 60.00 | 60.00 | 103.06 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 393.33 | 60.00 | 60.00 | 103.15 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 254.03 | 60.00 | 60.00 | 103.69 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 304.96 | 60.00 | 60.00 | 103.52 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 201.50 | 60.00 | 60.00 | 103.87 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 132.95 | 60.00 | 60.00 | 104.11 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 93.94 | 60.00 | 60.00 | 104.26 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 67.07 | 60.00 | 60.00 | 104.26 | 97.14 | 51.04 | 51.04 | 13.47 |
| Nov | 10 | 53.58 | 60.00 | 46.30 | 101.79 | 96.45 | 50.67 | 39.10 | 9.85 |
| | 10 | 48.42 | 60.00 | 40.11 | 101.76 | 97.04 | 50.98 | 34.08 | 8.85 |
| | 10 | 45.54 | 60.00 | 36.65 | 102.21 | 97.87 | 51.42 | 31.41 | 8.34 |
| Dec | 10 | 40.99 | 60.00 | 31.19 | 102.30 | 98.50 | 51.75 | 26.90 | 7.45 |
| | 10 | 35.19 | 60.00 | 24.23 | 102.13 | 99.00 | 52.01 | 21.00 | 6.28 |
| | 11 | 37.88 | 60.00 | 27.46 | 104.27 | 100.61 | 52.86 | 24.19 | 7.65 |



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| 1990 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 35.24 | 60.00 | 24.29 | 96.51 | 93.04 | 48.88 | 19.79 | 5.91 |
| | 10 | 32.43 | 60.00 | 20.92 | 97.01 | 93.93 | 49.35 | 17.21 | 5.42 |
| | 11 | 31.44 | 60.00 | 19.73 | 98.53 | 95.34 | 50.09 | 16.47 | 5.83 |
| Feb | 10 | 30.49 | 60.00 | 18.59 | 98.95 | 96.22 | 50.55 | 15.66 | 5.15 |
| | 10 | 29.04 | 60.00 | 16.85 | 99.74 | 97.22 | 51.08 | 14.35 | 4.91 |
| | 8 | 26.85 | 60.00 | 14.22 | 99.40 | 97.62 | 51.29 | 12.15 | 3.59 |
| Mar | 10 | 25.68 | 60.00 | 12.82 | 100.97 | 98.90 | 51.96 | 11.10 | 4.30 |
| | 10 | 25.26 | 60.00 | 12.31 | 101.95 | 99.97 | 52.52 | 10.77 | 4.26 |
| | 11 | 24.09 | 60.00 | 10.91 | 103.16 | 101.14 | 53.14 | 9.66 | 4.46 |
| Apr | 10 | 24.90 | 60.00 | 11.88 | 104.06 | 102.20 | 53.69 | 10.63 | 4.27 |
| | 10 | 27.40 | 60.00 | 14.88 | 104.36 | 102.25 | 53.72 | 13.32 | 4.81 |
| | 10 | 32.08 | 60.00 | 20.49 | 104.36 | 101.72 | 53.44 | 18.25 | 5.79 |
| May | 10 | 85.66 | 60.00 | 60.00 | 104.29 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 267.06 | 60.00 | 60.00 | 103.65 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 234.57 | 60.00 | 60.00 | 103.66 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 260.25 | 60.00 | 60.00 | 103.67 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 350.23 | 60.00 | 60.00 | 103.38 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 745.51 | 60.00 | 60.00 | 102.31 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 869.39 | 60.00 | 60.00 | 102.03 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 634.86 | 60.00 | 60.00 | 102.57 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 679.82 | 60.00 | 60.00 | 102.36 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 826.57 | 60.00 | 60.00 | 102.12 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 700.12 | 60.00 | 60.00 | 102.41 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 626.00 | 60.00 | 60.00 | 102.50 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 539.20 | 60.00 | 60.00 | 102.83 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 384.83 | 60.00 | 60.00 | 103.27 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 358.64 | 60.00 | 60.00 | 103.35 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 203.29 | 60.00 | 60.00 | 103.86 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 117.78 | 60.00 | 60.00 | 104.17 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 69.42 | 60.00 | 60.00 | 104.25 | 97.14 | 51.04 | 51.04 | 13.47 |
| Nov | 10 | 58.60 | 60.00 | 52.32 | 102.85 | 97.01 | 50.97 | 44.44 | 10.93 |
| | 10 | 51.72 | 60.00 | 44.07 | 102.46 | 97.40 | 51.17 | 37.59 | 9.56 |
| | 10 | 46.92 | 60.00 | 38.30 | 102.50 | 98.02 | 51.49 | 32.87 | 8.63 |
| Dec | 10 | 43.63 | 60.00 | 34.35 | 102.86 | 98.79 | 51.90 | 29.72 | 8.02 |
| | 10 | 40.25 | 60.00 | 30.30 | 103.20 | 99.54 | 52.30 | 26.41 | 7.37 |
| | 11 | 37.58 | 60.00 | 27.10 | 104.27 | 100.64 | 52.88 | 23.88 | 7.58 |



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|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 34.37 | 60.00 | 23.25 | 96.58 | 93.23 | 48.98 | 18.98 | 5.75 |
| | 10 | 31.49 | 60.00 | 19.78 | 97.07 | 94.11 | 49.45 | 16.30 | 5.24 |
| | 11 | 30.96 | 60.00 | 19.15 | 98.68 | 95.56 | 50.21 | 16.03 | 5.74 |
| Feb | 10 | 30.08 | 60.00 | 18.10 | 99.13 | 96.45 | 50.67 | 15.28 | 5.08 |
| | 10 | 29.36 | 60.00 | 17.23 | 100.07 | 97.53 | 51.24 | 14.71 | 4.99 |
| | 8 | 27.64 | 60.00 | 15.16 | 99.80 | 97.97 | 51.47 | 13.01 | 3.73 |
| Mar | 10 | 26.51 | 60.00 | 13.82 | 101.41 | 99.26 | 52.15 | 12.01 | 4.49 |
| | 10 | 33.29 | 60.00 | 21.94 | 103.88 | 101.07 | 53.10 | 19.42 | 6.01 |
| | 11 | 27.19 | 60.00 | 14.63 | 104.10 | 101.75 | 53.46 | 13.03 | 5.22 |
| Apr | 10 | 31.42 | 60.00 | 19.71 | 104.36 | 101.80 | 53.48 | 17.57 | 5.65 |
| | 10 | 30.30 | 60.00 | 18.36 | 104.36 | 101.92 | 53.55 | 16.38 | 5.42 |
| | 10 | 39.21 | 60.00 | 29.05 | 104.36 | 100.92 | 53.02 | 25.67 | 7.25 |
| May | 10 | 49.43 | 60.00 | 41.32 | 104.36 | 99.76 | 52.41 | 36.09 | 9.31 |
| | 10 | 74.07 | 60.00 | 60.00 | 104.33 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 84.82 | 60.00 | 60.00 | 104.19 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 212.60 | 60.00 | 60.00 | 103.83 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 363.89 | 60.00 | 60.00 | 103.33 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 287.71 | 60.00 | 60.00 | 103.58 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 433.34 | 60.00 | 60.00 | 103.13 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 512.39 | 60.00 | 60.00 | 102.90 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 522.96 | 60.00 | 60.00 | 102.77 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 596.07 | 60.00 | 60.00 | 102.67 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 515.79 | 60.00 | 60.00 | 102.89 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 516.10 | 60.00 | 60.00 | 102.79 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 555.01 | 60.00 | 60.00 | 102.78 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 473.99 | 60.00 | 60.00 | 103.01 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 201.20 | 60.00 | 60.00 | 103.87 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 102.19 | 60.00 | 60.00 | 104.22 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 65.99 | 60.00 | 60.00 | 104.36 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 54.97 | 60.00 | 47.96 | 104.27 | 98.44 | 51.72 | 41.34 | 11.37 |
| Nov | 10 | 45.39 | 60.00 | 36.46 | 102.39 | 98.08 | 51.53 | 31.32 | 8.32 |
| | 10 | 38.69 | 60.00 | 28.43 | 102.04 | 98.49 | 51.74 | 24.52 | 6.97 |
| | 10 | 36.66 | 60.00 | 25.99 | 102.66 | 99.39 | 52.22 | 22.62 | 6.61 |
| Dec | 10 | 35.78 | 60.00 | 24.93 | 103.52 | 100.40 | 52.75 | 21.92 | 6.49 |
| | 10 | 36.00 | 60.00 | 25.20 | 104.36 | 101.28 | 53.21 | 22.35 | 6.60 |
| | 11 | 32.20 | 60.00 | 20.64 | 104.27 | 101.31 | 53.23 | 18.31 | 6.37 |



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|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 31.41 | 60.00 | 19.69 | 97.94 | 95.04 | 49.93 | 16.39 | 5.27 |
| | 10 | 31.52 | 60.00 | 19.82 | 99.09 | 96.24 | 50.56 | 16.71 | 5.36 |
| | 11 | 31.09 | 60.00 | 19.31 | 100.67 | 97.65 | 51.30 | 16.51 | 5.89 |
| Feb | 10 | 29.68 | 60.00 | 17.62 | 100.99 | 98.45 | 51.72 | 15.19 | 5.11 |
| | 10 | 29.05 | 60.00 | 16.86 | 101.93 | 99.50 | 52.27 | 14.69 | 5.03 |
| | 8 | 27.68 | 60.00 | 15.21 | 101.74 | 99.96 | 52.52 | 13.32 | 3.81 |
| Mar | 10 | 26.77 | 60.00 | 14.12 | 103.34 | 101.23 | 53.18 | 12.52 | 4.63 |
| | 10 | 25.95 | 60.00 | 13.14 | 104.19 | 102.22 | 53.70 | 11.76 | 4.50 |
| | 11 | 25.06 | 60.00 | 12.07 | 104.27 | 102.19 | 53.69 | 10.80 | 4.74 |
| Apr | 10 | 25.51 | 60.00 | 12.62 | 104.36 | 102.45 | 53.83 | 11.32 | 4.42 |
| | 10 | 27.71 | 60.00 | 15.25 | 104.36 | 102.21 | 53.70 | 13.65 | 4.88 |
| | 10 | 35.44 | 60.00 | 24.53 | 104.36 | 101.35 | 53.25 | 21.76 | 6.48 |
| May | 10 | 35.65 | 60.00 | 24.78 | 104.36 | 101.32 | 53.23 | 21.99 | 6.53 |
| | 10 | 72.11 | 60.00 | 60.00 | 104.34 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 95.89 | 60.00 | 60.00 | 104.15 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 116.89 | 60.00 | 60.00 | 104.17 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 194.69 | 60.00 | 60.00 | 103.89 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 285.80 | 60.00 | 60.00 | 103.58 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 355.94 | 60.00 | 60.00 | 103.36 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 513.34 | 60.00 | 60.00 | 102.90 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 684.51 | 60.00 | 60.00 | 102.35 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 658.29 | 60.00 | 60.00 | 102.52 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 454.24 | 60.00 | 60.00 | 103.06 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 436.54 | 60.00 | 60.00 | 103.02 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 413.96 | 60.00 | 60.00 | 103.18 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 172.40 | 60.00 | 60.00 | 103.97 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 145.64 | 60.00 | 60.00 | 104.07 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 112.99 | 60.00 | 60.00 | 104.18 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 82.40 | 60.00 | 60.00 | 104.30 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 71.18 | 60.00 | 60.00 | 104.24 | 97.14 | 51.04 | 51.04 | 13.47 |
| Nov | 10 | 66.61 | 60.00 | 60.00 | 104.36 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 53.95 | 60.00 | 46.74 | 103.13 | 97.87 | 51.42 | 40.05 | 10.07 |
| | 10 | 45.44 | 60.00 | 36.53 | 102.40 | 98.08 | 51.53 | 31.37 | 8.34 |
| Dec | 10 | 43.89 | 60.00 | 34.67 | 103.12 | 99.04 | 52.03 | 30.07 | 8.09 |
| | 10 | 38.14 | 60.00 | 27.77 | 102.97 | 99.54 | 52.30 | 24.20 | 6.93 |
| | 11 | 31.65 | 60.00 | 19.97 | 103.21 | 100.25 | 52.67 | 17.53 | 6.18 |



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| 1993 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 29.92 | 60.00 | 17.91 | 96.89 | 94.12 | 49.45 | 14.76 | 4.93 |
| | 10 | 27.24 | 60.00 | 14.68 | 97.42 | 95.02 | 49.92 | 12.22 | 4.44 |
| | 11 | 27.07 | 60.00 | 14.49 | 99.01 | 96.44 | 50.67 | 12.23 | 4.92 |
| Feb | 10 | 26.68 | 60.00 | 14.02 | 99.66 | 97.42 | 51.18 | 11.96 | 4.44 |
| | 10 | 24.48 | 60.00 | 11.38 | 100.28 | 98.32 | 51.65 | 9.80 | 4.03 |
| | 8 | 24.23 | 60.00 | 11.08 | 100.47 | 98.98 | 52.00 | 9.60 | 3.20 |
| Mar | 10 | 23.34 | 60.00 | 10.00 | 101.97 | 100.20 | 52.64 | 8.78 | 3.86 |
| | 10 | 22.51 | 60.00 | 9.01 | 102.85 | 101.20 | 53.17 | 7.98 | 3.72 |
| | 11 | 21.06 | 60.00 | 7.28 | 103.91 | 102.30 | 53.75 | 6.52 | 3.80 |
| Apr | 10 | 21.21 | 60.00 | 7.45 | 104.36 | 102.93 | 54.08 | 6.72 | 3.51 |
| | 10 | 30.05 | 60.00 | 18.06 | 104.36 | 101.95 | 53.56 | 16.12 | 5.37 |
| | 10 | 85.78 | 60.00 | 60.00 | 104.29 | 97.94 | 51.46 | 51.46 | 12.35 |
| May | 10 | 110.10 | 60.00 | 60.00 | 104.20 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 67.58 | 60.00 | 60.00 | 104.35 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 100.24 | 60.00 | 60.00 | 104.13 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 160.87 | 60.00 | 60.00 | 104.01 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 280.64 | 60.00 | 60.00 | 103.60 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 365.43 | 60.00 | 60.00 | 103.33 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 603.22 | 60.00 | 60.00 | 102.66 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 440.03 | 60.00 | 60.00 | 103.11 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 459.44 | 60.00 | 60.00 | 102.95 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 516.79 | 60.00 | 60.00 | 102.89 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 385.80 | 60.00 | 60.00 | 103.27 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 365.04 | 60.00 | 60.00 | 103.23 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 366.66 | 60.00 | 60.00 | 103.33 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 256.69 | 60.00 | 60.00 | 103.68 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 179.74 | 60.00 | 60.00 | 103.94 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 129.40 | 60.00 | 60.00 | 104.12 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 101.27 | 60.00 | 60.00 | 104.23 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 69.47 | 60.00 | 60.00 | 104.25 | 97.14 | 51.04 | 51.04 | 13.47 |
| Nov | 10 | 58.53 | 60.00 | 52.23 | 102.84 | 97.00 | 50.96 | 44.37 | 10.91 |
| | 10 | 50.32 | 60.00 | 42.38 | 102.16 | 97.25 | 51.09 | 36.09 | 9.26 |
| | 10 | 45.05 | 60.00 | 36.06 | 102.10 | 97.81 | 51.39 | 30.89 | 8.23 |
| Dec | 10 | 38.40 | 60.00 | 28.09 | 101.75 | 98.22 | 51.60 | 24.16 | 6.90 |
| | 10 | 33.62 | 60.00 | 22.34 | 101.80 | 98.83 | 51.92 | 19.33 | 5.94 |
| | 11 | 31.64 | 60.00 | 19.97 | 103.00 | 100.03 | 52.55 | 17.49 | 6.16 |



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| 1994 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 31.17 | 60.00 | 19.41 | 96.66 | 93.72 | 49.24 | 15.93 | 5.15 |
| | 10 | 29.60 | 60.00 | 17.52 | 97.45 | 94.75 | 49.78 | 14.54 | 4.90 |
| | 11 | 28.63 | 60.00 | 16.36 | 98.90 | 96.11 | 50.49 | 13.77 | 5.25 |
| Feb | 10 | 27.00 | 60.00 | 14.40 | 99.23 | 96.93 | 50.93 | 12.22 | 4.48 |
| | 10 | 25.58 | 60.00 | 12.69 | 100.02 | 97.93 | 51.45 | 10.88 | 4.23 |
| | 8 | 25.25 | 60.00 | 12.30 | 100.16 | 98.56 | 51.78 | 10.61 | 3.36 |
| Mar | 10 | 25.24 | 60.00 | 12.29 | 101.90 | 99.91 | 52.49 | 10.75 | 4.25 |
| | 10 | 23.90 | 60.00 | 10.67 | 102.67 | 100.86 | 52.99 | 9.43 | 4.01 |
| | 11 | 24.02 | 60.00 | 10.82 | 104.11 | 102.15 | 53.67 | 9.68 | 4.49 |
| Apr | 10 | 26.41 | 60.00 | 13.69 | 104.36 | 102.36 | 53.77 | 12.27 | 4.60 |
| | 10 | 23.31 | 60.00 | 9.97 | 104.36 | 102.70 | 53.95 | 8.97 | 3.95 |
| | 10 | 29.99 | 60.00 | 17.99 | 104.36 | 101.96 | 53.57 | 16.06 | 5.35 |
| May | 10 | 59.82 | 60.00 | 53.78 | 104.36 | 98.55 | 51.78 | 46.41 | 11.35 |
| | 10 | 117.61 | 60.00 | 60.00 | 104.17 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 174.72 | 60.00 | 60.00 | 103.86 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 233.47 | 60.00 | 60.00 | 103.76 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 224.93 | 60.00 | 60.00 | 103.79 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 559.83 | 60.00 | 60.00 | 102.77 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 863.05 | 60.00 | 60.00 | 102.04 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 981.43 | 60.00 | 60.00 | 101.80 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 959.18 | 60.00 | 60.00 | 101.75 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 1101.71 | 60.00 | 60.00 | 101.58 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 730.51 | 60.00 | 60.00 | 102.34 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 777.63 | 60.00 | 60.00 | 102.13 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 569.67 | 60.00 | 60.00 | 102.74 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 239.90 | 60.00 | 60.00 | 103.74 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 131.13 | 60.00 | 60.00 | 104.12 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 110.42 | 60.00 | 60.00 | 104.19 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 76.07 | 60.00 | 60.00 | 104.32 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 66.36 | 60.00 | 60.00 | 104.26 | 97.14 | 51.04 | 51.04 | 13.47 |
| Nov | 10 | 53.60 | 60.00 | 46.32 | 101.80 | 96.45 | 50.67 | 39.12 | 9.85 |
| | 10 | 45.22 | 60.00 | 36.26 | 101.07 | 96.68 | 50.79 | 30.70 | 8.17 |
| | 10 | 39.94 | 60.00 | 29.92 | 101.01 | 97.25 | 51.09 | 25.48 | 7.14 |
| Dec | 10 | 36.31 | 60.00 | 25.58 | 101.31 | 98.00 | 51.48 | 21.95 | 6.45 |
| | 10 | 34.25 | 60.00 | 23.11 | 101.93 | 98.90 | 51.96 | 20.01 | 6.08 |
| | 11 | 32.99 | 60.00 | 21.59 | 103.31 | 100.19 | 52.64 | 18.94 | 6.48 |



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| 1995 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 29.41 | 60.00 | 17.29 | 96.66 | 93.95 | 49.36 | 14.22 | 4.82 |
| | 10 | 28.64 | 60.00 | 16.37 | 97.64 | 95.06 | 49.94 | 13.63 | 4.72 |
| | 11 | 28.95 | 60.00 | 16.74 | 99.37 | 96.56 | 50.73 | 14.15 | 5.35 |
| Feb | 10 | 28.41 | 60.00 | 16.10 | 99.93 | 97.50 | 51.22 | 13.74 | 4.80 |
| | 10 | 27.30 | 60.00 | 14.76 | 100.78 | 98.51 | 51.76 | 12.73 | 4.62 |
| | 8 | 25.77 | 60.00 | 12.92 | 100.63 | 99.00 | 52.01 | 11.20 | 3.46 |
| Mar | 10 | 23.96 | 60.00 | 10.76 | 102.00 | 100.16 | 52.62 | 9.43 | 3.99 |
| | 10 | 22.69 | 60.00 | 9.23 | 102.79 | 101.12 | 53.13 | 8.18 | 3.76 |
| | 11 | 23.61 | 60.00 | 10.33 | 104.27 | 102.36 | 53.78 | 9.26 | 4.40 |
| Apr | 10 | 22.27 | 60.00 | 8.73 | 104.36 | 102.81 | 54.01 | 7.86 | 3.73 |
| | 10 | 25.39 | 60.00 | 12.47 | 104.36 | 102.47 | 53.83 | 11.19 | 4.39 |
| | 10 | 35.63 | 60.00 | 24.76 | 104.36 | 101.33 | 53.23 | 21.96 | 6.52 |
| May | 10 | 67.49 | 60.00 | 60.00 | 104.36 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 148.12 | 60.00 | 60.00 | 104.06 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 74.84 | 60.00 | 60.00 | 104.23 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 138.05 | 60.00 | 60.00 | 104.09 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 321.21 | 60.00 | 60.00 | 103.47 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 287.61 | 60.00 | 60.00 | 103.58 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 547.23 | 60.00 | 60.00 | 102.80 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 769.63 | 60.00 | 60.00 | 102.25 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 693.08 | 60.00 | 60.00 | 102.33 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 622.83 | 60.00 | 60.00 | 102.61 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 689.49 | 60.00 | 60.00 | 102.44 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 618.43 | 60.00 | 60.00 | 102.52 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 211.70 | 60.00 | 60.00 | 103.83 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 152.83 | 60.00 | 60.00 | 104.04 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 167.21 | 60.00 | 60.00 | 103.99 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 122.44 | 60.00 | 60.00 | 104.15 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 52.06 | 60.00 | 44.47 | 102.74 | 97.67 | 51.31 | 38.03 | 9.66 |
| | 11 | 30.15 | 60.00 | 18.18 | 99.64 | 96.69 | 50.80 | 15.39 | 5.62 |
| Nov | 10 | 33.78 | 60.00 | 22.54 | 101.08 | 98.06 | 51.52 | 19.35 | 5.93 |
| | 10 | 41.00 | 60.00 | 31.20 | 103.66 | 99.95 | 52.51 | 27.31 | 7.56 |
| | 10 | 45.47 | 60.00 | 36.57 | 104.36 | 100.21 | 52.65 | 32.09 | 8.52 |
| Dec | 10 | 35.62 | 60.00 | 24.74 | 103.38 | 100.27 | 52.68 | 21.72 | 6.45 |
| | 10 | 30.91 | 60.00 | 19.10 | 103.44 | 100.87 | 53.00 | 16.87 | 5.49 |
| | 11 | 29.24 | 60.00 | 17.09 | 104.27 | 101.67 | 53.42 | 15.21 | 5.70 |



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| 1996 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 27.06 | 60.00 | 14.47 | 98.68 | 96.35 | 50.62 | 12.21 | 4.47 |
| | 10 | 25.96 | 60.00 | 13.16 | 99.54 | 97.38 | 51.16 | 11.22 | 4.29 |
| | 11 | 24.77 | 60.00 | 11.72 | 100.81 | 98.62 | 51.81 | 10.12 | 4.51 |
| Feb | 10 | 23.83 | 60.00 | 10.60 | 101.37 | 99.52 | 52.29 | 9.24 | 3.94 |
| | 10 | 22.80 | 60.00 | 9.36 | 102.22 | 100.52 | 52.81 | 8.24 | 3.76 |
| | 8 | 21.61 | 60.00 | 7.93 | 102.32 | 101.12 | 53.13 | 7.02 | 2.82 |
| Mar | 10 | 21.56 | 60.00 | 7.87 | 103.83 | 102.33 | 53.76 | 7.05 | 3.56 |
| | 10 | 22.93 | 60.00 | 9.52 | 104.36 | 102.74 | 53.98 | 8.57 | 3.87 |
| | 11 | 21.27 | 60.00 | 7.53 | 104.27 | 102.65 | 53.93 | 6.77 | 3.86 |
| Apr | 10 | 20.75 | 60.00 | 6.90 | 104.36 | 102.98 | 54.10 | 6.22 | 3.41 |
| | 10 | 26.03 | 60.00 | 13.24 | 104.36 | 102.40 | 53.80 | 11.87 | 4.53 |
| | 10 | 42.51 | 60.00 | 33.01 | 104.36 | 100.55 | 52.83 | 29.07 | 7.93 |
| May | 10 | 31.39 | 60.00 | 19.67 | 103.12 | 100.48 | 52.79 | 17.30 | 5.57 |
| | 10 | 35.07 | 60.00 | 24.08 | 104.36 | 101.39 | 53.27 | 21.38 | 6.41 |
| | 11 | 75.25 | 60.00 | 60.00 | 104.23 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 162.25 | 60.00 | 60.00 | 104.01 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 347.31 | 60.00 | 60.00 | 103.39 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 373.33 | 60.00 | 60.00 | 103.31 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 446.88 | 60.00 | 60.00 | 103.09 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 479.44 | 60.00 | 60.00 | 102.99 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 564.28 | 60.00 | 60.00 | 102.66 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 720.09 | 60.00 | 60.00 | 102.37 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 726.57 | 60.00 | 60.00 | 102.35 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 322.03 | 60.00 | 60.00 | 103.37 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 313.09 | 60.00 | 60.00 | 103.50 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 321.96 | 60.00 | 60.00 | 103.47 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 203.88 | 60.00 | 60.00 | 103.86 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 136.56 | 60.00 | 60.00 | 104.10 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 72.07 | 60.00 | 60.00 | 104.34 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 58.52 | 60.00 | 52.23 | 104.27 | 97.99 | 51.48 | 44.81 | 12.12 |
| Nov | 10 | 46.90 | 60.00 | 38.28 | 101.89 | 97.36 | 51.15 | 32.63 | 8.57 |
| | 10 | 39.05 | 60.00 | 28.86 | 101.28 | 97.64 | 51.30 | 24.67 | 6.99 |
| | 10 | 36.80 | 60.00 | 26.17 | 101.87 | 98.53 | 51.77 | 22.57 | 6.59 |
| Dec | 10 | 34.72 | 60.00 | 23.67 | 102.48 | 99.43 | 52.24 | 20.60 | 6.21 |
| | 10 | 32.41 | 60.00 | 20.89 | 103.05 | 100.29 | 52.69 | 18.34 | 5.78 |
| | 11 | 30.83 | 60.00 | 19.00 | 104.27 | 101.48 | 53.31 | 16.88 | 6.06 |



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| 1997 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 31.77 | 60.00 | 20.12 | 98.28 | 95.35 | 50.10 | 16.80 | 5.36 |
| | 10 | 31.54 | 60.00 | 19.84 | 99.35 | 96.51 | 50.70 | 16.77 | 5.38 |
| | 11 | 31.15 | 60.00 | 19.38 | 100.93 | 97.92 | 51.44 | 16.62 | 5.92 |
| Feb | 10 | 30.03 | 60.00 | 18.04 | 101.31 | 98.74 | 51.88 | 15.60 | 5.19 |
| | 10 | 29.76 | 60.00 | 17.72 | 102.32 | 99.83 | 52.45 | 15.49 | 5.19 |
| | 8 | 29.66 | 60.00 | 17.59 | 102.31 | 100.37 | 52.73 | 15.46 | 4.16 |
| Mar | 10 | 28.33 | 60.00 | 16.00 | 103.89 | 101.64 | 53.40 | 14.24 | 4.98 |
| | 10 | 25.94 | 60.00 | 13.13 | 104.36 | 102.41 | 53.80 | 11.77 | 4.51 |
| | 11 | 24.85 | 60.00 | 11.82 | 104.27 | 102.21 | 53.70 | 10.58 | 4.69 |
| Apr | 10 | 25.52 | 60.00 | 12.63 | 104.36 | 102.45 | 53.83 | 11.33 | 4.42 |
| | 10 | 34.82 | 60.00 | 23.78 | 104.36 | 101.42 | 53.28 | 21.12 | 6.35 |
| | 10 | 52.60 | 60.00 | 45.12 | 104.36 | 99.39 | 52.22 | 39.27 | 9.94 |
| May | 10 | 73.35 | 60.00 | 60.00 | 104.33 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 46.89 | 60.00 | 38.26 | 101.64 | 97.10 | 51.01 | 32.53 | 8.55 |
| | 11 | 81.91 | 60.00 | 60.00 | 104.20 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 133.69 | 60.00 | 60.00 | 104.11 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 175.93 | 60.00 | 60.00 | 103.96 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 248.53 | 60.00 | 60.00 | 103.71 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 214.25 | 60.00 | 60.00 | 103.82 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 481.98 | 60.00 | 60.00 | 102.98 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 537.27 | 60.00 | 60.00 | 102.73 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 268.59 | 60.00 | 60.00 | 103.64 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 445.80 | 60.00 | 60.00 | 103.09 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 358.95 | 60.00 | 60.00 | 103.25 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 203.20 | 60.00 | 60.00 | 103.86 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 208.04 | 60.00 | 60.00 | 103.85 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 165.15 | 60.00 | 60.00 | 104.00 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 113.05 | 60.00 | 60.00 | 104.18 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 90.63 | 60.00 | 60.00 | 104.27 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 68.84 | 60.00 | 60.00 | 104.25 | 97.14 | 51.04 | 51.04 | 13.47 |
| Nov | 10 | 52.62 | 60.00 | 45.14 | 101.59 | 96.34 | 50.62 | 38.08 | 9.64 |
| | 10 | 43.44 | 60.00 | 34.13 | 100.68 | 96.48 | 50.69 | 28.83 | 7.79 |
| | 10 | 39.99 | 60.00 | 29.98 | 101.02 | 97.26 | 51.10 | 25.53 | 7.15 |
| Dec | 10 | 37.40 | 60.00 | 26.88 | 101.54 | 98.12 | 51.55 | 23.09 | 6.68 |
| | 10 | 35.25 | 60.00 | 24.30 | 102.15 | 99.01 | 52.02 | 21.07 | 6.29 |
| | 11 | 34.27 | 60.00 | 23.12 | 103.60 | 100.34 | 52.71 | 20.31 | 6.79 |



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| 1998 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 30.72 | 60.00 | 18.87 | 96.66 | 93.78 | 49.27 | 15.49 | 5.07 |
| | 10 | 28.65 | 60.00 | 16.38 | 97.34 | 94.75 | 49.78 | 13.59 | 4.71 |
| | 11 | 28.04 | 60.00 | 15.65 | 98.85 | 96.14 | 50.51 | 13.18 | 5.12 |
| Feb | 10 | 28.94 | 60.00 | 16.73 | 99.76 | 97.25 | 51.09 | 14.24 | 4.89 |
| | 10 | 29.47 | 60.00 | 17.36 | 100.97 | 98.45 | 51.72 | 14.97 | 5.06 |
| | 8 | 29.10 | 60.00 | 16.92 | 100.93 | 98.99 | 52.01 | 14.66 | 4.01 |
| Mar | 10 | 27.55 | 60.00 | 15.06 | 102.48 | 100.25 | 52.67 | 13.22 | 4.75 |
| | 10 | 26.95 | 60.00 | 14.34 | 103.40 | 101.27 | 53.21 | 12.72 | 4.67 |
| | 11 | 25.81 | 60.00 | 12.97 | 104.27 | 102.09 | 53.64 | 11.59 | 4.91 |
| Apr | 10 | 26.09 | 60.00 | 13.31 | 104.36 | 102.39 | 53.79 | 11.94 | 4.54 |
| | 10 | 30.33 | 60.00 | 18.40 | 104.36 | 101.92 | 53.55 | 16.42 | 5.43 |
| | 10 | 44.82 | 60.00 | 35.79 | 104.36 | 100.28 | 52.69 | 31.42 | 8.39 |
| May | 10 | 63.84 | 60.00 | 58.61 | 104.36 | 98.08 | 51.53 | 50.33 | 12.13 |
| | 10 | 116.70 | 60.00 | 60.00 | 104.17 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 216.28 | 60.00 | 60.00 | 103.72 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 274.75 | 60.00 | 60.00 | 103.62 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 451.22 | 60.00 | 60.00 | 103.07 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 649.46 | 60.00 | 60.00 | 102.54 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 763.42 | 60.00 | 60.00 | 102.26 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 832.02 | 60.00 | 60.00 | 102.11 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 607.13 | 60.00 | 60.00 | 102.55 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 581.22 | 60.00 | 60.00 | 102.71 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 568.59 | 60.00 | 60.00 | 102.75 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 406.63 | 60.00 | 60.00 | 103.11 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 493.48 | 60.00 | 60.00 | 102.95 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 345.06 | 60.00 | 60.00 | 103.39 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 190.28 | 60.00 | 60.00 | 103.91 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 132.75 | 60.00 | 60.00 | 104.11 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 110.03 | 60.00 | 60.00 | 104.20 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 81.49 | 60.00 | 60.00 | 104.20 | 97.14 | 51.04 | 51.04 | 13.47 |
| Nov | 10 | 64.03 | 60.00 | 58.84 | 103.97 | 97.61 | 51.28 | 50.29 | 12.11 |
| | 10 | 54.65 | 60.00 | 47.58 | 103.07 | 97.72 | 51.34 | 40.71 | 10.20 |
| | 10 | 48.89 | 60.00 | 40.66 | 102.91 | 98.23 | 51.61 | 34.97 | 9.06 |
| Dec | 10 | 45.18 | 60.00 | 36.22 | 103.18 | 98.96 | 51.99 | 31.38 | 8.36 |
| | 10 | 41.18 | 60.00 | 31.41 | 103.39 | 99.64 | 52.35 | 27.41 | 7.58 |
| | 11 | 35.54 | 60.00 | 24.64 | 103.88 | 100.48 | 52.79 | 21.68 | 7.09 |



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| 1999 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 31.31 | 60.00 | 19.57 | 96.66 | 93.71 | 49.23 | 16.06 | 5.18 |
| | 10 | 29.17 | 60.00 | 17.00 | 97.32 | 94.67 | 49.74 | 14.09 | 4.81 |
| | 11 | 27.84 | 60.00 | 15.41 | 98.67 | 95.98 | 50.42 | 12.95 | 5.07 |
| Feb | 10 | 27.77 | 60.00 | 15.32 | 99.37 | 96.99 | 50.95 | 13.01 | 4.64 |
| | 10 | 27.05 | 60.00 | 14.46 | 100.32 | 98.05 | 51.52 | 12.42 | 4.54 |
| | 8 | 26.53 | 60.00 | 13.83 | 100.35 | 98.64 | 51.82 | 11.95 | 3.57 |
| Mar | 10 | 28.31 | 60.00 | 15.97 | 102.52 | 100.20 | 52.64 | 14.01 | 4.91 |
| | 10 | 27.73 | 60.00 | 15.28 | 103.44 | 101.23 | 53.18 | 13.54 | 4.84 |
| | 11 | 25.25 | 60.00 | 12.30 | 104.27 | 102.16 | 53.67 | 11.00 | 4.78 |
| Apr | 10 | 28.39 | 60.00 | 16.07 | 104.36 | 102.13 | 53.66 | 14.37 | 5.02 |
| | 10 | 37.52 | 60.00 | 27.02 | 104.36 | 101.11 | 53.12 | 23.92 | 6.91 |
| | 10 | 38.41 | 60.00 | 28.09 | 104.36 | 101.01 | 53.07 | 24.84 | 7.09 |
| May | 10 | 53.70 | 60.00 | 46.44 | 104.36 | 99.26 | 52.15 | 40.37 | 10.16 |
| | 10 | 75.28 | 60.00 | 60.00 | 104.33 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 130.25 | 60.00 | 60.00 | 104.02 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 241.23 | 60.00 | 60.00 | 103.73 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 362.08 | 60.00 | 60.00 | 103.34 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 373.10 | 60.00 | 60.00 | 103.31 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 619.41 | 60.00 | 60.00 | 102.61 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 640.87 | 60.00 | 60.00 | 102.56 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 678.04 | 60.00 | 60.00 | 102.37 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 948.50 | 60.00 | 60.00 | 101.87 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 766.53 | 60.00 | 60.00 | 102.26 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 542.17 | 60.00 | 60.00 | 102.72 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 271.56 | 60.00 | 60.00 | 103.63 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 207.04 | 60.00 | 60.00 | 103.85 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 225.08 | 60.00 | 60.00 | 103.79 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 119.69 | 60.00 | 60.00 | 104.16 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 64.05 | 60.00 | 58.86 | 104.36 | 98.05 | 51.51 | 50.54 | 12.17 |
| | 11 | 49.74 | 60.00 | 41.69 | 103.39 | 98.14 | 51.56 | 35.83 | 10.15 |
| Nov | 10 | 47.34 | 60.00 | 38.81 | 103.10 | 98.61 | 51.81 | 33.51 | 8.77 |
| | 10 | 41.11 | 60.00 | 31.33 | 102.84 | 99.07 | 52.05 | 27.18 | 7.52 |
| | 10 | 36.66 | 60.00 | 25.99 | 102.96 | 99.70 | 52.38 | 22.69 | 6.63 |
| Dec | 10 | 36.59 | 60.00 | 25.91 | 103.97 | 100.79 | 52.95 | 22.87 | 6.69 |
| | 10 | 36.46 | 60.00 | 25.75 | 104.36 | 101.23 | 53.18 | 22.83 | 6.69 |
| | 11 | 36.21 | 60.00 | 25.45 | 104.27 | 100.82 | 52.97 | 22.46 | 7.27 |



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| 2000 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 34.86 | 60.00 | 23.83 | 96.93 | 93.54 | 49.14 | 19.52 | 5.87 |
| | 10 | 29.24 | 60.00 | 17.08 | 96.79 | 94.10 | 49.44 | 14.08 | 4.79 |
| | 11 | 26.77 | 60.00 | 14.12 | 97.87 | 95.28 | 50.06 | 11.78 | 4.79 |
| Feb | 10 | 25.31 | 60.00 | 12.37 | 98.29 | 96.16 | 50.52 | 10.42 | 4.10 |
| | 10 | 24.19 | 60.00 | 11.02 | 99.16 | 97.20 | 51.06 | 9.38 | 3.92 |
| | 8 | 23.47 | 60.00 | 10.17 | 99.29 | 97.84 | 51.40 | 8.71 | 3.04 |
| Mar | 10 | 23.02 | 60.00 | 9.62 | 100.88 | 99.11 | 52.07 | 8.35 | 3.75 |
| | 10 | 22.50 | 60.00 | 9.00 | 101.84 | 100.17 | 52.62 | 7.89 | 3.68 |
| | 11 | 23.17 | 60.00 | 9.80 | 103.41 | 101.52 | 53.34 | 8.71 | 4.26 |
| Apr | 10 | 23.51 | 60.00 | 10.22 | 104.23 | 102.53 | 53.87 | 9.17 | 3.99 |
| | 10 | 32.47 | 60.00 | 20.97 | 104.36 | 101.68 | 53.42 | 18.67 | 5.87 |
| | 10 | 52.76 | 60.00 | 45.31 | 104.36 | 99.37 | 52.21 | 39.43 | 9.97 |
| May | 10 | 122.09 | 60.00 | 60.00 | 104.15 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 249.88 | 60.00 | 60.00 | 103.70 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 277.60 | 60.00 | 60.00 | 103.51 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 217.12 | 60.00 | 60.00 | 103.81 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 418.80 | 60.00 | 60.00 | 103.17 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 444.45 | 60.00 | 60.00 | 103.09 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 376.29 | 60.00 | 60.00 | 103.30 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 504.59 | 60.00 | 60.00 | 102.92 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 660.93 | 60.00 | 60.00 | 102.41 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 593.83 | 60.00 | 60.00 | 102.68 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 501.90 | 60.00 | 60.00 | 102.93 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 374.88 | 60.00 | 60.00 | 103.20 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 355.65 | 60.00 | 60.00 | 103.36 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 337.22 | 60.00 | 60.00 | 103.42 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 163.93 | 60.00 | 60.00 | 104.00 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 91.37 | 60.00 | 60.00 | 104.27 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 67.55 | 60.00 | 60.00 | 104.36 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 66.18 | 60.00 | 60.00 | 104.26 | 97.14 | 51.04 | 51.04 | 13.47 |
| Nov | 10 | 61.99 | 60.00 | 56.39 | 103.56 | 97.38 | 51.16 | 48.08 | 11.66 |
| | 10 | 49.80 | 60.00 | 41.76 | 102.05 | 97.19 | 51.06 | 35.54 | 9.15 |
| | 10 | 42.70 | 60.00 | 33.24 | 101.60 | 97.56 | 51.25 | 28.40 | 7.73 |
| Dec | 10 | 33.95 | 60.00 | 22.74 | 100.80 | 97.74 | 51.35 | 19.46 | 5.95 |
| | 10 | 32.61 | 60.00 | 21.13 | 101.58 | 98.73 | 51.87 | 18.27 | 5.73 |
| | 11 | 31.61 | 60.00 | 19.93 | 102.99 | 100.03 | 52.55 | 17.45 | 6.15 |



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| 2001 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 30.98 | 60.00 | 19.18 | 96.66 | 93.75 | 49.25 | 15.74 | 5.12 |
| | 10 | 29.80 | 60.00 | 17.76 | 97.54 | 94.82 | 49.82 | 14.74 | 4.94 |
| | 11 | 28.75 | 60.00 | 16.50 | 98.97 | 96.17 | 50.52 | 13.90 | 5.28 |
| Feb | 10 | 27.77 | 60.00 | 15.32 | 99.44 | 97.06 | 50.99 | 13.02 | 4.64 |
| | 10 | 27.01 | 60.00 | 14.41 | 100.38 | 98.12 | 51.55 | 12.38 | 4.54 |
| | 8 | 26.24 | 60.00 | 13.49 | 100.37 | 98.69 | 51.85 | 11.66 | 3.52 |
| Mar | 10 | 25.19 | 60.00 | 12.23 | 101.93 | 99.94 | 52.51 | 10.71 | 4.24 |
| | 10 | 24.74 | 60.00 | 11.69 | 102.89 | 100.99 | 53.06 | 10.34 | 4.19 |
| | 11 | 25.51 | 60.00 | 12.62 | 104.27 | 102.13 | 53.66 | 11.28 | 4.84 |
| Apr | 10 | 34.68 | 60.00 | 23.62 | 104.36 | 101.43 | 53.29 | 20.98 | 6.33 |
| | 10 | 54.32 | 60.00 | 47.19 | 104.36 | 99.19 | 52.11 | 40.98 | 10.28 |
| | 10 | 54.49 | 60.00 | 47.39 | 104.36 | 99.17 | 52.10 | 41.15 | 10.31 |
| May | 10 | 110.11 | 60.00 | 60.00 | 104.20 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 218.87 | 60.00 | 60.00 | 103.81 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 273.54 | 60.00 | 60.00 | 103.52 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 394.33 | 60.00 | 60.00 | 103.24 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 587.42 | 60.00 | 60.00 | 102.70 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 444.04 | 60.00 | 60.00 | 103.09 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 911.83 | 60.00 | 60.00 | 101.94 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 815.20 | 60.00 | 60.00 | 102.15 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 769.07 | 60.00 | 60.00 | 102.15 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 603.87 | 60.00 | 60.00 | 102.65 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 698.31 | 60.00 | 60.00 | 102.42 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 583.61 | 60.00 | 60.00 | 102.61 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 390.83 | 60.00 | 60.00 | 103.25 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 214.00 | 60.00 | 60.00 | 103.82 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 121.56 | 60.00 | 60.00 | 104.15 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 125.18 | 60.00 | 60.00 | 104.14 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 87.92 | 60.00 | 60.00 | 104.28 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 67.94 | 60.00 | 60.00 | 104.25 | 97.14 | 51.04 | 51.04 | 13.47 |
| Nov | 10 | 56.38 | 60.00 | 49.66 | 102.39 | 96.76 | 50.84 | 42.08 | 10.45 |
| | 10 | 41.94 | 60.00 | 32.33 | 100.36 | 96.31 | 50.60 | 27.26 | 7.48 |
| | 10 | 36.38 | 60.00 | 25.66 | 100.24 | 96.86 | 50.89 | 21.76 | 6.39 |
| Dec | 10 | 33.19 | 60.00 | 21.82 | 100.63 | 97.66 | 51.31 | 18.66 | 5.78 |
| | 10 | 31.37 | 60.00 | 19.65 | 101.32 | 98.59 | 51.80 | 16.96 | 5.46 |
| | 11 | 30.05 | 60.00 | 18.05 | 102.63 | 99.85 | 52.46 | 15.78 | 5.78 |



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|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 27.67 | 60.00 | 15.20 | 96.66 | 94.17 | 49.47 | 12.53 | 4.49 |
| | 10 | 28.01 | 60.00 | 15.61 | 97.89 | 95.41 | 50.12 | 13.04 | 4.61 |
| | 11 | 27.18 | 60.00 | 14.62 | 99.32 | 96.75 | 50.83 | 12.39 | 4.96 |
| Feb | 10 | 26.29 | 60.00 | 13.55 | 99.85 | 97.66 | 51.31 | 11.59 | 4.37 |
| | 10 | 26.70 | 60.00 | 14.04 | 101.03 | 98.84 | 51.93 | 12.15 | 4.51 |
| | 8 | 26.23 | 60.00 | 13.47 | 101.09 | 99.43 | 52.24 | 11.73 | 3.55 |
| Mar | 10 | 26.30 | 60.00 | 13.55 | 102.86 | 100.78 | 52.95 | 11.96 | 4.51 |
| | 10 | 24.80 | 60.00 | 11.76 | 103.59 | 101.71 | 53.44 | 10.47 | 4.23 |
| | 11 | 25.48 | 60.00 | 12.57 | 104.27 | 102.13 | 53.66 | 11.25 | 4.83 |
| Apr | 10 | 25.68 | 60.00 | 12.81 | 104.36 | 102.44 | 53.82 | 11.49 | 4.45 |
| | 10 | 34.11 | 60.00 | 22.94 | 104.36 | 101.50 | 53.32 | 20.38 | 6.21 |
| | 10 | 48.28 | 60.00 | 39.94 | 104.36 | 99.89 | 52.48 | 34.93 | 9.09 |
| May | 10 | 52.19 | 60.00 | 44.63 | 104.36 | 99.44 | 52.24 | 38.86 | 9.86 |
| | 10 | 114.61 | 60.00 | 60.00 | 104.18 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 163.83 | 60.00 | 60.00 | 103.90 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 306.78 | 60.00 | 60.00 | 103.52 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 375.35 | 60.00 | 60.00 | 103.30 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 375.53 | 60.00 | 60.00 | 103.30 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 472.76 | 60.00 | 60.00 | 103.01 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 416.73 | 60.00 | 60.00 | 103.17 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 431.91 | 60.00 | 60.00 | 103.03 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 526.13 | 60.00 | 60.00 | 102.86 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 573.44 | 60.00 | 60.00 | 102.73 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 562.90 | 60.00 | 60.00 | 102.66 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 367.42 | 60.00 | 60.00 | 103.32 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 250.85 | 60.00 | 60.00 | 103.70 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 162.92 | 60.00 | 60.00 | 104.00 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 128.05 | 60.00 | 60.00 | 104.13 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 99.14 | 60.00 | 60.00 | 104.24 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 75.96 | 60.00 | 60.00 | 104.22 | 97.14 | 51.04 | 51.04 | 13.47 |
| Nov | 10 | 53.95 | 60.00 | 46.73 | 101.87 | 96.49 | 50.69 | 39.49 | 9.92 |
| | 10 | 42.62 | 60.00 | 33.15 | 100.51 | 96.39 | 50.64 | 27.98 | 7.62 |
| | 10 | 38.40 | 60.00 | 28.08 | 100.68 | 97.08 | 51.00 | 23.87 | 6.81 |
| Dec | 10 | 35.28 | 60.00 | 24.34 | 101.08 | 97.88 | 51.43 | 20.86 | 6.23 |
| | 10 | 33.92 | 60.00 | 22.70 | 101.86 | 98.87 | 51.94 | 19.65 | 6.01 |
| | 11 | 31.91 | 60.00 | 20.30 | 103.06 | 100.06 | 52.57 | 17.78 | 6.23 |



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|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 29.47 | 60.00 | 17.36 | 96.66 | 93.94 | 49.35 | 14.28 | 4.83 |
| | 10 | 29.93 | 60.00 | 17.92 | 97.91 | 95.20 | 50.01 | 14.93 | 4.99 |
| | 11 | 29.57 | 60.00 | 17.48 | 99.50 | 96.62 | 50.76 | 14.79 | 5.49 |
| Feb | 10 | 27.79 | 60.00 | 15.35 | 99.78 | 97.41 | 51.18 | 13.09 | 4.67 |
| | 10 | 25.88 | 60.00 | 13.06 | 100.46 | 98.34 | 51.67 | 11.24 | 4.32 |
| | 8 | 24.12 | 60.00 | 10.94 | 100.33 | 98.85 | 51.93 | 9.47 | 3.18 |
| Mar | 10 | 22.81 | 60.00 | 9.37 | 101.74 | 100.03 | 52.55 | 8.21 | 3.74 |
| | 10 | 21.50 | 60.00 | 7.79 | 102.52 | 100.98 | 53.05 | 6.89 | 3.50 |
| | 11 | 21.88 | 60.00 | 8.26 | 103.99 | 102.28 | 53.73 | 7.40 | 3.99 |
| Apr | 10 | 23.61 | 60.00 | 10.33 | 104.36 | 102.66 | 53.94 | 9.29 | 4.02 |
| | 10 | 37.15 | 60.00 | 26.58 | 104.36 | 101.16 | 53.14 | 23.54 | 6.83 |
| | 10 | 44.90 | 60.00 | 35.88 | 104.36 | 100.28 | 52.68 | 31.51 | 8.41 |
| May | 10 | 49.41 | 60.00 | 41.29 | 104.36 | 99.76 | 52.41 | 36.07 | 9.31 |
| | 10 | 57.21 | 60.00 | 50.65 | 104.36 | 98.86 | 51.94 | 43.84 | 10.85 |
| | 11 | 126.74 | 60.00 | 60.00 | 104.04 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 260.19 | 60.00 | 60.00 | 103.67 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 321.89 | 60.00 | 60.00 | 103.47 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 519.50 | 60.00 | 60.00 | 102.88 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 668.08 | 60.00 | 60.00 | 102.49 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 672.59 | 60.00 | 60.00 | 102.48 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 874.08 | 60.00 | 60.00 | 101.92 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 649.90 | 60.00 | 60.00 | 102.54 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 451.47 | 60.00 | 60.00 | 103.07 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 439.78 | 60.00 | 60.00 | 103.01 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 444.39 | 60.00 | 60.00 | 103.09 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 329.32 | 60.00 | 60.00 | 103.44 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 239.47 | 60.00 | 60.00 | 103.74 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 107.11 | 60.00 | 60.00 | 104.21 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 79.33 | 60.00 | 60.00 | 104.31 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 69.60 | 60.00 | 60.00 | 104.25 | 97.14 | 51.04 | 51.04 | 13.47 |
| Nov | 10 | 68.46 | 60.00 | 60.00 | 104.35 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 57.90 | 60.00 | 51.48 | 103.94 | 98.30 | 51.65 | 44.31 | 10.93 |
| | 10 | 46.99 | 60.00 | 38.39 | 102.73 | 98.25 | 51.62 | 33.03 | 8.67 |
| Dec | 10 | 41.41 | 60.00 | 31.69 | 102.60 | 98.77 | 51.89 | 27.41 | 7.56 |
| | 10 | 38.87 | 60.00 | 28.64 | 103.12 | 99.62 | 52.34 | 24.98 | 7.09 |
| | 11 | 35.97 | 60.00 | 25.17 | 104.18 | 100.75 | 52.93 | 22.20 | 7.21 |



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| 2004 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 52.53 | 60.00 | 45.03 | 96.89 | 91.21 | 47.92 | 35.96 | 9.11 |
| | 10 | 48.21 | 60.00 | 39.85 | 97.05 | 91.95 | 48.31 | 32.08 | 8.35 |
| | 11 | 45.46 | 60.00 | 36.55 | 98.48 | 93.37 | 49.05 | 29.88 | 8.73 |
| Feb | 10 | 43.99 | 60.00 | 34.79 | 98.48 | 94.04 | 49.41 | 28.64 | 7.71 |
| | 10 | 42.82 | 60.00 | 33.38 | 99.33 | 95.11 | 49.97 | 27.80 | 7.56 |
| | 8 | 41.70 | 60.00 | 32.05 | 98.56 | 95.30 | 50.07 | 26.74 | 5.88 |
| Mar | 10 | 40.79 | 60.00 | 30.95 | 100.86 | 96.99 | 50.96 | 26.28 | 7.29 |
| | 10 | 40.26 | 60.00 | 30.32 | 101.83 | 98.08 | 51.53 | 26.04 | 7.27 |
| | 11 | 39.48 | 60.00 | 29.38 | 103.44 | 99.50 | 52.28 | 25.60 | 7.93 |
| Apr | 10 | 47.06 | 60.00 | 38.47 | 104.36 | 100.03 | 52.55 | 33.69 | 8.84 |
| | 10 | 47.27 | 60.00 | 38.72 | 104.36 | 100.00 | 52.54 | 33.91 | 8.88 |
| | 10 | 64.12 | 60.00 | 58.94 | 104.36 | 98.05 | 51.51 | 50.60 | 12.18 |
| May | 10 | 64.61 | 60.00 | 59.53 | 104.36 | 97.99 | 51.48 | 51.08 | 12.28 |
| | 10 | 149.07 | 60.00 | 60.00 | 104.05 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 255.35 | 60.00 | 60.00 | 103.59 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 318.93 | 60.00 | 60.00 | 103.48 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 549.57 | 60.00 | 60.00 | 102.80 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 451.55 | 60.00 | 60.00 | 103.07 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 470.58 | 60.00 | 60.00 | 103.02 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 409.17 | 60.00 | 60.00 | 103.20 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 349.65 | 60.00 | 60.00 | 103.28 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 411.37 | 60.00 | 60.00 | 103.19 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 346.58 | 60.00 | 60.00 | 103.39 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 268.37 | 60.00 | 60.00 | 103.54 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 176.65 | 60.00 | 60.00 | 103.95 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 147.68 | 60.00 | 60.00 | 104.06 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 106.40 | 60.00 | 60.00 | 104.21 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 76.68 | 60.00 | 60.00 | 104.32 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 73.10 | 60.00 | 60.00 | 104.33 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 67.54 | 60.00 | 60.00 | 104.26 | 97.14 | 51.04 | 51.04 | 13.47 |
| Nov | 10 | 64.68 | 60.00 | 59.62 | 104.10 | 97.68 | 51.32 | 50.99 | 12.25 |
| | 10 | 63.98 | 60.00 | 58.78 | 104.36 | 98.06 | 51.52 | 50.47 | 12.16 |
| | 10 | 63.08 | 60.00 | 57.69 | 104.36 | 98.17 | 51.57 | 49.59 | 11.98 |
| Dec | 10 | 59.72 | 60.00 | 53.66 | 104.36 | 98.56 | 51.78 | 46.31 | 11.33 |
| | 10 | 57.96 | 60.00 | 51.55 | 104.36 | 98.77 | 51.89 | 44.58 | 10.99 |
| | 11 | 56.65 | 60.00 | 49.97 | 104.27 | 98.23 | 51.61 | 42.98 | 11.73 |



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| 2005 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 54.63 | 60.00 | 47.55 | 91.50 | 84.94 | 44.63 | 35.37 | 8.86 |
| | 10 | 53.71 | 60.00 | 46.46 | 92.53 | 86.22 | 45.30 | 35.07 | 8.83 |
| | 11 | 51.81 | 60.00 | 44.18 | 94.43 | 87.97 | 46.22 | 34.03 | 9.52 |
| Feb | 10 | 50.37 | 60.00 | 42.45 | 94.28 | 88.63 | 46.56 | 32.94 | 8.45 |
| | 10 | 49.38 | 60.00 | 41.26 | 95.24 | 89.82 | 47.19 | 32.44 | 8.38 |
| | 8 | 46.83 | 60.00 | 38.20 | 93.82 | 89.71 | 47.13 | 30.00 | 6.31 |
| Mar | 10 | 40.35 | 60.00 | 30.43 | 95.23 | 91.01 | 47.82 | 24.25 | 6.76 |
| | 10 | 35.40 | 60.00 | 24.48 | 95.25 | 91.68 | 48.17 | 19.65 | 5.86 |
| | 11 | 34.02 | 60.00 | 22.83 | 96.77 | 93.12 | 48.92 | 18.62 | 6.25 |
| Apr | 10 | 37.73 | 60.00 | 27.27 | 98.22 | 94.54 | 49.67 | 22.58 | 6.50 |
| | 10 | 50.65 | 60.00 | 42.78 | 102.14 | 97.18 | 51.06 | 36.40 | 9.32 |
| | 10 | 80.75 | 60.00 | 60.00 | 104.31 | 97.94 | 51.46 | 51.46 | 12.35 |
| May | 10 | 209.95 | 60.00 | 60.00 | 103.84 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 232.86 | 60.00 | 60.00 | 103.76 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 161.05 | 60.00 | 60.00 | 103.91 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 205.17 | 60.00 | 60.00 | 103.85 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 366.52 | 60.00 | 60.00 | 103.33 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 1215.51 | 60.00 | 60.00 | 101.39 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 955.30 | 60.00 | 60.00 | 101.86 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 1393.52 | 60.00 | 60.00 | 101.12 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 1026.96 | 60.00 | 60.00 | 101.62 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 654.34 | 60.00 | 60.00 | 102.53 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 416.89 | 60.00 | 60.00 | 103.17 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 380.13 | 60.00 | 60.00 | 103.19 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 338.60 | 60.00 | 60.00 | 103.41 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 303.93 | 60.00 | 60.00 | 103.52 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 155.95 | 60.00 | 60.00 | 104.03 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 118.93 | 60.00 | 60.00 | 104.16 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 96.26 | 60.00 | 60.00 | 104.25 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 78.44 | 60.00 | 60.00 | 104.21 | 97.14 | 51.04 | 51.04 | 13.47 |
| Nov | 10 | 55.74 | 60.00 | 48.89 | 102.25 | 96.69 | 50.80 | 41.40 | 10.31 |
| | 10 | 51.31 | 60.00 | 43.57 | 102.37 | 97.36 | 51.15 | 37.14 | 9.47 |
| | 10 | 51.51 | 60.00 | 43.81 | 103.46 | 98.51 | 51.76 | 37.79 | 9.63 |
| Dec | 10 | 51.90 | 60.00 | 44.29 | 104.36 | 99.47 | 52.26 | 38.57 | 9.80 |
| | 10 | 48.55 | 60.00 | 40.26 | 104.36 | 99.86 | 52.46 | 35.20 | 9.14 |
| | 11 | 40.37 | 60.00 | 30.45 | 104.27 | 100.30 | 52.69 | 26.74 | 8.20 |



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| 2006 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 36.63 | 60.00 | 25.96 | 95.87 | 92.18 | 48.43 | 20.95 | 6.13 |
| | 10 | 36.26 | 60.00 | 25.51 | 96.94 | 93.37 | 49.06 | 20.86 | 6.13 |
| | 11 | 35.58 | 60.00 | 24.70 | 98.62 | 94.88 | 49.85 | 20.52 | 6.71 |
| Feb | 10 | 35.14 | 60.00 | 24.17 | 99.07 | 95.77 | 50.32 | 20.27 | 6.07 |
| | 10 | 34.88 | 60.00 | 23.85 | 100.12 | 96.91 | 50.91 | 20.24 | 6.08 |
| | 8 | 34.69 | 60.00 | 23.63 | 99.87 | 97.36 | 51.15 | 20.14 | 4.86 |
| Mar | 10 | 34.75 | 60.00 | 23.70 | 102.03 | 98.95 | 51.98 | 20.53 | 6.19 |
| | 10 | 34.00 | 60.00 | 22.80 | 102.93 | 99.98 | 52.53 | 19.96 | 6.09 |
| | 11 | 31.88 | 60.00 | 20.26 | 104.07 | 101.14 | 53.14 | 17.94 | 6.29 |
| Apr | 10 | 31.62 | 60.00 | 19.94 | 104.36 | 101.78 | 53.47 | 17.77 | 5.69 |
| | 10 | 31.99 | 60.00 | 20.38 | 104.36 | 101.73 | 53.45 | 18.16 | 5.77 |
| | 10 | 54.38 | 60.00 | 47.26 | 104.36 | 99.18 | 52.11 | 41.04 | 10.29 |
| May | 10 | 100.49 | 60.00 | 60.00 | 104.23 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 297.11 | 60.00 | 60.00 | 103.55 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 319.27 | 60.00 | 60.00 | 103.38 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 230.18 | 60.00 | 60.00 | 103.77 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 231.17 | 60.00 | 60.00 | 103.77 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 440.45 | 60.00 | 60.00 | 103.10 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 486.47 | 60.00 | 60.00 | 102.97 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 433.26 | 60.00 | 60.00 | 103.13 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 479.62 | 60.00 | 60.00 | 102.89 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 596.24 | 60.00 | 60.00 | 102.67 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 467.41 | 60.00 | 60.00 | 103.03 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 415.30 | 60.00 | 60.00 | 103.08 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 257.13 | 60.00 | 60.00 | 103.68 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 180.96 | 60.00 | 60.00 | 103.94 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 142.20 | 60.00 | 60.00 | 104.08 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 117.29 | 60.00 | 60.00 | 104.17 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 94.15 | 60.00 | 60.00 | 104.25 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 79.50 | 60.00 | 60.00 | 104.21 | 97.14 | 51.04 | 51.04 | 13.47 |
| Nov | 10 | 71.76 | 60.00 | 60.00 | 104.34 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 68.99 | 60.00 | 60.00 | 104.35 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 66.06 | 60.00 | 60.00 | 104.36 | 97.94 | 51.46 | 51.46 | 12.35 |
| Dec | 10 | 62.52 | 60.00 | 57.02 | 104.36 | 98.23 | 51.61 | 49.05 | 11.87 |
| | 10 | 57.03 | 60.00 | 50.44 | 104.27 | 98.77 | 51.89 | 43.62 | 10.80 |
| | 11 | 53.87 | 60.00 | 46.64 | 104.27 | 98.59 | 51.79 | 40.26 | 11.14 |



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| 2007 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 53.16 | 60.00 | 45.79 | 92.27 | 86.01 | 45.19 | 34.48 | 8.70 |
| | 10 | 48.94 | 60.00 | 40.72 | 92.46 | 86.83 | 45.62 | 30.96 | 8.02 |
| | 11 | 45.12 | 60.00 | 36.15 | 93.74 | 88.23 | 46.35 | 27.93 | 8.18 |
| Feb | 10 | 39.75 | 60.00 | 29.70 | 92.79 | 88.47 | 46.48 | 23.01 | 6.46 |
| | 10 | 35.86 | 60.00 | 25.03 | 93.06 | 89.29 | 46.91 | 19.57 | 5.79 |
| | 8 | 32.49 | 60.00 | 20.98 | 92.10 | 89.46 | 47.00 | 16.44 | 4.13 |
| Mar | 10 | 31.94 | 60.00 | 20.33 | 94.30 | 91.13 | 47.88 | 16.22 | 5.16 |
| | 10 | 34.04 | 60.00 | 22.85 | 95.99 | 92.65 | 48.67 | 18.54 | 5.65 |
| | 11 | 34.79 | 60.00 | 23.74 | 98.00 | 94.33 | 49.56 | 19.61 | 6.49 |
| Apr | 10 | 35.36 | 60.00 | 24.43 | 98.70 | 95.36 | 50.10 | 20.40 | 6.08 |
| | 10 | 36.41 | 60.00 | 25.69 | 100.04 | 96.65 | 50.78 | 21.74 | 6.38 |
| | 10 | 35.82 | 60.00 | 24.99 | 101.00 | 97.74 | 51.35 | 21.38 | 6.33 |
| May | 10 | 75.89 | 60.00 | 60.00 | 104.32 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 217.55 | 60.00 | 60.00 | 103.81 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 290.05 | 60.00 | 60.00 | 103.47 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 368.74 | 60.00 | 60.00 | 103.32 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 546.05 | 60.00 | 60.00 | 102.81 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 454.05 | 60.00 | 60.00 | 103.07 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 395.43 | 60.00 | 60.00 | 103.24 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 425.67 | 60.00 | 60.00 | 103.15 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 377.95 | 60.00 | 60.00 | 103.19 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 357.23 | 60.00 | 60.00 | 103.36 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 348.92 | 60.00 | 60.00 | 103.38 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 250.89 | 60.00 | 60.00 | 103.60 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 204.13 | 60.00 | 60.00 | 103.86 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 194.36 | 60.00 | 60.00 | 103.89 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 149.43 | 60.00 | 60.00 | 104.05 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 121.95 | 60.00 | 60.00 | 104.15 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 97.03 | 60.00 | 60.00 | 104.24 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 74.00 | 60.00 | 60.00 | 104.23 | 97.14 | 51.04 | 51.04 | 13.47 |
| Nov | 10 | 57.31 | 60.00 | 50.77 | 102.58 | 96.87 | 50.89 | 43.06 | 10.65 |
| | 10 | 53.28 | 60.00 | 45.93 | 102.79 | 97.57 | 51.26 | 39.24 | 9.90 |
| | 10 | 51.81 | 60.00 | 44.17 | 103.52 | 98.55 | 51.77 | 38.12 | 9.69 |
| Dec | 10 | 47.91 | 60.00 | 39.49 | 103.75 | 99.25 | 52.14 | 34.32 | 8.95 |
| | 10 | 45.97 | 60.00 | 37.16 | 104.36 | 100.15 | 52.61 | 32.59 | 8.62 |
| | 11 | 41.28 | 60.00 | 31.54 | 104.27 | 100.18 | 52.63 | 27.67 | 8.40 |



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| 2008 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 41.40 | 60.00 | 31.68 | 95.63 | 91.30 | 47.97 | 25.33 | 6.98 |
| | 10 | 39.84 | 60.00 | 29.81 | 96.43 | 92.37 | 48.53 | 24.11 | 6.76 |
| | 11 | 40.87 | 60.00 | 31.05 | 98.63 | 94.16 | 49.47 | 25.60 | 7.81 |
| Feb | 10 | 41.20 | 60.00 | 31.44 | 99.13 | 95.09 | 49.96 | 26.18 | 7.23 |
| | 10 | 41.37 | 60.00 | 31.64 | 100.27 | 96.29 | 50.59 | 26.68 | 7.36 |
| | 8 | 41.62 | 60.00 | 31.95 | 99.82 | 96.63 | 50.77 | 27.03 | 5.95 |
| Mar | 10 | 41.77 | 60.00 | 32.12 | 102.30 | 98.40 | 51.70 | 27.68 | 7.60 |
| | 10 | 43.71 | 60.00 | 34.45 | 103.74 | 99.73 | 52.39 | 30.08 | 8.11 |
| | 11 | 44.44 | 60.00 | 35.33 | 104.27 | 99.78 | 52.42 | 30.87 | 9.10 |
| Apr | 10 | 46.55 | 60.00 | 37.86 | 104.36 | 100.09 | 52.58 | 33.18 | 8.74 |
| | 10 | 51.75 | 60.00 | 44.10 | 104.36 | 99.49 | 52.27 | 38.42 | 9.77 |
| | 10 | 59.63 | 60.00 | 53.56 | 104.36 | 98.57 | 51.79 | 46.23 | 11.32 |
| May | 10 | 78.96 | 60.00 | 60.00 | 104.31 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 102.16 | 60.00 | 60.00 | 104.22 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 214.61 | 60.00 | 60.00 | 103.72 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 382.78 | 60.00 | 60.00 | 103.28 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 656.23 | 60.00 | 60.00 | 102.52 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 672.51 | 60.00 | 60.00 | 102.48 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 691.15 | 60.00 | 60.00 | 102.44 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 843.05 | 60.00 | 60.00 | 102.09 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 573.35 | 60.00 | 60.00 | 102.64 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 798.79 | 60.00 | 60.00 | 102.18 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 634.35 | 60.00 | 60.00 | 102.58 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 404.33 | 60.00 | 60.00 | 103.11 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 310.24 | 60.00 | 60.00 | 103.50 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 232.76 | 60.00 | 60.00 | 103.76 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 245.31 | 60.00 | 60.00 | 103.72 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 92.46 | 60.00 | 60.00 | 104.26 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 76.05 | 60.00 | 60.00 | 104.32 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 72.23 | 60.00 | 60.00 | 104.24 | 97.14 | 51.04 | 51.04 | 13.47 |
| Nov | 10 | 75.72 | 60.00 | 60.00 | 104.32 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 68.19 | 60.00 | 60.00 | 104.35 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 57.54 | 60.00 | 51.04 | 103.87 | 98.26 | 51.62 | 43.92 | 10.85 |
| Dec | 10 | - | - | - | 93.45 | 93.45 | 0.00 | 0.00 | 0.00 |
| | 10 | - | - | - | 93.45 | 93.45 | 0.00 | 0.00 | 0.00 |
| | 11 | - | - | - | 93.45 | 93.45 | 0.00 | 0.00 | 0.00 |



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| 2009 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 40.72 | 60.00 | 30.87 | 91.96 | 87.44 | 45.94 | 23.63 | 6.56 |
| | 10 | 40.34 | 60.00 | 30.41 | 93.11 | 88.73 | 46.61 | 23.63 | 6.59 |
| | 11 | 39.92 | 60.00 | 29.90 | 95.06 | 90.44 | 47.51 | 23.68 | 7.30 |
| Feb | 10 | 39.48 | 60.00 | 29.38 | 95.43 | 91.34 | 47.99 | 23.50 | 6.62 |
| | 10 | 39.19 | 60.00 | 29.02 | 96.54 | 92.56 | 48.63 | 23.52 | 6.65 |
| | 8 | 38.89 | 60.00 | 28.67 | 96.05 | 92.93 | 48.82 | 23.33 | 5.30 |
| Mar | 10 | 38.69 | 60.00 | 28.42 | 98.48 | 94.71 | 49.76 | 23.57 | 6.70 |
| | 10 | 38.14 | 60.00 | 27.77 | 99.47 | 95.83 | 50.35 | 23.30 | 6.67 |
| | 11 | 37.60 | 60.00 | 27.12 | 101.16 | 97.32 | 51.13 | 23.11 | 7.33 |
| Apr | 10 | 37.89 | 60.00 | 27.47 | 101.70 | 98.23 | 51.61 | 23.63 | 6.79 |
| | 10 | 40.48 | 60.00 | 30.58 | 103.30 | 99.63 | 52.34 | 26.68 | 7.43 |
| | 10 | 43.24 | 60.00 | 33.89 | 104.36 | 100.46 | 52.78 | 29.81 | 8.07 |
| May | 10 | 48.74 | 60.00 | 40.48 | 104.36 | 99.84 | 52.45 | 35.39 | 9.18 |
| | 10 | 67.81 | 60.00 | 60.00 | 104.35 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 151.56 | 60.00 | 60.00 | 103.95 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 291.56 | 60.00 | 60.00 | 103.56 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 265.64 | 60.00 | 60.00 | 103.65 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 334.13 | 60.00 | 60.00 | 103.43 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 492.01 | 60.00 | 60.00 | 102.96 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 537.63 | 60.00 | 60.00 | 102.83 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 664.21 | 60.00 | 60.00 | 102.40 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 773.43 | 60.00 | 60.00 | 102.24 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 679.81 | 60.00 | 60.00 | 102.46 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 473.62 | 60.00 | 60.00 | 102.91 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 374.97 | 60.00 | 60.00 | 103.30 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 250.66 | 60.00 | 60.00 | 103.70 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 198.38 | 60.00 | 60.00 | 103.88 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 194.56 | 60.00 | 60.00 | 103.89 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 158.88 | 60.00 | 60.00 | 104.02 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 142.22 | 60.00 | 60.00 | 103.98 | 97.14 | 51.04 | 51.04 | 13.47 |
| Nov | 10 | 112.57 | 60.00 | 60.00 | 104.19 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 103.29 | 60.00 | 60.00 | 104.22 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 88.18 | 60.00 | 60.00 | 104.28 | 97.94 | 51.46 | 51.46 | 12.35 |
| Dec | 10 | - | - | - | - | - | - | - | - |
| | 10 | - | - | - | - | - | - | - | - |
| | 11 | - | - | - | - | - | - | - | - |



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|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 29.02 | 60.00 | 16.82 | 90.69 | 87.72 | 46.09 | 12.92 | 4.43 |
| | 10 | 19.65 | 60.00 | 5.58 | 89.56 | 87.85 | 46.15 | 4.29 | 2.70 |
| | 11 | 14.94 | 59.66 | 0.00 | 89.91 | 88.72 | 46.35 | 0.00 | 2.04 |
| Feb | 10 | 17.46 | 60.00 | 2.95 | 91.69 | 90.34 | 47.46 | 2.33 | 2.37 |
| | 10 | 15.68 | 60.00 | 0.81 | 92.50 | 91.41 | 48.02 | 0.65 | 2.05 |
| | 8 | 14.78 | 58.70 | 0.00 | 93.06 | 92.33 | 47.46 | 0.00 | 1.52 |
| Mar | 10 | 14.40 | 56.42 | 0.00 | 94.47 | 93.57 | 46.23 | 0.00 | 1.85 |
| | 10 | 14.21 | 55.24 | 0.00 | 95.65 | 94.79 | 45.85 | 0.00 | 1.83 |
| | 11 | 15.65 | 60.00 | 0.78 | 97.28 | 96.17 | 50.53 | 0.66 | 2.37 |
| Apr | 10 | 19.24 | 60.00 | 5.09 | 99.10 | 97.72 | 51.34 | 4.36 | 2.93 |
| | 10 | 26.05 | 60.00 | 13.26 | 101.67 | 99.58 | 52.32 | 11.56 | 4.40 |
| | 10 | 42.96 | 60.00 | 33.55 | 104.36 | 100.50 | 52.80 | 29.52 | 8.02 |
| May | 10 | 40.91 | 60.00 | 31.09 | 104.36 | 100.73 | 52.92 | 27.42 | 7.60 |
| | 10 | 59.69 | 60.00 | 53.62 | 104.36 | 98.57 | 51.78 | 46.28 | 11.33 |
| | 11 | 86.90 | 60.00 | 60.00 | 104.18 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 115.33 | 60.00 | 60.00 | 104.18 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 217.69 | 60.00 | 60.00 | 103.81 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 479.74 | 60.00 | 60.00 | 102.99 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 456.10 | 60.00 | 60.00 | 103.06 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 671.80 | 60.00 | 60.00 | 102.48 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 744.02 | 60.00 | 60.00 | 102.21 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 821.45 | 60.00 | 60.00 | 102.13 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 949.83 | 60.00 | 60.00 | 101.87 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 600.17 | 60.00 | 60.00 | 102.57 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 423.51 | 60.00 | 60.00 | 103.15 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 317.59 | 60.00 | 60.00 | 103.48 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 173.93 | 60.00 | 60.00 | 103.96 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 128.18 | 60.00 | 60.00 | 104.13 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 111.03 | 60.00 | 60.00 | 104.19 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 85.96 | 60.00 | 60.00 | 104.19 | 97.14 | 51.04 | 51.04 | 13.47 |
| Nov | 10 | 79.06 | 60.00 | 60.00 | 104.31 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 72.03 | 60.00 | 60.00 | 104.34 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 64.30 | 60.00 | 59.16 | 104.36 | 98.02 | 51.50 | 50.78 | 12.22 |
| Dec | 10 | 50.74 | 60.00 | 42.89 | 102.61 | 97.68 | 51.32 | 36.69 | 9.39 |
| | 10 | 42.89 | 60.00 | 33.47 | 102.01 | 97.96 | 51.47 | 28.71 | 7.80 |
| | 11 | 36.18 | 60.00 | 25.42 | 102.31 | 98.72 | 51.86 | 21.97 | 7.12 |



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|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 44.17 | 60.00 | 35.00 | 94.70 | 89.93 | 47.25 | 27.56 | 7.40 |
| | 10 | 41.46 | 60.00 | 31.75 | 95.25 | 90.89 | 47.75 | 25.27 | 6.96 |
| | 11 | 73.86 | 60.00 | 60.00 | 104.23 | 97.14 | 51.04 | 51.04 | 13.47 |
| Feb | 10 | 48.54 | 60.00 | 40.25 | 100.71 | 95.88 | 50.38 | 33.79 | 8.77 |
| | 10 | 40.09 | 60.00 | 30.11 | 99.95 | 96.11 | 50.49 | 25.34 | 7.09 |
| | 8 | 35.63 | 60.00 | 24.75 | 98.71 | 96.06 | 50.47 | 20.82 | 4.95 |
| Mar | 10 | 30.37 | 60.00 | 18.44 | 99.79 | 97.12 | 51.02 | 15.68 | 5.18 |
| | 10 | 67.54 | 60.00 | 60.00 | 104.36 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 89.69 | 60.00 | 60.00 | 104.17 | 97.14 | 51.04 | 51.04 | 13.47 |
| Apr | 10 | 59.14 | 60.00 | 52.96 | 102.96 | 97.07 | 51.00 | 45.02 | 11.04 |
| | 10 | 49.22 | 60.00 | 41.06 | 101.93 | 97.12 | 51.03 | 34.92 | 9.03 |
| | 10 | 65.66 | 60.00 | 60.00 | 104.36 | 97.94 | 51.46 | 51.46 | 12.35 |
| May | 10 | 86.83 | 60.00 | 60.00 | 104.28 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 103.14 | 60.00 | 60.00 | 104.22 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 166.85 | 60.00 | 60.00 | 103.89 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 266.03 | 60.00 | 60.00 | 103.65 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 431.15 | 60.00 | 60.00 | 103.13 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 635.93 | 60.00 | 60.00 | 102.57 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 517.05 | 60.00 | 60.00 | 102.89 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 470.43 | 60.00 | 60.00 | 103.02 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 565.29 | 60.00 | 60.00 | 102.66 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 560.97 | 60.00 | 60.00 | 102.77 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 497.46 | 60.00 | 60.00 | 102.94 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 362.62 | 60.00 | 60.00 | 103.24 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 403.53 | 60.00 | 60.00 | 103.21 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 370.33 | 60.00 | 60.00 | 103.32 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 216.16 | 60.00 | 60.00 | 103.82 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 168.18 | 60.00 | 60.00 | 103.98 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 128.43 | 60.00 | 60.00 | 104.13 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 108.97 | 60.00 | 60.00 | 104.10 | 97.14 | 51.04 | 51.04 | 13.47 |
| Nov | 10 | 94.08 | 60.00 | 60.00 | 104.25 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 87.67 | 60.00 | 60.00 | 104.28 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 78.32 | 60.00 | 60.00 | 104.31 | 97.94 | 51.46 | 51.46 | 12.35 |
| Dec | 10 | 71.31 | 60.00 | 60.00 | 104.34 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 64.06 | 60.00 | 58.87 | 104.36 | 98.05 | 51.51 | 50.55 | 12.17 |
| | 11 | 55.28 | 60.00 | 48.34 | 104.27 | 98.40 | 51.70 | 41.65 | 11.44 |



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|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 48.65 | 60.00 | 40.38 | 91.88 | 86.23 | 45.30 | 30.49 | 7.91 |
| | 10 | 42.50 | 60.00 | 33.00 | 91.59 | 86.79 | 45.59 | 25.08 | 6.84 |
| | 11 | 41.21 | 60.00 | 31.45 | 93.41 | 88.46 | 46.47 | 24.36 | 7.40 |
| Feb | 10 | 37.12 | 60.00 | 26.55 | 92.87 | 88.91 | 46.71 | 20.67 | 6.00 |
| | 10 | 33.02 | 60.00 | 21.62 | 93.09 | 89.71 | 47.13 | 16.98 | 5.28 |
| | 8 | 98.52 | 60.00 | 60.00 | 104.44 | 99.51 | 52.28 | 52.28 | 10.04 |
| Mar | 10 | 48.82 | 60.00 | 40.59 | 104.36 | 99.83 | 52.45 | 35.48 | 9.19 |
| | 10 | 37.12 | 60.00 | 26.54 | 103.00 | 99.69 | 52.38 | 23.17 | 6.73 |
| | 11 | 34.48 | 60.00 | 23.37 | 104.09 | 100.83 | 52.98 | 20.64 | 6.87 |
| Apr | 10 | 37.27 | 60.00 | 26.73 | 104.36 | 101.14 | 53.14 | 23.67 | 6.86 |
| | 10 | 46.19 | 60.00 | 37.43 | 104.36 | 100.13 | 52.60 | 32.82 | 8.67 |
| | 10 | 57.67 | 60.00 | 51.20 | 104.36 | 98.80 | 51.91 | 44.30 | 10.94 |
| May | 10 | 72.16 | 60.00 | 60.00 | 104.34 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 164.31 | 60.00 | 60.00 | 104.00 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 107.20 | 60.00 | 60.00 | 104.11 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 148.05 | 60.00 | 60.00 | 104.06 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 245.39 | 60.00 | 60.00 | 103.72 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 399.07 | 60.00 | 60.00 | 103.23 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 513.76 | 60.00 | 60.00 | 102.90 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 611.61 | 60.00 | 60.00 | 102.63 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 560.34 | 60.00 | 60.00 | 102.67 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 655.41 | 60.00 | 60.00 | 102.52 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 495.10 | 60.00 | 60.00 | 102.95 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 591.46 | 60.00 | 60.00 | 102.59 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 480.71 | 60.00 | 60.00 | 102.99 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 362.07 | 60.00 | 60.00 | 103.34 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 208.18 | 60.00 | 60.00 | 103.84 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 112.35 | 60.00 | 60.00 | 104.19 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 79.07 | 60.00 | 60.00 | 104.31 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 67.27 | 60.00 | 60.00 | 104.26 | 97.14 | 51.04 | 51.04 | 13.47 |
| Nov | 10 | 60.77 | 60.00 | 54.92 | 103.30 | 97.25 | 51.09 | 46.77 | 11.40 |
| | 10 | 53.73 | 60.00 | 46.47 | 102.88 | 97.62 | 51.29 | 39.72 | 10.00 |
| | 10 | 44.09 | 60.00 | 34.91 | 101.90 | 97.71 | 51.33 | 29.87 | 8.03 |
| Dec | 10 | 39.57 | 60.00 | 29.49 | 102.00 | 98.35 | 51.67 | 25.40 | 7.15 |
| | 10 | 37.92 | 60.00 | 27.50 | 102.71 | 99.29 | 52.17 | 23.91 | 6.87 |
| | 11 | 37.01 | 60.00 | 26.41 | 104.21 | 100.65 | 52.88 | 23.28 | 7.45 |



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|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 44.83 | 60.00 | 35.80 | 96.66 | 91.97 | 48.32 | 28.83 | 7.70 |
| | 10 | 45.58 | 60.00 | 36.70 | 97.98 | 93.30 | 49.02 | 29.98 | 7.96 |
| | 11 | 35.48 | 60.00 | 24.57 | 97.51 | 93.71 | 49.23 | 20.16 | 6.60 |
| Feb | 10 | 35.26 | 60.00 | 24.31 | 98.02 | 94.65 | 49.72 | 20.15 | 6.02 |
| | 10 | 29.85 | 60.00 | 17.82 | 97.93 | 95.22 | 50.03 | 14.85 | 4.97 |
| | 8 | 27.79 | 60.00 | 15.35 | 97.56 | 95.63 | 50.24 | 12.85 | 3.66 |
| Mar | 10 | 34.00 | 60.00 | 22.80 | 100.84 | 97.78 | 51.37 | 19.52 | 5.96 |
| | 10 | 33.68 | 60.00 | 22.42 | 101.85 | 98.88 | 51.95 | 19.41 | 5.96 |
| | 11 | 44.00 | 60.00 | 34.80 | 104.27 | 99.84 | 52.45 | 30.42 | 9.00 |
| Apr | 10 | 40.41 | 60.00 | 30.49 | 103.87 | 100.24 | 52.66 | 26.76 | 7.46 |
| | 10 | 48.07 | 60.00 | 39.68 | 104.36 | 99.91 | 52.49 | 34.72 | 9.04 |
| | 10 | 58.59 | 60.00 | 52.31 | 104.36 | 98.69 | 51.85 | 45.21 | 11.12 |
| May | 10 | 76.99 | 60.00 | 60.00 | 104.32 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 109.72 | 60.00 | 60.00 | 104.20 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 217.32 | 60.00 | 60.00 | 103.71 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 382.76 | 60.00 | 60.00 | 103.28 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 559.84 | 60.00 | 60.00 | 102.77 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 565.63 | 60.00 | 60.00 | 102.75 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 484.58 | 60.00 | 60.00 | 102.98 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 609.87 | 60.00 | 60.00 | 102.64 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 768.41 | 60.00 | 60.00 | 102.15 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 735.39 | 60.00 | 60.00 | 102.33 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 566.36 | 60.00 | 60.00 | 102.75 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 505.44 | 60.00 | 60.00 | 102.82 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 451.96 | 60.00 | 60.00 | 103.07 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 366.90 | 60.00 | 60.00 | 103.33 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 265.05 | 60.00 | 60.00 | 103.65 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 167.18 | 60.00 | 60.00 | 103.99 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 124.49 | 60.00 | 60.00 | 104.14 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 100.28 | 60.00 | 60.00 | 104.13 | 97.14 | 51.04 | 51.04 | 13.47 |
| Nov | 10 | 75.54 | 60.00 | 60.00 | 104.32 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 65.39 | 60.00 | 60.00 | 104.36 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 56.14 | 60.00 | 49.36 | 103.59 | 98.11 | 51.54 | 42.41 | 10.54 |
| Dec | 10 | 48.05 | 60.00 | 39.67 | 102.95 | 98.37 | 51.68 | 34.16 | 8.90 |
| | 10 | 43.74 | 60.00 | 34.49 | 103.09 | 99.02 | 52.02 | 29.91 | 8.06 |
| | 11 | 39.53 | 60.00 | 29.43 | 103.96 | 100.07 | 52.57 | 25.79 | 7.99 |



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|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 36.47 | 60.00 | 25.77 | 95.73 | 92.05 | 48.36 | 20.77 | 6.09 |
| | 10 | 35.92 | 60.00 | 25.11 | 96.77 | 93.23 | 48.98 | 20.49 | 6.06 |
| | 11 | 33.02 | 60.00 | 21.62 | 97.89 | 94.45 | 49.62 | 17.88 | 6.12 |
| Feb | 10 | 33.38 | 60.00 | 22.06 | 98.58 | 95.47 | 50.16 | 18.44 | 5.69 |
| | 10 | 34.86 | 60.00 | 23.83 | 100.02 | 96.81 | 50.86 | 20.20 | 6.07 |
| | 8 | 29.47 | 60.00 | 17.37 | 98.85 | 96.80 | 50.86 | 14.72 | 3.98 |
| Mar | 10 | 28.16 | 60.00 | 15.80 | 100.52 | 98.14 | 51.56 | 13.57 | 4.78 |
| | 10 | 28.50 | 60.00 | 16.20 | 101.67 | 99.30 | 52.17 | 14.09 | 4.90 |
| | 11 | 28.01 | 60.00 | 15.62 | 103.11 | 100.60 | 52.85 | 13.76 | 5.35 |
| Apr | 10 | 26.10 | 60.00 | 13.32 | 103.38 | 101.35 | 53.25 | 11.82 | 4.49 |
| | 10 | 29.47 | 60.00 | 17.36 | 104.36 | 102.02 | 53.60 | 15.51 | 5.25 |
| | 10 | 40.00 | 60.00 | 30.00 | 104.36 | 100.83 | 52.97 | 26.49 | 7.42 |
| May | 10 | 61.29 | 60.00 | 55.55 | 104.36 | 98.38 | 51.69 | 47.85 | 11.64 |
| | 10 | 74.01 | 60.00 | 60.00 | 104.33 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 120.08 | 60.00 | 60.00 | 104.06 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 154.26 | 60.00 | 60.00 | 104.03 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 262.41 | 60.00 | 60.00 | 103.66 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 280.29 | 60.00 | 60.00 | 103.60 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 446.33 | 60.00 | 60.00 | 103.09 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 490.51 | 60.00 | 60.00 | 102.96 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 577.69 | 60.00 | 60.00 | 102.62 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 569.35 | 60.00 | 60.00 | 102.74 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 560.66 | 60.00 | 60.00 | 102.77 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 433.44 | 60.00 | 60.00 | 103.03 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 291.21 | 60.00 | 60.00 | 103.57 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 214.15 | 60.00 | 60.00 | 103.82 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 169.93 | 60.00 | 60.00 | 103.98 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 123.95 | 60.00 | 60.00 | 104.14 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 104.67 | 60.00 | 60.00 | 104.22 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 83.25 | 60.00 | 60.00 | 104.20 | 97.14 | 51.04 | 51.04 | 13.47 |
| Nov | 10 | 67.10 | 60.00 | 60.00 | 104.36 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 60.58 | 60.00 | 54.70 | 104.36 | 98.46 | 51.73 | 47.16 | 11.50 |
| | 10 | 52.53 | 60.00 | 45.03 | 103.75 | 98.72 | 51.86 | 38.93 | 9.86 |
| Dec | 10 | 46.27 | 60.00 | 37.52 | 103.49 | 99.16 | 52.10 | 32.58 | 8.60 |
| | 10 | 40.94 | 60.00 | 31.13 | 103.43 | 99.71 | 52.38 | 27.17 | 7.53 |
| | 11 | 35.21 | 60.00 | 24.25 | 103.89 | 100.54 | 52.82 | 21.35 | 7.02 |



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| 2015 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **Days** | **Q of River ($m^3/s$)** | **$Q_{pk}$ ($m^3/s$)** | **$Q_{op}$ ($m^3/s$)** | **H net $_{pk}$** | **H net $_{op}$** | **$P_{pk}$ (MW)** | **$P_{op}$ (MW)** | **Energy (GWh)** |
| Jan | 10 | 30.44 | 60.00 | 18.52 | 96.76 | 93.92 | 49.34 | 15.23 | 5.02 |
| | 10 | 29.16 | 60.00 | 16.99 | 97.61 | 94.98 | 49.90 | 14.13 | 4.82 |
| | 11 | 27.74 | 60.00 | 15.29 | 98.93 | 96.27 | 50.58 | 12.89 | 5.06 |
| Feb | 10 | 26.59 | 60.00 | 13.91 | 99.40 | 97.15 | 51.04 | 11.83 | 4.41 |
| | 10 | 26.09 | 60.00 | 13.30 | 100.39 | 98.24 | 51.61 | 11.45 | 4.35 |
| | 8 | 24.72 | 60.00 | 11.66 | 100.32 | 98.78 | 51.89 | 10.09 | 3.27 |
| Mar | 10 | 23.53 | 60.00 | 10.23 | 101.78 | 99.98 | 52.53 | 8.96 | 3.89 |
| | 10 | 26.45 | 60.00 | 13.74 | 103.44 | 101.37 | 53.26 | 12.19 | 4.57 |
| | 11 | 28.77 | 60.00 | 16.53 | 104.27 | 101.73 | 53.45 | 14.72 | 5.59 |
| Apr | 10 | 33.63 | 60.00 | 22.35 | 104.36 | 101.55 | 53.35 | 19.88 | 6.11 |
| | 10 | 40.13 | 60.00 | 30.15 | 104.36 | 100.82 | 52.97 | 26.62 | 7.44 |
| | 10 | 48.84 | 60.00 | 40.61 | 104.36 | 99.82 | 52.45 | 35.49 | 9.20 |
| May | 10 | 63.17 | 60.00 | 57.80 | 104.36 | 98.16 | 51.57 | 49.68 | 12.00 |
| | 10 | 102.70 | 60.00 | 60.00 | 104.22 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 159.99 | 60.00 | 60.00 | 103.92 | 97.14 | 51.04 | 51.04 | 13.47 |
| Jun | 10 | 201.84 | 60.00 | 60.00 | 103.87 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 233.33 | 60.00 | 60.00 | 103.76 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 227.68 | 60.00 | 60.00 | 103.78 | 97.94 | 51.46 | 51.46 | 12.35 |
| Jul | 10 | 338.55 | 60.00 | 60.00 | 103.41 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 620.56 | 60.00 | 60.00 | 102.61 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 736.23 | 60.00 | 60.00 | 102.23 | 97.14 | 51.04 | 51.04 | 13.47 |
| Aug | 10 | 839.81 | 60.00 | 60.00 | 102.09 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 666.20 | 60.00 | 60.00 | 102.50 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 469.61 | 60.00 | 60.00 | 102.92 | 97.14 | 51.04 | 51.04 | 13.47 |
| Sep | 10 | 237.38 | 60.00 | 60.00 | 103.74 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 194.29 | 60.00 | 60.00 | 103.89 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 150.40 | 60.00 | 60.00 | 104.05 | 97.94 | 51.46 | 51.46 | 12.35 |
| Oct | 10 | 109.84 | 60.00 | 60.00 | 104.20 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 110.63 | 60.00 | 60.00 | 104.19 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 11 | 98.03 | 60.00 | 60.00 | 104.14 | 97.14 | 51.04 | 51.04 | 13.47 |
| Nov | 10 | 79.67 | 60.00 | 60.00 | 104.31 | 97.94 | 51.46 | 51.46 | 12.35 |
| | 10 | 62.78 | 60.00 | 57.33 | 104.36 | 98.20 | 51.59 | 49.30 | 11.92 |
| | 10 | 55.79 | 60.00 | 48.94 | 103.97 | 98.57 | 51.79 | 42.25 | 10.52 |
| Dec | 10 | 46.69 | 60.00 | 38.02 | 103.13 | 98.72 | 51.86 | 32.87 | 8.65 |
| | 10 | 38.05 | 60.00 | 27.65 | 102.36 | 98.91 | 51.97 | 23.95 | 6.87 |
| | 11 | 33.89 | 60.00 | 22.66 | 103.14 | 99.90 | 52.49 | 19.82 | 6.67 |



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PAKISTAN
WATER AND POWER DEVELOPMENT AUTHORITY

Management Consulting Services for Review of Feasibility Study, Procurement of EPC Contractor and Contract Management & Administration of the

# ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

## FEASIBILITY REVIEW / VALIDATION REPORT (FINAL)

DOCUMENT NO.: 4464-FRR

AHMC ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

NESPAK PES DOLSAR

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# FINAL FEASIBILITY REVIEW / VALIDATION REPORT

## MAY 2023

### TABLE OF CONTENTS

**LIST OF TABLES** ..... **VII**
**LIST OF FIGURES** ..... **IX**

**1 INTRODUCTION** ..... **1-1**

1.1 GENERAL ..... 1-1
1.2 LOCATION ..... 1-1
1.3 ACCESSIBILITY ..... 1-4
1.4 CLIMATE ..... 1-4
1.5 PROJECT OBJECTIVES ..... 1-4
1.6 PREVIOUS STUDIES ..... 1-6
1.7 PROJECT COMPONENTS FROM FEASIBILITY STUDY BY WAPDA ..... 1-6
1.8 SALIENT FEATURES ..... 1-8
1.9 PROJECT MANAGEMENT CONSULTANTS ..... 1-9
1.10 SCOPE OF MANAGEMENT CONSULTANCY SERVICES ..... 1-9
1.11 CURRENT REVIEW REPORT ..... 1-10

**2 REVIEW OF POWER MARKET AND DEMAND FORECAST STUDIES** ..... **2-1**

2.1 GENERAL ..... 2-1
2.2 POWER GENERATION AND DEMAND COMPARISON OF GILGIT BALTISTAN ..... 2-1
2.3 POWER DISTRIBUTION, TRANSMISSION AND NATIONAL GRID CONNECTIVITY OF GILGIT BALTISTAN ..... 2-1
2.4 REVIEW FINDINGS AND RECOMMENDATIONS ..... 2-6

**3 REVIEW OF TOPOGRAPHIC AND HYDROGRAPHIC SURVEY** ..... **3-1**

3.1 GENERAL ..... 3-1
3.2 REVIEW FINDINGS ..... 3-1
3.2.1 Establishment of the Permanent Control Benchmarks ..... 3-1
3.2.2 Observed Spot Levels ..... 3-2
3.2.3 Survey of Locations of Geotechnical Investigations ..... 3-2
3.2.4 Satellite Based Survey of the Project Area ..... 3-2
3.2.5 Results of Hydrographic Survey ..... 3-2
3.3 REVIEW RECOMMENDATIONS ..... 3-2

**4 REVIEW OF HYDROLOGY AND SEDIMENTATION STUDIES** ..... **4-1**

4.1 GENERAL ..... 4-1
4.2 WATERSHED BOUNDARY OF WEIR ..... 4-1
4.3 CLIMATOLOGY ..... 4-3
4.3.1 Climatological Data - Skardu ..... 4-3
4.3.2 Climatological Data - Gilgit ..... 4-4
4.4 HYDROLOGICAL STATIONS ..... 4-5
4.5 FLOW STUDY ..... 4-6

4.5.1 Estimation of Flows – Feasibility Study 2021 ..... 4-6
4.5.2 Estimation of Flows - Review Study ..... 4-8
4.5.3 Water Availability and Reservoir Operational Study – Review Study ..... 4-13
4.5.4 Comparison of Flows Study (Feasibility Study vs. Review Study) ..... 4-15
4.6 FLOOD STUDY ..... 4-16
4.6.1 Flood Estimation - Feasibility Study 2021 ..... 4-16
4.6.2 Flood Estimation - Review Study ..... 4-17
4.7 HYDROLOGICAL FLOOD ROUTING ..... 4-19
4.7.1 Flood Routing - Feasibility Study 2021 ..... 4-20
4.7.2 Flood Routing - Review Study ..... 4-21
4.8 SEDIMENTATION STUDY ..... 4-25
4.8.1 Sedimentation Study - Feasibility Study 2021 ..... 4-25
4.8.2 Sedimentation Study – Review Study ..... 4-25
4.9 SUMMARY OF REVIEW STUDY ..... 4-28
4.10 ANALYSIS ON ADDITIONAL AVAILABLE DATA ..... 4-29
4.11 RECOMMENDATIONS ..... 4-30

**5 REVIEW OF GEOLOGY AND GEOTECHNICAL STUDIES ..... 5-1**

5.1 GENERAL ..... 5-1
5.2 REVIEW OF GEOLOGICAL STUDIES ..... 5-1
5.2.1 Review Scope of Geological Studies ..... 5-1
5.2.2 Regional Geology and Regional Faults ..... 5-2
5.2.3 Site Geology ..... 5-2
5.2.4 Geological Structures ..... 5-3
5.2.5 Geomorphology ..... 5-4
5.2.6 Review of Surface Geological Investigations ..... 5-6
5.3 REVIEW OF GEOTECHNICAL STUDIES AND SUBSURFACE INVESTIGATIONS 5-7
5.3.1 Review of Field Testing Data ..... 5-13
5.3.2 Review of Laboratory Testing Data ..... 5-14
5.4 ADDITIONALLY PROPOSED FIELD AND LABORATORY INVESTIGATIONS ..... 5-17
5.5 REVIEW OF FOUNDATION EVALUATION ..... 5-21
5.5.1 Review Findings ..... 5-21
5.5.2 Technical Considerations for Foundations ..... 5-22
5.5.3 Recommendations for Foundation Evaluations ..... 5-24
5.6 REVIEW OF CONSTRUCTION MATERIAL STUDIES ..... 5-26
5.6.1 General Review ..... 5-26
5.6.2 Material Specific Review ..... 5-26
5.6.3 Recommendation for Construction Material Studies ..... 5-27

**6 REVIEW OF NEOTECTONICS STUDY AND SEISMIC HAZARD ANALYSIS ..... 6-1**

6.1 GENERAL ..... 6-1
6.2 REVIEW FINDINGS ..... 6-1
6.3 RECOMMENDATIONS ..... 6-1

**7 REVIEW OF PROJECT LAYOUT STUDIES ..... 7-1**

7.1 GENERAL ..... 7-1
7.2 ALTERNATIVE-I: PROJECT LAYOUT ON THE LEFT BANK ..... 7-1
7.3 ALTERNATIVE-II: PROJECT LAYOUT ON THE RIGHT BANK ..... 7-1
7.4 SELECTED LAYOUT AT FEASIBILITY STAGE 2021 ..... 7-1
7.5 PROJECT LAYOUT STUDIES AT REVIEW STAGE ..... 7-3
7.5.1 Site Visit Observations and Feasibility Review Findings for Project Layout ..... 7-3
7.5.2 Proposal for Detail Design Regarding Project Layout ..... 7-13



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7.5.3 Future Prospects of Modified Layout ..... 7-16

**8 REVIEW OF POWER POTENTIAL STUDIES ..... 8-1**

8.1 GENERAL ..... 8-1
8.2 WATER AVAILABILITY AT RESERVOIR ..... 8-1
8.2.1 Flow Duration Curve (FDC) ..... 8-3
8.2.2 Tail Water Rating Curve ..... 8-4
8.3 POWER AND ENERGY STUDIES ..... 8-4
8.3.1 Net Head ..... 8-4
8.3.2 Power and Energy Potential ..... 8-4
8.3.3 Optimization of Power and Energy ..... 8-5
8.4 REVIEW STAGE CONFIRMATORY ENERGY CALCULATIONS ..... 8-6
8.4.1 Power and Energy Calculations based on Flow Duration Curve (FDC) method with Two (02) No. of Generating Units. ..... 8-7
8.4.2 Power and Energy Calculations based on Flow Duration Curve (FDC) method with Three (03) No. of Generating Units ..... 8-18
8.4.3 Power and Energy Calculations based on Flow Duration Curve (FDC) method with Three (03) No. of Generating Units ..... 8-28
8.5 REVIEW FINDINGS ..... 8-37

**9 REVIEW OF STRUCTURE DESIGN STUDIES ..... 9-1**

9.1 GENERAL ..... 9-1
9.2 HYDRAULIC MODELLING OF RESERVOIR ..... 9-1
9.3 NATURAL DAMMING ON HUNZA RIVER ..... 9-3
9.4 HYDRAULIC DESIGN ..... 9-3
9.4.1 Hydraulic Design of Weir/Spillway and Stilling Basin ..... 9-3
9.4.2 Flushing Outlets ..... 9-4
9.4.3 Freeboard Calculations ..... 9-5
9.5 DESIGN OF RIVER DIVERSION WORKS ..... 9-5
9.5.1 Discharge Capacity of River Diversion Works ..... 9-5
9.6 POWER INTAKE STRUCTURE ..... 9-6
9.6.1 Hydraulic Design of Intake ..... 9-6
9.7 LOW PRESSURE TUNNEL ..... 9-8
9.8 SURGE TANK ..... 9-9
9.8.1 Hydraulic Design of Surge Tank ..... 9-9
9.8.2 Load Case Maximum Upsurge ..... 9-10
9.8.3 Results of Surge Tank Simulation ..... 9-12
9.9 WATER HAMMER ANALYSIS IN PENSTOCKS ..... 9-12
9.9.1 Water Hammer Calculations for Single Penstock ..... 9-14
9.9.2 Pressure Wave Velocity ..... 9-14
9.9.3 Water Hammer Pressure (Allievi Chart) ..... 9-14
9.10 POWERHOUSE ..... 9-15
9.11 TAILRACE CHANNEL ..... 9-16

**10 REVIEW OF GEOTECHNICAL AND STRUCTURAL STABILITY ANALYSIS ..... 10-1**

10.1 REVIEW OF SLOPE STABILITY ANALYSIS ..... 10-1
10.2 REVIEW OF SEEPAGE ANALYSIS ..... 10-1

**11 REVIEW OF HYDROMECHANICAL EQUIPMENT STUDIES ..... 11-1**

11.1 TURBINE ..... 11-1
11.1.1 Turbine Selection Criteria ..... 11-1
11.1.2 Type, Rated Speed & Setting ..... 11-1



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11.1.3 Turbine Shaft....11-1
11.1.4 Air Admission System for Aeration against Pressure Pulsation and Vortexes....11-1
11.1.5 Power and Energy Potential....11-1
11.2 GOVERNOR SYSTEM....11-13
11.3 INLET VALVE....11-13
11.4 MECHANICAL AUXILIARY SYSTEMS....11-14
11.4.1 Cooling Water System....11-14
11.4.2 Oil Handling System....11-14
11.4.3 Fire Protection System....11-14
11.5 POWERHOUSE (PH) LAYOUT....11-15
11.6 PENSTOCK....11-15
11.7 HYDRAULIC STEEL STRUCTURES....11-16
11.7.1 General....11-16
11.7.2 Power Intake Structure....11-16
11.7.4 Tail race Structure....11-18
11.8 SUMMARY OF REVIEW FINDINGS....11-18

**12 REVIEW OF ELECTRICAL EQUIPMENT STUDIES....12-1**

12.1 GENERAL....12-1
12.2 REVIEW OF POWERHOUSE ELECTRICAL WORKS STUDIES....12-1
12.2.1 Generator & Excitation System....12-1
12.2.2 Generator Circuit Breaker....12-2
12.2.3 Power Transformer....12-2
12.2.4 Station Service Transformer....12-2
12.2.5 Unit Auxiliary Transformers....12-2
12.2.6 Medium & Low Voltage System....12-3
12.2.7 Control & Instrumentation System....12-3
12.2.8 Protection Equipment....12-4
12.2.9 DC & UPS System....12-4
12.2.10 Cables....12-4
12.2.11 Illumination & Small Power System....12-5
12.2.12 Emergency Diesel Generator....12-5
12.2.13 Electrical Workshop....12-5
12.2.14 Earthing & Lightning System....12-5
12.2.15 Fire Detection & Alarm System....12-5
12.2.16 Drawings....12-5
12.3 REVIEW OF SWITCHYARD STUDIES....12-5
12.3.1 Review Findings....12-5
12.3.2 Main Single Line Diagram and Protection Single Line Diagram....12-7
12.3.3 11/132kV Unit Transformer....12-7
12.4 REVIEW OF DISTRIBUTION STUDIES....12-8
12.5 REVIEW OF SCADA AND TELECOM STUDIES....12-9
12.5.1 Functional Overview / Scope of Work....12-9
12.5.2 Station Instrumentation and Control (I&C) System....12-10
12.5.3 Recommendations....12-10

**13 REVIEW OF TRANSMISSION LINE STUDY....13-1**

13.1 TRANSMISSION LINES FROM ATTABAD LAKE HPP....13-1
13.2 TYPE OF TOWERS AND BASIC DATA....13-1
13.3 INSULATORS....13-1
13.4 LOAD FLOW STUDIES....13-2



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**14 REVIEW OF PROJECT QUANTITIES AND COST ESTIMATES ..... 14-1**

14.1 GENERAL ..... 14-1
14.1.1 Rate Assumption ..... 14-1
14.1.2 Price Index ..... 14-1
14.1.3 Development of Unit Rates ..... 14-1
14.1.4 Rate Analysis ..... 14-1
14.2 QUANTITY AND COST ESTIMATE OF MAIN WEIR AND FLUSHING SECTION ..... 14-1
14.3 QUANTITY AND COST ESTIMATE OF GEOTECHNICAL WORKS ..... 14-2
14.4 QUANTITY AND COST ESTIMATE OF HYDROMECHANICAL WORKS ..... 14-2
14.5 QUANTITY AND COST ESTIMATE OF TRANSMISSION LINE WORKS ..... 14-3
14.6 QUANTITY AND COST ESTIMATE OF PENSTOCK ..... 14-3
14.7 QUANTITY AND COST ESTIMATE OF POWERHOUSE AND TAILRACE CHANNEL ..... 14-3
14.8 REVIEW OF ANNEXURE A EQUIPMENT, MATERIAL AND LABOUR RATES ..... 14-3
14.9 COMPARISON OF QUANTITIES FOR FEASIBILITY STUDY AND REVIEW STAGE STUDY ..... 14-3

**15 REVIEW OF CONSTRUCTION PLANNING AND COST ESTIMATES ..... 15-1**

15.1 FACTORS AFFECTING PROGRESS OF CONSTRUCTION WORKS ..... 15-1
15.2 PROCUREMENT AND STORAGE OF MATERIALS ..... 15-1
15.2.1 Cement ..... 15-1
15.2.2 Coarse Aggregate ..... 15-1
15.2.3 Fine Aggregate (Sand) ..... 15-1
15.2.4 Reinforcing Steel ..... 15-1
15.2.5 Explosive Materials ..... 15-1
15.2.6 Steel Plates and Steel Formwork ..... 15-1
15.2.7 Water and Stone for Riprap and Fill Material ..... 15-1
15.3 REVIEW OF CONSTRUCTION PLANNING AND METHODOLOGY ..... 15-2
15.3.1 Care and Handling of Water ..... 15-2
15.3.2 Sediment Flushing Tunnel / Channel (Under sluice) ..... 15-2
15.3.3 Power Intake ..... 15-2
15.3.4 Overflow Weir / Ungated Spillway ..... 15-2
15.3.5 Access Tunnels / Adits for Headrace Tunnel ..... 15-3
15.3.6 Low Pressure Headrace Tunnel ..... 15-3
15.3.7 Surge Tank ..... 15-3
15.3.8 Penstock ..... 15-3
15.3.9 Powerhouse Civil Works ..... 15-3
15.3.10 Unit Erection ..... 15-3
15.3.11 Mechanical & Electrical Installations ..... 15-3
15.3.12 Tailrace Channel ..... 15-3
15.3.13 Switchyard ..... 15-3
15.3.14 Transmission Lines ..... 15-4
15.3.15 Assembly of Electro-Mechanical Equipment ..... 15-4
15.3.16 Testing and Commissioning ..... 15-4
15.4 REVIEW OF PROJECT IMPLEMENTATION SCHEDULE ..... 15-4
15.5 CONSTRUCTION MANAGEMENT ..... 15-4
15.5.1 Project Executing Agency ..... 15-4
15.5.2 Consultants ..... 15-4

**16 REVIEW OF ENVIRONMENTAL IMPACT STUDY ..... 16-1**

16.1 GENERAL ..... 16-1
16.2 CHAPTER 1: INTRODUCTION ..... 16-1



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16.3 CHAPTER 2: PROJECT DESCRIPTION ..... 16-1
16.4 CHAPTER 3: REGULATORY LAWS AND THE INSTITUTIONAL FRAMEWORK ..... 16-2
16.5 CHAPTER 4: BASELINE CONDITIONS ..... 16-2
16.6 CHAPTER 5: ESIA AND MITIGATION MEASURES ..... 16-3
16.7 CHAPTER 6: ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN ..... 16-3
16.8 CONCLUSIONS AND RECOMMENDATIONS ..... 16-4

**17 REVIEW OF ECONOMIC AND FINANCIAL ANALYSIS ..... 17-1**

17.1 GENERAL ..... 17-1
17.2 REVIEW OF ECONOMIC ANALYSIS ..... 17-1
17.3 REVIEW OF FINANCIAL ANALYSIS ..... 17-2
17.4 RECOMMENDATIONS FOR FURTHER IMPROVEMENT OF STUDIES ..... 17-3

**18 CONCLUSIONS AND RECOMMENDATIONS OF REVIEW STUDY ..... 18-1**

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS



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## LIST OF TABLES


Table 1.1 Coordinates of Weir and Power House site (From Feasibility Report) ..... 1-1
Table 1.2 Project Salient Features (From Feasibility Report) ..... 1-8
Table 2.1 Current Power Scenario of Gilgit-Baltistan ..... 2-4
Table 4.1 Mean Monthly Temperature & Precipitation - Skardu ..... 4-3
Table 4.2 Mean Monthly Climatic Data at Gilgit ..... 4-5
Table 4.3 Availability of Data at SWHP Hydrological Stations ..... 4-6
Table 4.4 Monthly Flows at Weir - Attabad Lake (1966-2015) ..... 4-7
Table 4.5 Flow Duration Curve-Feasibility Study ..... 4-7
Table 4.6 Mean Monthly Flows at Dainyor Bridge - Hunza River (1966-2015) ..... 4-9
Table 4.7 Estimated Mean Monthly and Annual Flow at Weir ..... 4-11
Table 4.8 Daily Flow Duration Curve at Weir Site ..... 4-12
Table 4.9 Water Availability and Reservoir Operation for Power Potential ..... 4-14
Table 4.10 Flood Estimation Results - Attabad Lake ..... 4-17
Table 4.11 Floods against Different Return Period - Attabad Lake Weir ..... 4-18
Table 4.12 Flood Routing Results - Attabad Lake ..... 4-24
Table 4.13 Observed Suspended Sediment at Dainyor Bridge ..... 4-25
Table 4.14 Comparative Summary of Feasibility vs. Review Study ..... 4-28
Table 5.1 Boreholes and Summary of Analysis ..... 5-10
Table 5.2 Test Pits and Summary of Analysis ..... 5-12
Table 5.3 Proposed Lugeon interpretation procedure using the flow loss vs. pressure ..... 5-14
Table 5.4 Results of Petrographic Analysis ..... 5-15
Table 5.5 Results of Rock Core Modulus Determination ..... 5-15
Table 5.6 Results of Point Load Strength Index Test ..... 5-16
Table 5.7 Results of Uniaxial Compressive Strength Test ..... 5-16
Table 5.8 Results of Hoek Triaxial Compressive Strength Test ..... 5-17
Table 5.9 Coordinates and Locations of Proposed Boreholes for Detail Design ..... 5-18
Table 8.1 Flow Duration Curve Results ..... 8-4
Table 8.2 Efficiency Coefficients of various Power Plant Components ..... 8-5
Table 8.3 Summary of Power and Energy Potential ..... 8-6
Table 9.1 Diversion channel discharge rating calculations ..... 9-6
Table 9.2 Minimum Cross Section for Surge Tank at Headrace Tunnel ..... 9-10
Table 10.1 Material parameters used for Feasibility study Slope Stability Analysis ..... 10-1
Table 11.1 Power and Energy Potential ..... 11-3
Table 11.2 Comparison of FSR (2021) and Review Report Parameters ..... 11-13
Table 11.3 Comparison of FSR (2021) and FSR (2017) Parameters ..... 11-13
Table 11.4 Summary of Hydraulic Steel Structures Mentioned in the FSR (2021) and Shortcomings Identified in the Review Remarks ..... 11-19
Table 14.1 Review of Quantity Estimates for Excavation Works ..... 14-2
Table 14.2 Comparison of Quantities for Rigid Weir and Flexible Overflow structure ..... 14-4
Table 14.3 Comparison of Quantities for Under Sluices and Flushing Tunnel ..... 14-5
Table 14.4 Comparison of Quantities for Power Tunnel ..... 14-6
Table 14.5 Comparison of Quantities for Penstock ..... 14-8
Table 14.6 Comparison of Quantities for Powerhouse ..... 14-10





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Table 14.7 Comparison of Quantities for Tailrace Channel.....14-11

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## LIST OF FIGURES


Figure1.1: Project Location Map ..... 1-2
Figure 1.2: Project Vicinity Map ..... 1-3
Figure 1.3: Project Accessibility Map ..... 1-5
Figure 1.4: Feasibility Stage Project Layout ..... 1-7
Figure 2.1: District Map of Gilgit-Baltistan ..... 2-2
Figure 2.2: Electricity Generation and Demand Comparison of Gilgit-Baltistan in Summer & Winter season ..... 2-3
Figure 2.3: District wise Summer Power Scenario in Gilgit-Baltistan ..... 2-5
Figure 2.4: District wise Winter Power Scenario in Gilgit-Baltistan ..... 2-5
Figure 2.5: District wise Overall Power Demand in Gilgit-Baltistan ..... 2-6
Figure 4.1: Watershed Boundary for Weir Site ..... 4-2
Figure 4.2: Mean Monthly Precipitation Skardu (2007-2015) ..... 4-4
Figure 4.3: Mean Monthly Max, Min and Mean Temperature Skardu (1952-2004) ..... 4-4
Figure 4.4: Mean Monthly Max, Min and Mean Temperature Gilgit (1951-2014) ..... 4-5
Figure 4.5: Flow Duration Curve - Feasibility Study 2021 ..... 4-8
Figure 4.6: Mean Monthly Flows Dainyor Bridge at Hunza River (1966-2015) ..... 4-8
Figure 4.7: Extended Mean Monthly Flows at Weir (1966-2015) ..... 4-10
Figure 4.8: Estimated Mean Annual Flows at Attabad Lake - Weir ..... 4-10
Figure 4.9: Net Daily Flow Duration Curve at Weir Site ..... 4-12
Figure 4.10: Comparison of Annual Flows (Review Study vs Feasibility Study) ..... 4-15
Figure 4.11: Comparison of Monthly Flows (Review Study vs Feasibility Study) ..... 4-15
Figure 4.12: Comparison of FDC (Review Study vs. Feasibility Study) ..... 4-16
Figure 4.13: Instantaneous Peak Flows at Attabad Lake (1966-2015) ..... 4-17
Figure 4.14: Flood Frequency at Weir - Gumble Distribution ..... 4-18
Figure 4.15: Flood Frequency at Weir - Lognormal Distribution ..... 4-19
Figure 4.16: Flood Frequency at Weir - Pearson Type 3 Distribution ..... 4-19
Figure 4.17: Flow Hydrograph of 3250 Cumecs ..... 4-20
Figure 4.18: Rating Curve of Spillway ..... 4-20
Figure 4.19: Attabad Lake Flood Routing Feasibility Study ..... 4-21
Figure 4.20: Unit Hydrograph ..... 4-21
Figure 4.21: Flow Hydrograph of 3320 Cumecs ..... 4-22
Figure 4.22: HEC HMS Model - Simulation Results ..... 4-22
Figure 4.23: Attabad Lake Flood Routing - Review Study ..... 4-23
Figure 4.24: Correlation between Suspended Sediment and Discharge - Dainyor Bridge ..... 4-26
Figure 4.25: Monthly Sus Sediment at Attabad Lake ..... 4-27
Figure 4.26: Annual Sus Sediment at Attabad Lake ..... 4-27
Figure 4.27: Comparison of Mean Monthly Flows - Hunza River at Dainyor Bridge ..... 4-29
Figure 4.28: Comparison of Mean Monthly Flows - Hunza River at Attabad Lake ..... 4-30
Figure 5.1: Simplified Geomorphological Map of Project Area ..... 5-5
Figure 5.2: Interface of RocScience DIPS Software Showing Kinematic Analysis ..... 5-7
Figure 5.3: Field Investigation Plan of Feasibility Study 2021 ..... 5-8
Figure 5.4: Proposed Borehole Locations of the Weir and Intake Area ..... 5-19
Figure 5.5: Borehole Locations between Surge Tank and Powerhouse ..... 5-20
Figure 7.1: Feasibility stage Project Layout Alternative-1A ..... 7-2





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Figure 7.2: Weir and Under Sluices layout plan from Feasibility Study ..... 7-4
Figure 7.3: Weir and Under Sluices longitudinal section from Feasibility Study ..... 7-5
Figure 7.4: Weir site view from Attabad Lake ..... 7-6
Figure 7.5: View from Just Upstream of Weir Axis ..... 7-7
Figure 7.6: Upstream View from Weir Axis, Muddy water & migrated fines on banks ..... 7-7
Figure 7.7: Excavated Spillway view from Weir Axis ..... 7-8
Figure 7.8: Right Abutment view from Left Abutment, Slide Mound of ABGM ..... 7-8
Figure 7.9: Left Abutment view on side track, Large size Boulders from slide material ..... 7-9
Figure 7.10: Left Abutment, Fresh Slide area and completely damaged walkway / path towards chute area ..... 7-9
Figure 7.11: Intake Area view from Upstream of Weir, Sound Rock Exposed ..... 7-10
Figure 7.12: Flagged Surge shaft Area, Sheared and Jointed Rock Exposed ..... 7-11
Figure 7.13: Marked Power House Area near Left Bank Hunza River, Overburden visible along the Penstock Alignment ..... 7-12
Figure 7.14: Flagged Power House Site ..... 7-12
Figure 7.15: Proposed Modified Alternative-1A layout ..... 7-15
Figure 8.1: Area Capacity Curve ..... 8-1
Figure 8.2: Mean Annual Flows ..... 8-2
Figure 8.3: Mean Monthly Flows ..... 8-2
Figure 8.4: Mean, Maximum & Minimum Daily Flows ..... 8-3
Figure 8.5: Attabad Lake Flow Duration Curve (FDC) ..... 8-3
Figure 9.1: View from Attabad Lake HPP Reservoir ..... 9-1
Figure 9.2: Weir Site Location Downstream View ..... 9-2
Figure 9.3: Weir Site Location upstream view ..... 9-2
Figure 9.4: Water Intake Location ..... 9-7
Figure 9.5: Penstock and Surge Tank Location ..... 9-9
Figure 9.6: Water Level Variation in Surge Tank ..... 9-11
Figure 9.7: Discharge Variation in Surge Tank ..... 9-13
Figure 9.8: Emergency Butterfly Valve After Surge Tank 1/2 ..... 9-13
Figure 9.9: Emergency Butterfly Valve After Surge Tank 2/2 ..... 9-13
Figure 9.10: Feasibility stage Proposed Powerhouse Location 1/2 ..... 9-15
Figure 9.11: Feasibility stage Proposed Powerhouse Location 2/2 ..... 9-16



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## LIST OF ABBREVIATIONS

| | |
|---|---|
| ACE | Associated Consulting Engineers |
| ADP | Annual Development Programme |
| ALHPP | Attabad Lake Hydropower Project |
| EPC | Engineering, Procurement, and Construction |
| FSR | Feasibility Study Report |
| GCEP | Generation Capacity Expansion Plan |
| GoGB | Government of Gilgit Baltistan |
| KKH | Karakoram Highway |
| KP | Khyber Pakhtunkhwa |
| MC | Management Consultants |
| MW | Mega Watts |
| NESPAK | National Engineering Services Pakistan |
| O&M | Operation and Maintenance |
| PES | Pakistan Engineering Services |
| RFP | Request for Proposal |
| WAPDA | Water and Power Development Authority |
| NEQS | National Environment Quality Standards |
| HSS | Hydraulic Steel Structure |
| EMMP | Environmental Management and Monitoring Plan |
| EIA | Environmental Impact Assessment |
| EDG | Emergency Diesel Generator |
| CMTL | Central Material Testing Laboratory |
| CCTV | Closed Circuit Television |
| UCS | Uniaxial Compressive Strength |
| RPM | Rotation per Minute |
| PCS | Plant Control System |
| ONAN | Oil Natural Air Natural |
| ONAF | Oil Natural Air Forced |



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# 1 INTRODUCTION

## 1.1 GENERAL

Gilgit-Baltistan of Pakistan is blessed with abundant renewable hydropower resources. More than 95% of Pakistan hydel potential is located in mountainous areas of Gilgit-Baltistan (GB), Khyber Pakhtunkhwa (KP) and Azad Jammu and Kashmir (AJK). The reconnaissance study of hydel potential for whole Gilgit-Baltistan is almost complete, and identified potential sites are still to be optimized in terms of capacity, cost and need of power for growing load centers.

Attabad Lake was created due to a massive land slide in January, 2010. In November, 2015, Prime Minister of Pakistan announced the construction of Attabad Lake Hydropower Project (ALHPP) and accordingly, Govt. of Gilgit-Baltistan undertook its Feasibility Study with proposed capacity of 32.5 MW.

Later, In August 2017, Ministry of Water and Power sought expert opinion from Chairman WAPDA on construction of ALHPP. WAPDA conducted Topographic surveys and Geotechnical Investigations for an updated study and proposed installed capacity to 54 MW with a 2320 m long headrace low pressure tunnel on the left side of Hunza River.

54 MW power generation was planned to meet the winter power demand of Hunza Valley by utilizing the peaking storage facility at existing Attabad Lake. As a result of the assessment of field investigations and engineering studies, it was concluded that the Project of 54 MW is technically, economically feasible and environmentally safe. The Project can further enhance due to available potential at the location of Hunza River once the regional and national grids are established.

The project is proposed to be implemented through Engineering, Procurement and Construction (EPC) mode for which services of Management Consultants (MC) have been acquired for the review of Feasibility Study, Procurement of EPC Contractor and Contract Management & Administration.

## 1.2 LOCATION

The most promising project layout, as assessed at Feasibility stage, was located at the Attabad Lake on the left bank of Hunza River at a distance of about 20 km from Karimabad, 120 km from Gilgit and 735 km from Islamabad.

The coordinates of the Weir and Power House site are given in the Table 1.1.

**Table 1.1 Coordinates of Weir and Power House site (From Feasibility Report)**

| | | | |
|---|---|---|---|
| Overflow Weir/Ungated Spillway | 484036.834 m E | 4018143.837 m N | 2414 m.a.s.l |
| Powerhouse | 481645.920 m E | 4017963.719 m N | 2300 m.a.s.l |

The Project is to be constructed on marginal lands owned by the community of Ahmadabad village, where minimum environmental and social issues have been anticipated.

The project location map and vicinity map are shown in Figure 1.1 & Figure 1.2 respectively.



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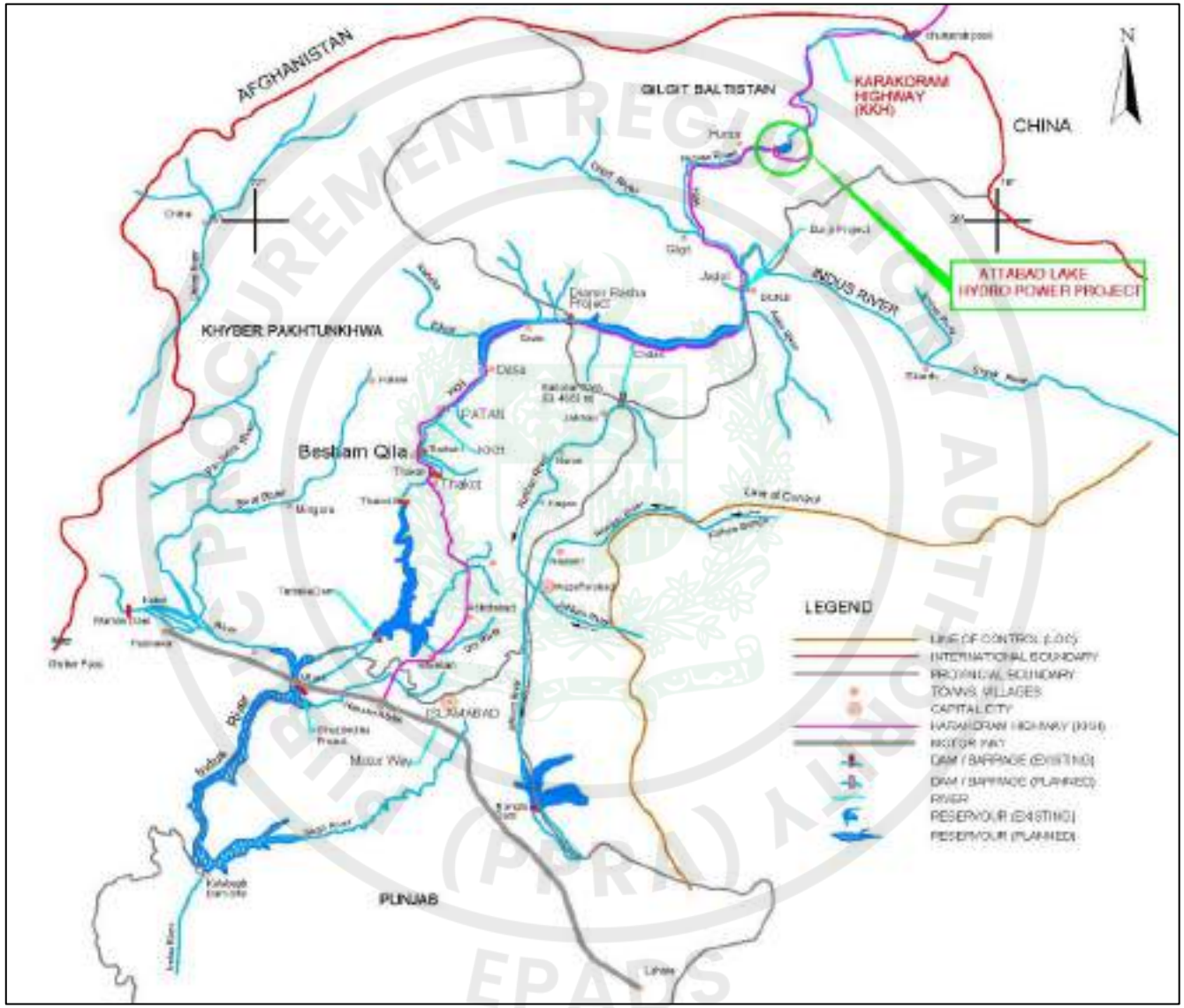


**Figure1.1: Project Location Map**



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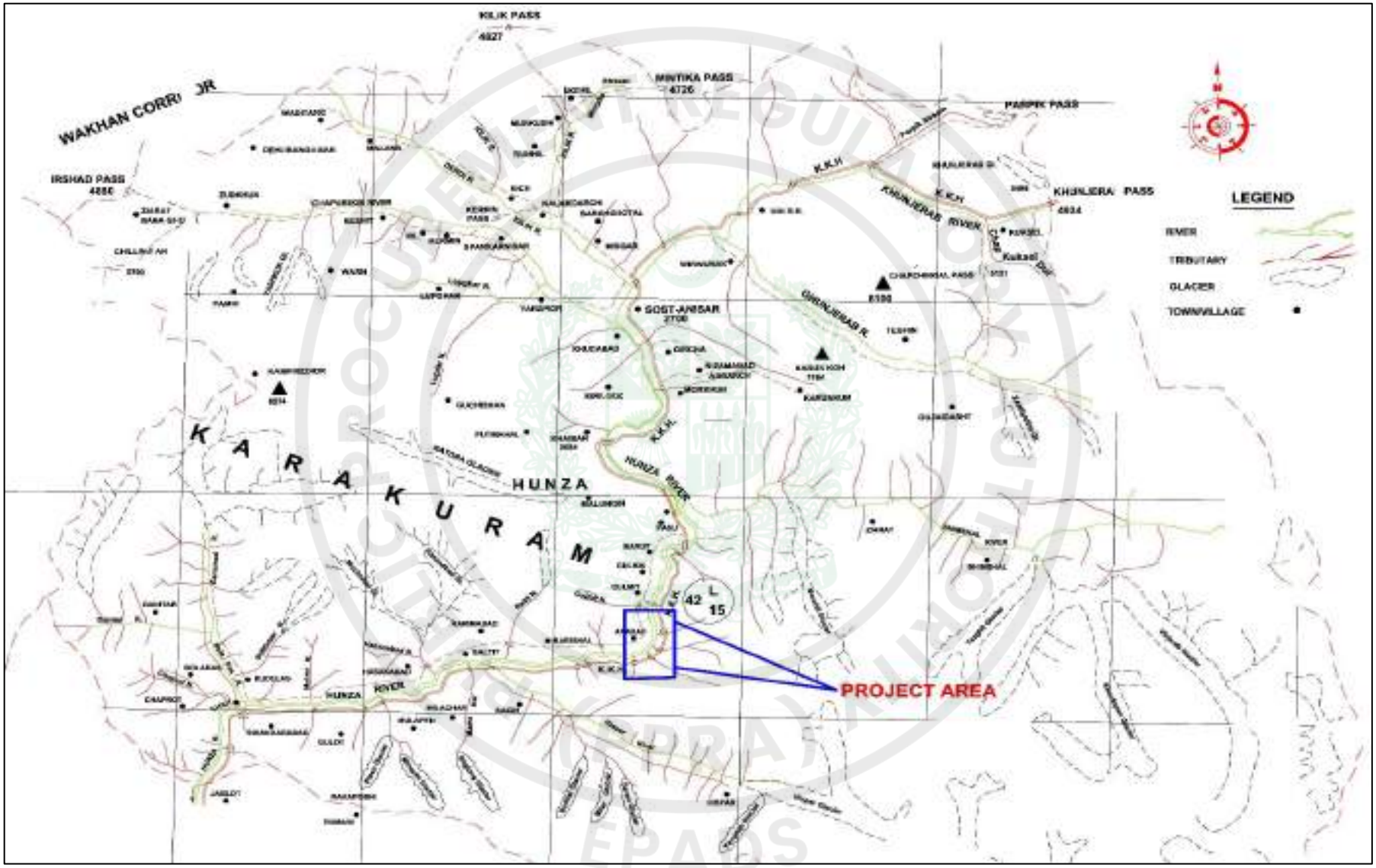


**Figure 1.2: Project Vicinity Map**



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## 1.3 ACCESSIBILITY

The Project site is accessible from Federal Capital (Islamabad) connected to Gilgit along the existing N-35 Karakoram Highway (KKH), which leads to Project Area at Attabad Lake near Hunza. The route through KKH can be accessed via Motorways from Islamabad to Burhan Interchange near Hassanabdal (M-1 Islamabad-Peshawar Motorway-44 km) and from Burhan Interchange to Thakot (M-15 Hazara Motorway – 186 km). The access onward to Gilgit and Hunza continues as a part of KKH (Thakot to Gilgit– 390 km; Gilgit to Attabad Lake/ Hunza along Hunza River – 120 km). There is another route from Islamabad to Gilgit and Hunza via Babusar Pass, through National Highway (N-15). The route, although shorter than KKH through Besham, to reach up to Chilas, usually remains closed for six months in a year due to heavy snowfall during the winter season.

Gilgit Airport is the nearest air travel facility to the Project Area which is about 120 km from the Project Site. Domestic flights are regularly scheduled from Islamabad airport to Gilgit. However, flight operations largely depend upon the weather conditions. Project accessibility map is shown in Figure 1.3.

## 1.4 CLIMATE

The Gilgit Meteorological Station is the nearest weather station to Hunza Valley that has a sound historical record covering more than five decades. Monthly temperature variations at Gilgit indicate parabolic trend, with peak in the month of July. Summer prevails in months from June to August. In July and August, mean maximum and minimum temperatures are normally above 35˚C and 15˚C respectively. The winter is cold and chilly, starting from November and continuing till end of March. The lowest temperatures are in the month of January with mean maximum and minimum temperatures reaching below 10˚C and (-) 2˚C respectively.

## 1.5 PROJECT OBJECTIVES

The major objectives of the Project are following.

a. Meet the winter power demand of Hunza valley.
b. Ensure the socio-economic uplift of the locals.
c. Boost tourism in the area by uplifting power availability in the area.
d. Address the issue of pollution by increasing power capacity of the region and reduce the usage of industrial backup diesel generators.



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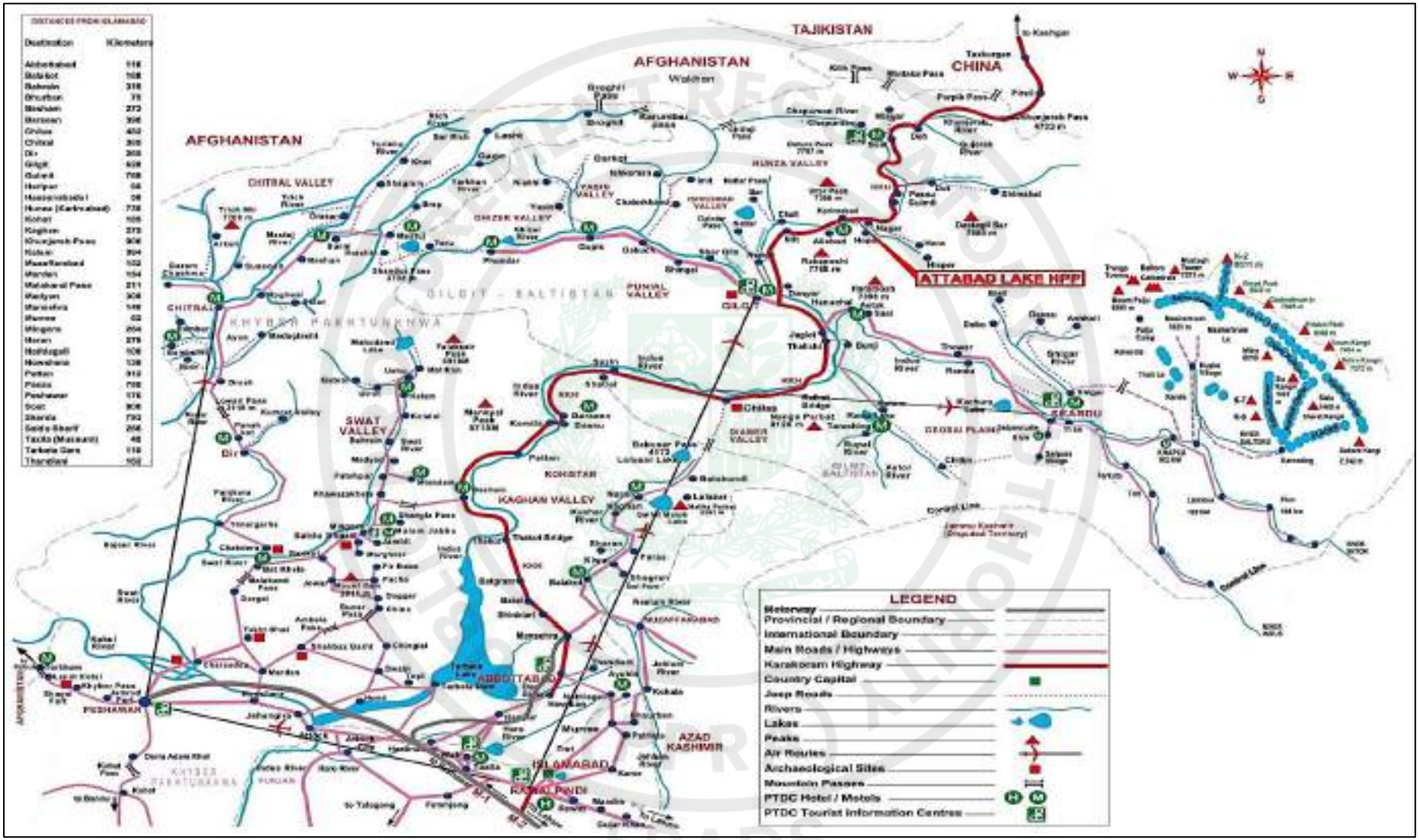


**Figure 1.3: Project Accessibility Map**



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## 1.6 PREVIOUS STUDIES

Following studies have been previously carried out on Attabad Lake Hydropower Project:

**a. Feasibility Study (conducted by local consultants, 2017)**

Water and Power Department of Govt. of Gilgit Baltistan (GoGB) intended to utilize the storage of Attabad Lake as an opportunity to develop Hydropower Project of appropriate capacity to meet the ever increasing demand of Hunza City and its suburbs. In this regards, GoGB conducted a Feasibility study through local consultant of GB, Designmen Consulting Engineers (Pvt.) Ltd, Islamabad in association with Mountain Infrastructure & Engineering Services Gilgit for the power capacity of 32.5 MW.

The left bank of the Attabad Lake was used for the layout of the project where it comprised of intake with normal head pond level 2416 m.a.s.l., 2015.62 m long power tunnel, 340m long steel penstock, surface powerhouse and 255 m long tailrace with outlet into Hunza River.

**b. Updated Feasibility Study (conducted by WAPDA, 2021)**

WAPDA prepared a Feasibility Report by utilizing in-house technical expertise. The project was sized as per flows availability, size of conveyance system and suitability of surface powerhouse according to prevailing topographic and geological features. The plant size of 54 MW was planned to provide the installed power during peak hours throughout the years. A Weir was proposed to divert the flow of Hunza River into Head Race tunnel, 2300 m long nearby Karakoram Highway, then 450m long penstock bifurcating into three high pressure pipes through a manifold will lead to Power House. A deep flushing channel/ diversion/ under sluices structure was proposed to evacuate the water from lake on the left side of existing outlet and act as flushing channel for sediments from the lake once project comes into operation.

## 1.7 PROJECT COMPONENTS FROM FEASIBILITY STUDY BY WAPDA

Attabad Lake Hydropower Project comprises of the following components and Feasibility stage project layout is shown in Figure 1.4.

1. Natural dam of 45 m height from river bed to act as diversion structure with low level outlet for flushing and an overflow ungated spillway.
2. Power Intake structure, proposed on the left bank of river to take the design discharge of 60 $m^3/s$.
3. Low pressure headrace tunnel having diameter of 5.5 m with total length of 2320 m.
4. Vertical surge shaft of 10 m diameter with height of 49 m
5. Concrete lined pressure shaft of 3.6 m diameter having a length of 80 m.
6. Steel penstock having a length of 470 m and diameter of 3.5 m.
7. Surface powerhouse with three (03) Francis units with an installed capacity of 54 MW and open switchyard.
8. Tailrace channel of 18 m length.



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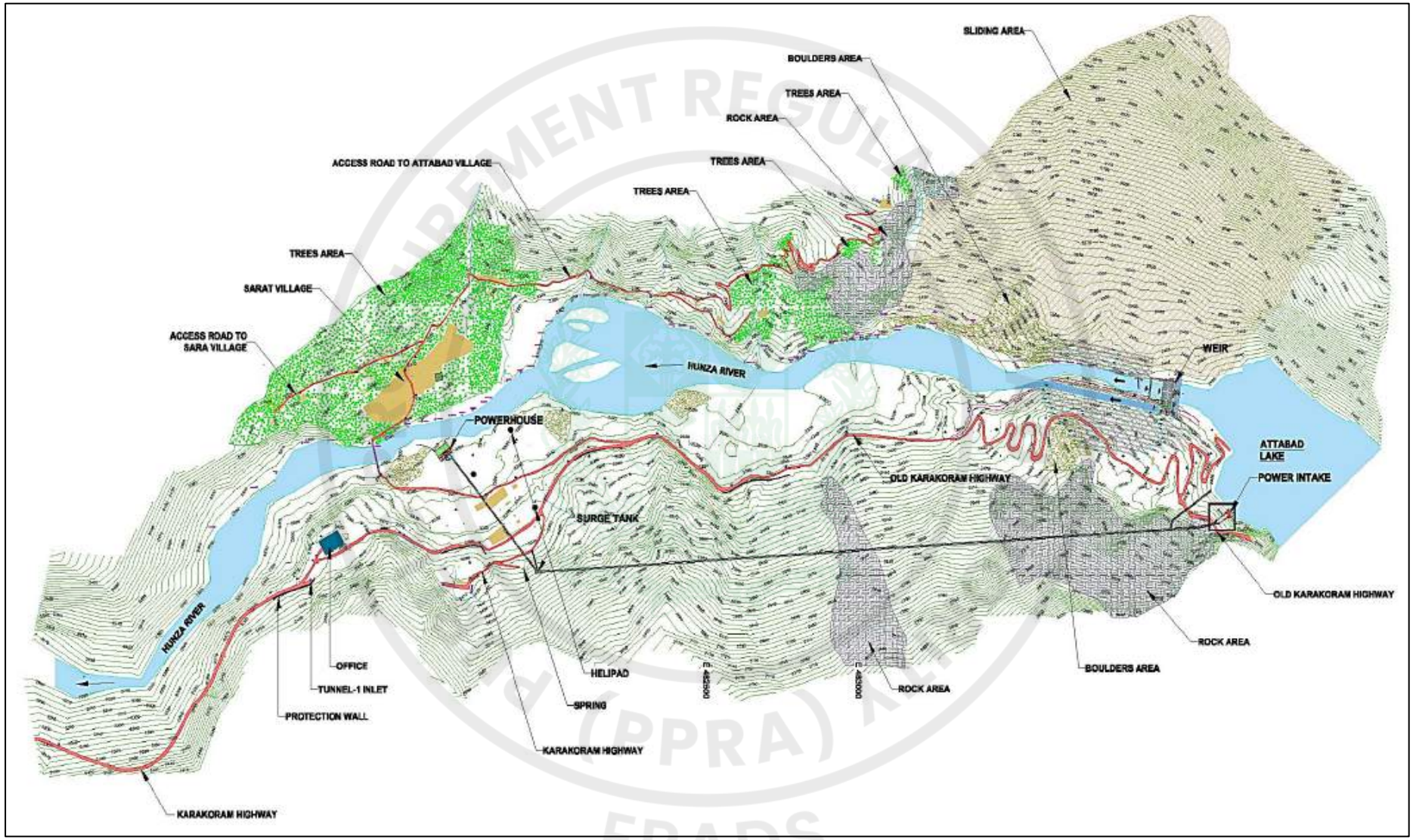


**Figure 1.4: Feasibility Stage Project Layout**



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## 1.8 SALIENT FEATURES

Salient features of the project from Feasibility study are listed in Table 1.2.

**Table 1.2 Project Salient Features (From Feasibility Report)**

| | | | |
|---|---|---|---|
| **Location** | Attabad village, Hunza District, Gilgit-Baltistan of Pakistan, 120 km west of Gilgit & 735 km north- of Islamabad | **Design Discharge**<br>**Gross head**<br>**Net head**<br>**Installed Capacity**<br>**Mean Annual Energy**<br>**Plant Factor** | 60 $m^3/s$<br>112.0 m<br>106.0 m<br>54 MW<br>373.69 GWh<br>79 % |
| **River**<br>**Catchment Area**<br>**Mean Annual Flow**<br>**Mean Annual Vol.** | Hunza<br>8901 $km^2$<br>209 $m^3/s$<br>6591 M $m^3$ | **Penstock**<br>**Length**<br>**Diameter**<br>**Thickness** | 1No.<br>470 m<br>3.5 m<br>15 mm |
| **Weir**<br>**Crest elevation**<br>**Crest length**<br>**Weir height**<br>**Design Flood**<br>**Max. Flood level**<br>**Sediment Flushing Channel**<br>**Sill level**<br>**Nos. and Gate size** | Overflow Weir/ Ungated Spillway<br>2414 m.a.s.l<br>60 m<br>30 m<br>3250 $m^3/s$ (1:10,000 returned period)<br>2421 m.a.s.l<br>Under Sluice/Diversion Channel<br>2402 m.a.s.l<br>3 & 5m x 5m | **Powerhouse**<br>**Size**<br>**Height**<br>**Type of units**<br>**No. of units**<br>**Speed**<br>**No. of Transformer** | External Slope type<br>45 m x 18 m<br>22 m<br>Francis<br>3<br>375 rpm<br>3, 22 MVA |
| **Attaabad Lake length**<br>**Lake width**<br>**Lake depth** | 14000 m<br>400 to 600 m<br>50 to 60 m | **Tailrace**<br>**Turbine level**<br>**Max. Flood level** | 18 m, concrete lined<br>2300.0 m.a.s.l<br>2307.0 m.a.s.l |
| **Tunnel length**<br>**Diameter of Tunnel**<br>**Typel** | 2320 m<br>5.5 m<br>Horse shoe | **Firm Power**<br>**Off peak winter**<br>**Peak Summer** | 26 MW<br>18 MW<br>54 MW |
| **Peaking storage**<br>**Full supply level**<br>**Minimum supply level**<br>**Gross Storage** | 5 M $m^3$<br>2414 m.a.s.l<br>2412 m.a.s.l<br>125 M $m^3$ | **Distance up to Gilgit**<br>**Voltage Level**<br>**Transmission Line**<br>**Areas to be served** | 120 km<br>132 KV<br>70 km single circuit upto Sost & 27 km double circuit upto Aliabad.<br>Hunza, Gilgit & Ghizar Region |



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## 1.9 PROJECT MANAGEMENT CONSULTANTS

Request for Proposal (RFP) for Management Consulting Services for Review of Feasibility Study, Procurement of EPC Contractor and Contract Management and Administration of Attabad Lake Hydropower Project (54 MW) was issued by Pakistan Water and Power Development Authority (WAPDA). The Contract for Consultancy Services, through competitive bidding, was awarded to the Joint Venture of National Engineering Services Pakistan (Pvt.) Ltd. (NESPAK) the lead firm, Associated Consulting Engineers (ACE.) Ltd, Pakistan Engineering Services (Pvt.) Ltd. (PES), BARQAAB Consulting Services (Pvt.) Ltd. and DOLSAR Engineering Inc. Co., as JV Partners.

The Consultancy Services Agreement was signed after pre-contract negotiations between the Pakistan Water and Power Development Authority (WAPDA). i.e. the Client, and Joint Venture Members i.e. the Consultant, on June 08, 2022, at the office of GM Projects (Northern Areas) WAPDA, Sunny view, Lahore. The effective date of the commencement of services is July 07, 2022.

## 1.10 SCOPE OF MANAGEMENT CONSULTANCY SERVICES

The detailed scope of consultancy services is listed below:

**a. Phase I (Procurement)**

1. Review of Feasibility Study Report
2. Visit the site and submit recommendations.
3. Prepare Generation Capacity Expansion Plan (GCEP)
4. Prepare EPC Tender Documents for International Competitive Bidding.
5. Prepare pre/post qualification criteria for finalization and approval from the Client. Assist the Client in pre/post qualification of bidders, replies to bidders' queries, evaluation of technical and financial bids, negotiations with successful bidder, award and finalization of the Contract Agreement.

**b. Phase II (Mobilization, Detail Engineering Design, Construction)**

1. Review the EPC Contractor's major design documents and data and verify his basis of design.
2. Monitor submission of documents against the Engineering Review Documents Schedule, review in a timely manner, the EPC Contractor's drawings, specifications, O&M manuals etc., to ensure compliance with the EPC specification.
3. Provide timely notice of events or trends to Client, which could have potential negative impacts to project and propose resolutions.
4. Be cognizant of and pro-active in reviewing the overall design of the Project for design improvements, which may result in long term benefits including cost reductions, schedule improvements and/or better operability, maintainability etc.
5. Review and comment on major purchase orders and sub-contracts.
6. Respond to any major design or equipment change requests submitted by the EPC Contractor.
7. Attend any model tests or final workshop inspections for the plant to be installed in the Project.
8. Monitor procurement and expediting activities performed by the EPC Contractor.
9. Witness In-works Performance, Commissioning and reliability tests for major items of equipment.



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10. Review the construction methods of the contractor prior to application, to avoid the use of unfair or improper methods, which could result in delays, defective works or intolerable exposure to hazards of persons or property.
11. Review the procurement, implementation, delivery and disbursement schedule.
12. Coordinate the post construction services to be carried out by the EPC Contractor during the Defect Liability Period.
13. Maintain the necessary presence until the site is cleared by the EPC Contractor.
14. Develop an effective working relationship with EPC Contractor ensuring clear and appropriate forms of communication are established and maintained through-out onsite construction, commissioning and testing phase of project.
15. Review, comment and monitor the EPC Contractor's compliance with its own procedures, for example: Construction Management Plan and Environmental Management Plan.
16. Certify the EPC contractor's requests for payment against the contract requirement.
17. Prepare an MC Project Close-Out Report containing a historical record of the project.
18. Review and comment on the EPC Contractor's Project Completion Final Report, including the As Built Documentation and O & M manuals before final acceptance.
19. Certify to client that the project works have been completed in accordance with the Contract in view of the monitoring of the construction and evaluation of the performance tests including defect liability period.
20. Review and approve Contractor's "Quality Assurance Plans" and monitor the work of the Quality Assurance units established by the Contractor.
21. Monitor / coordinate field and laboratory tests being carried out during construction.
22. Monitor the collection of samples through drilling and tests pits and testing of fill materials, rip rap, concrete aggregate, etc.
23. Coordinate and monitor the selection of prospective borrow areas and identification of processing requirements.

## 1.11 CURRENT REVIEW REPORT

After the site visit, a detailed technical review was carried out to confirm that the design study is consistent with Feasibility level engineering requirements. Consultants reviewed all the sections of the Feasibility Report of 54 MW Attabad Lake Hydropower Project. The Review Report includes some specific data, geologic maps, plans, and sections, taken from previous reports, for quick reference. Review findings are presented in each chapter with further recommendations for Detail Design by EPC Contractor.



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# 2 REVIEW OF POWER MARKET AND DEMAND FORECAST STUDIES

## 2.1 GENERAL

Electrification of the remote areas remains a critical issue for the Gilgit-Baltistan (GB) region of Pakistan, where most of the population lives without access to the national grid and mostly relies on traditional energy resources, which ignores the huge potential of renewable energy in the region. This section addresses the energy access issue of 1.8 million people of Gilgit-Baltistan (GB), of which 86% reside in the rural areas.

Gilgit-Baltistan in the North, faces severe electricity shortfalls despite having a good potential of untapped photovoltaic (PV), wind and hydro resources due to lack of proper energy policy, infrastructural development issues, and investment barriers for private sector. Sustainable access to energy is a major issue of the region, with 15 to 18 hours of daily power outages that have critically hampered the commercial activities. Across Gilgit-Baltistan, energy sources used in households and commercial enterprises are still firewood, kerosene oil, candles, dung cakes, diesel oil, batteries, liquefied petroleum gas (LPG), and coal. The current energy mix of the GB region is 45% firewood, 30% LPG, 6% kerosene oil and only 19% from (distributed hydro plants).

## 2.2 POWER GENERATION AND DEMAND COMPARISON OF GILGIT BALTISTAN

Electricity being generated by small hydropower stations with capacities ranging from 50 kW to 4000 kW. Currently, 119 hydropower stations are in operation with a total installed capacity of 148.69 MW. During winter, the supply of electricity reduces due to low water flows in rivers; however, demand remains high because of harsh weather. The seasonal shifting of the population from higher altitudes to lower valleys also affects the overall demand for energy in winter. During summer, a substantial influx of tourists is another factor in the increased energy demand across GB. However, the region is significantly affected in winter, as river flows decrease to drastic low levels. Seasonal variation in electricity generation, demand, and shortfall of the ten districts of GB are illustrated in Fig. 2.1. Gilgit region has six (06) districts namely Gilgit, Nagar, Hunza, Ghizer, Diamer (Chilas) and Astore, while Baltistan Region has four (04) Districts namely Skardu, Ghanche, Kharmang and Shiger. Gilgit is the capital of the GB region and due to trade activities, it has highest gap of 54.8MW in winter, while the total shortfall of the whole GB is about 242MW.

## 2.3 POWER DISTRIBUTION, TRANSMISSION AND NATIONAL GRID CONNECTIVITY OF GILGIT BALTISTAN

Gilgit-Baltistan has a rugged terrain that makes an extension of the national grid very costly. Therefore, GB remains electrically isolated from the country and consequently faces severe shortfalls. In near future, a mega hydro project like Diamer-Basha will enable the construction of a 765kV double-circuit transmission line to connect the region with the national grid (National Transmission & Dispatch Company, NTDCL). Though a small region of GB in south-east will be connected to national grid, interconnection of all the dispersedly populated areas through the mountainous terrain is a daunting task for provincial government. SG technologies made it favorable to share energy among distributed region with a robust centralized and distributed energy management system coupled with smart energy hubs and storages, which provide reliable, secure and resilient clean energy with minimum transmission congestions. Therefore, micro grid technologies will remain most suitable for provision of electricity to these off-grid areas. Moreover, micro grids are crucial building blocks of future national grids with in-built resilience.



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Across GB, power is generally distributed over short distances through 11kV distribution lines for domestic, commercial, and industrial usage. In only a few areas of Gilgit and Skardu, the power supply network has been augmented with 66kV transmission lines, while a majority of the GB region relies on 11kV feeders, where each feeder is independently supplied by a group of hydel and thermal power plants. This transmission and distribution system experiences tremendous operational difficulties in terms of selective tripping and load management. Faults are cleared by tripping an entire feeder because of limited switchgear deployment along the length of the feeder. Moreover, load shedding by intentional simultaneous tripping of multiple feeders is practiced throughout GB to manage severe power shortages.

District Map of Gilgit Baltistan is shown in Figure 2.1 and District wise generation and demand comparison (from a research paper) for both summer and winter season is shown in Figure 2.2.

**Figure 2.1: District Map of Gilgit-Baltistan**



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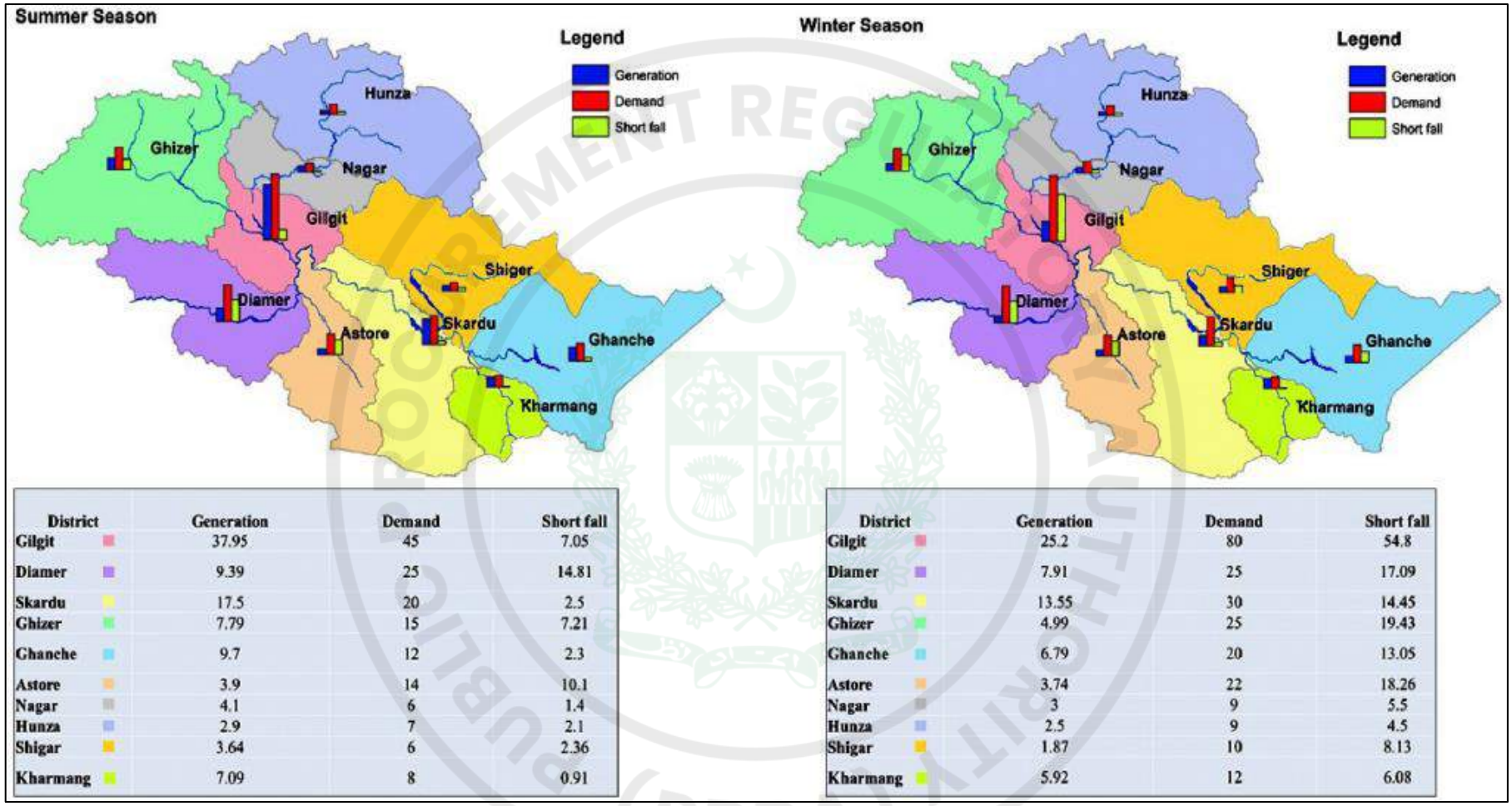


| District | Generation | Demand | Short fall |
|---|---|---|---|
| Gilgit | 37.95 | 45 | 7.05 |
| Diamer | 9.39 | 25 | 14.81 |
| Skardu | 17.5 | 20 | 2.5 |
| Ghizer | 7.79 | 15 | 7.21 |
| Ghanche | 9.7 | 12 | 2.3 |
| Astore | 3.9 | 14 | 10.1 |
| Nagar | 4.1 | 6 | 1.4 |
| Hunza | 2.9 | 7 | 2.1 |
| Shigar | 3.64 | 6 | 2.36 |
| Kharmang | 7.09 | 8 | 0.91 |

| District | Generation | Demand | Short fall |
|---|---|---|---|
| Gilgit | 25.2 | 80 | 54.8 |
| Diamer | 7.91 | 25 | 17.09 |
| Skardu | 13.55 | 30 | 14.45 |
| Ghizer | 4.99 | 25 | 19.43 |
| Ghanche | 6.79 | 20 | 13.05 |
| Astore | 3.74 | 22 | 18.26 |
| Nagar | 3 | 9 | 5.5 |
| Hunza | 2.5 | 9 | 4.5 |
| Shigar | 1.87 | 10 | 8.13 |
| Kharmang | 5.92 | 12 | 6.08 |

**Figure 2.2: Electricity Generation and Demand Comparison of Gilgit-Baltistan in Summer & Winter season**

*Source: Research paper – Techno-economic assessment & sustainability impact of hybrid energy systems, Gilgit–Baltistan, Pakistan (2021)*

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According to the statistics provided by Water & Power Division GILGIT-BALTISTAN, the power generation & demand is grouped for two seasons i.e. summer and winter. Table 2.1 shows these statistics season wise.

**Table 2.1 Current Power Scenario of Gilgit-Baltistan**

| District | Present Generation (MW) | | | | | | Present Demand (MW) | | Present Shortfall (MW) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Summer | | | Winter | | | Summer | Winter | Summer | Winter |
| | Hydel | Thermal | Total | Hydel | Thermal | Total | | | | |
| **Gilgit** | 49.00 | 0.00 | 49.00 | 25.80 | 7.80 | 33.6 | 49.89 | 94.51 | 0.89 | 60.91 |
| **Diamer** | 9.79 | 0.80 | 10.59 | 6.75 | 4.00 | 10.75 | 36.02 | 50.34 | 25.43 | 39.59 |
| **Skardu** | 20.30 | 0.00 | 20.30 | 14.20 | 2.00 | 16.20 | 50.6 | 94.47 | 30.3 | 78.27 |
| **Ghizer** | 12.50 | 0.00 | 12.50 | 8.80 | 0.58 | 9.38 | 38.88 | 71.34 | 26.38 | 61.96 |
| **Ghanche** | 8.09 | 0.00 | 8.09 | 5.00 | 0.16 | 5.16 | 25.5 | 48.52 | 17.41 | 43.36 |
| **Astore** | 4.50 | 0.00 | 4.50 | 4.00 | 0.00 | 4.00 | 14.83 | 24.53 | 10.33 | 20.53 |
| **Nagar** | 4.56 | 0.00 | 4.56 | 2.03 | 0.50 | 2.53 | 9.27 | 16.97 | 4.71 | 14.44 |
| **Hunza** | 3.91 | 0.80 | 4.71 | 2.78 | 0.80 | 3.58 | 12.83 | 20.61 | 8.12 | 17.03 |
| **Shiger** | 3.50 | 0.00 | 3.50 | 2.00 | 0.00 | 2.00 | 10.35 | 18.36 | 6.85 | 16.36 |
| **Khermang** | 4.61 | 0.00 | 4.61 | 4.07 | 0.00 | 4.07 | 6.65 | 12.54 | 2.04 | 8.47 |
| **Total** | **120.76** | **1.60** | **122.36** | **75.43** | **15.84** | **91.27** | **254.82** | **452.19** | **132.46** | **360.92** |

Power scenario is sketched out in Figure 2.3 and Figure 2.4 for the summer and winter 2020, for Gilgit Baltistan, which show that due to bulk supply of water in summer deficit between demand and generation is less than from winter power scenario.

In Figure 2.5, comparison for the power demand in Gilgit-Baltistan for the both season of summer and winter is presented.



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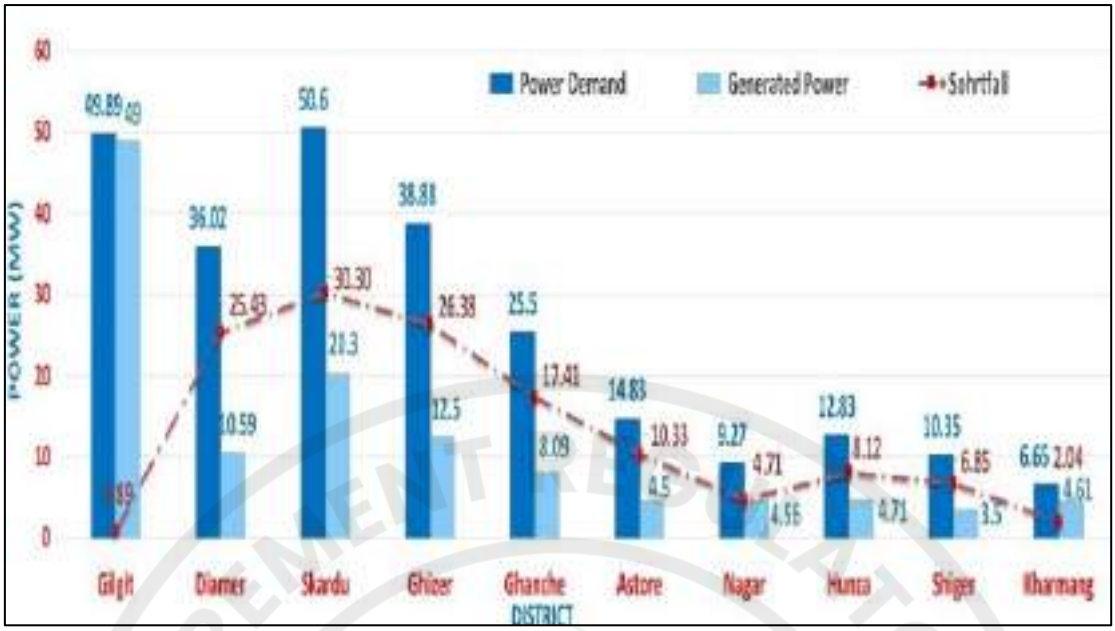


**Figure 2.3: District wise Summer Power Scenario in Gilgit-Baltistan**

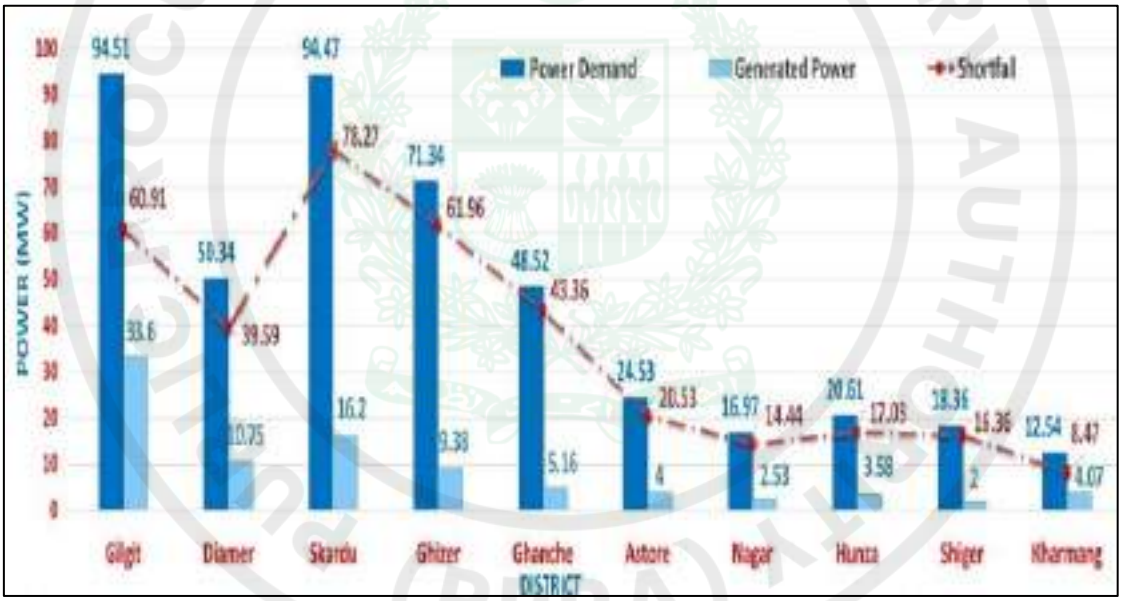


**Figure 2.4: District wise Winter Power Scenario in Gilgit-Baltistan**




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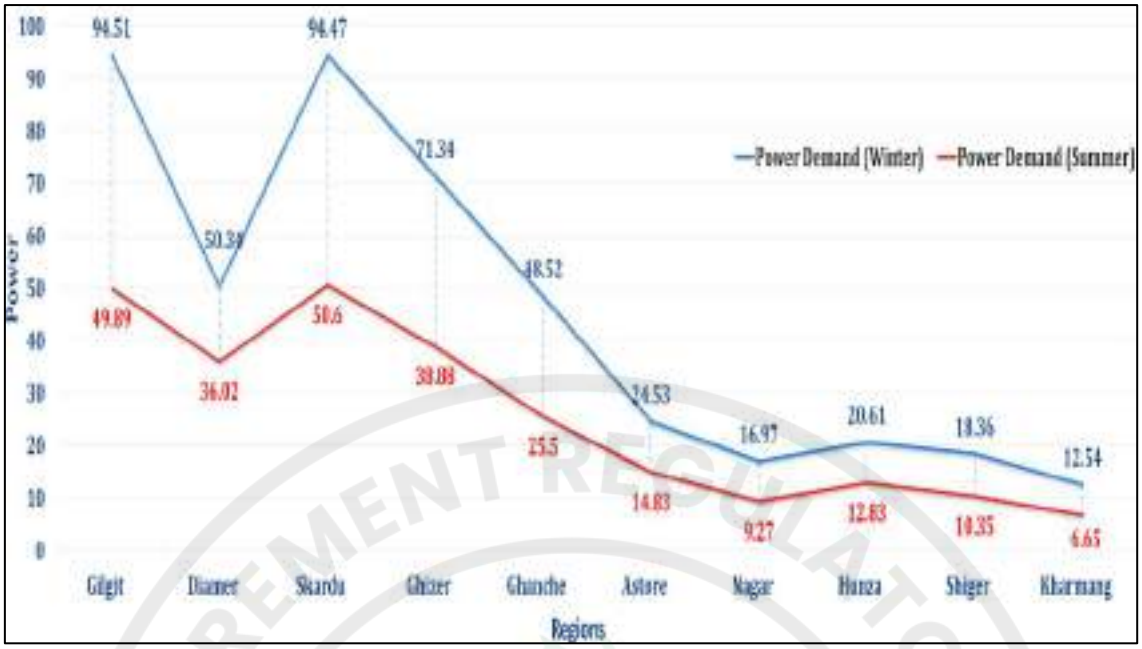


**Figure 2.5: District wise Overall Power Demand in Gilgit-Baltistan**

## 2.4 REVIEW FINDINGS AND RECOMMENDATIONS

Energy is a critical input for economic development and correspondingly power sector comprises an indispensable infrastructure in any economy. Providing adequate and affordable electric power is essential for economic development, human welfare and better living standards. The growth of the economy along with its global competitiveness hinges on the availability of reliable and quality power at competitive rates to all consumers throughout the country. Electricity is central to achieving economic, social and environmental objective.

Attabad Lake Hydropower Project is located in the Hunza District, it is worthy to discuss the current Power scenario of Hunza district in detail for understanding the imperial impact of project in the region and forecast the demand for the future. The power supply area of the proposed site covers mainly the Upper, Middle and Lower Hunza District.

Based on review of chapter presented in the Feasibility report MC validate the data and importance to construct the Attabad Lake Project as early as possible.



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# 3 REVIEW OF TOPOGRAPHIC AND HYDROGRAPHIC SURVEY

## 3.1 GENERAL

The Feasibility stage topographic survey of ALHPP was executed using terrestrial survey and mapping technique. An area of approx. 04 $km^2$ was covered with an average extent of 1 km x 4.5 km. Following instruments were used to perform the activity.

- Topcon Total Station W0303
- DGPS Trimble R8s GNSS
- Raytheon echo sounder

As part of the Topographic survey the scope was as follows:

1. Setup a Project trigonometric network with a system of Benchmarks.
2. Terrestrial survey of the area of Project components about 400 hectares at scale 1:1000 with contour interval of 2 m, covering 4 km downstream of weir site along Hunza River.
3. Longitudinal profile of Hunza River, 4 km downstream from weir site.
4. Terrestrial survey of valley cross sections along Hunza River, 4 km downstream of weir site at an interval of 200 m, covering the main river course and valley slopes upto 200 m on either side.
5. Terrestrial survey of borehole locations.
6. Satellite based survey of the Project Area.

As part of the Hydrographic survey the scope was as follows:

1. Cross-sections of the lake along range lines from left to right bank, at 250 m interval for first 3 km & 500 m interval for rest of the lake.
2. Computation of existing storage capacity of the lake.
3. Development of area-capacity curve.
4. Development of contour maps of the Lake.
5. Discharge Measurement at Ganish Bridge.

## 3.2 REVIEW FINDINGS

### 3.2.1 Establishment of the Permanent Control Benchmarks

The project's permanent reference benchmarks, BM-1 and BM-2 were established using DGPS with an achieved accuracy of 50 cm and these benchmarks are 600 m apart, as discussed in section 3.7.3. The established two (02) permanent benchmarks do not conform with the survey standards and requirements discussed in its section 3.6.3, wherein it mentions the accuracy standard of

- Horizontal 3 mm + 0.1 ppm RMS
- Vertical 3.5 mm + 0.4 ppm RMS

The established permanent benchmarks and levels observed near the structure areas require field verification.



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### 3.2.2 Observed Spot Levels

Considering the treacherous terrain and difficult access conditions, due to steep slopes, as the limiting factors, the spot levels collected during the field survey are very sparse, hence due to rigorous interpolation, the modeled topography does not depict the ground condition.

Moreover, near the Intake area, the developed contours do not match with the nearby spot levels and the difference ranges from 5 m to 10 m.

### 3.2.3 Survey of Locations of Geotechnical Investigations

In Feasibility report, refer section 3.8.6, the boreholes and test pits locations were marked at major project components prior to start of drilling work and considering the safe installation of the drilling rig the recorded ground levels were reported to be deviating up to 5 m from the NSL. The change of ground levels (Z) implies variation in the horizontal coordinates (X, Y) as well, hence requires clarity.

### 3.2.4 Satellite Based Survey of the Project Area

Satellite based various remote sensing dataset as discussed in the report, refer section 3.10, but the outputs and its application require clarity. Moreover, the calibration of remotely sensed datasets with respect to established geodetic control network is not known.

### 3.2.5 Results of Hydrographic Survey

In Feasibility report, refer section 3.12.2, describes that all the cross-sections observed during hydrographic survey are connected to the geodetic control, established for the topographic survey. Furthermore, a comparison of observed cross-sections with previous data of 2011, was made and deduced an average deposition of 30 to 40 m over 09 years. This comparison can be made if same geodetic reference is used during both survey campaigns.

## 3.3 REVIEW RECOMMENDATIONS

Considering difficult site accessibility and stated data limitations, the topographic survey data is required to be enriched by deploying modern survey and mapping techniques.



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# 4 REVIEW OF HYDROLOGY AND SEDIMENTATION STUDIES

## 4.1 GENERAL

Northern Areas of Pakistan is unique in its geographical configuration and layout which houses confluence of three major mountain ranges i.e. Hindukush, Karakorum and Himalayans and 5 out of 14 peaks above 8000 m.a.s.l. The Hindukush-Karakoram-Himalaya (HKKH) Region, often called “Water Towers of Asia,” provides natural reserves of fresh water in the form of snow and glaciers that sustain water availability in mountainous or Himalayan Areas, as well as in adjacent areas.

Hydrology and its applications are inevitable for planning and building hydraulic structures. The hydrological series that represents variations in river flow throughout the year is utilized to estimate the water availability and sediment inflow at weir/dam site for assessment of water storage, reservoir operational study, flows diversion, power and energy production from the available stream flow.

Hydrological and sediment transport studies play a pivotal role in the planning, design and execution of the hydropower projects. The important hydrological parameters required to be evaluated are the availability of flows; extreme flow events along various project components. Flood studies are needed for sizing as well as safe design of structures. Moreover, the design flows for the hydropower machinery are also decided on the basis of available flows at dam site. Sediment study defines the life of reservoir.

In Feasibility study, Daily flow data of Dainyor Bridge station at Hunza River for the period of 1966 to 2015 was used for the estimation of flows at Attabad Lake. Mean Annual Flows Varies from 127m³/s to 310m³/s. Mean annual flows estimated as 208.36m³/s. Mean Monthly flows vary from 28.34 cumecs in March to 696.45 cumecs in July. Average mean monthly flows estimated as 206.13 cumecs. Rated design discharge of 60m³/s was available for almost 50% of the time for the installed capacity of 54 MW power generations. Design flood of 3,250m³/s at weir site had been selected for the calculations of design of structures. Average annual suspended sediment estimated as 20.06MMT and bed load had been considered as 20% of the total suspended load. Total Sediment load at weir site worked out to be 24.06 M Tons. Without flushing, reservoir would be filled with sediments in 10 years.

## 4.2 WATERSHED BOUNDARY OF WEIR

The catchment area upto proposed weir site has been meausred by using GIS software. It has been estimated as 8922.9Km². Maximum Elevation of catchment area is 5237m amsl. The watershed boundary for the proposed Weir site is shown in Figure 4.1.



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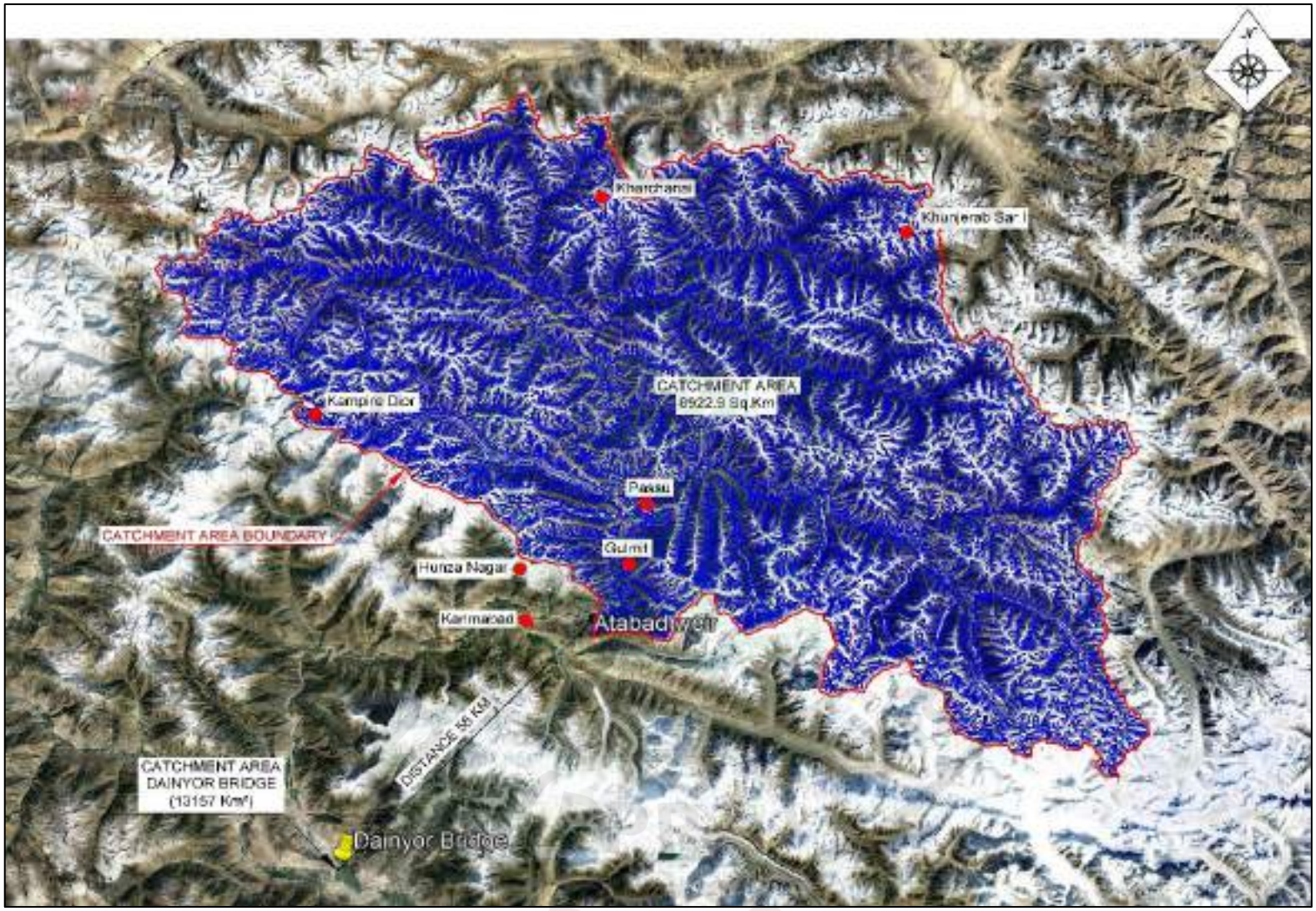


**Figure 4.1: Watershed Boundary for Weir Site**



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## 4.3 CLIMATOLOGY

Precipitation, air temperature, relative humidity and evaporation are the important climatological parameters required for understanding the climate of the region. There are number of climatic stations in the vicinity of project area, which are operated by Pakistan Meteorological Department (PMD) and Surface Water Hydrology Project (SWHP) of WAPDA. In the review of feasibility study, the climatic data of Skardu and Gilgit station is collected.

### 4.3.1 Climatological Data - Skardu

Precipitation and tempreture data at Skardu are collected from Pakistan Meteorological Department (PMD), which are summarised in Table 4.1 and presented in Figure 4.2 & Figure 4.3.

**Table 4.1 Mean Monthly Temperature & Precipitation - Skardu**

| Months | Air Temperature °C (1952-2004) | | | Precipitation (2007-2015) |
|---|---|---|---|---|
| | Mean Min Temp | Mean Max Temp | Mean Temp | (mm) |
| **Jan** | -8.08 | 2.87 | -2.44 | 32.38 |
| **Feb** | -4.79 | 5.70 | 0.45 | 63.27 |
| **Mar** | 1.51 | 12.01 | 6.72 | 41.63 |
| **Apr** | 6.53 | 18.49 | 12.53 | 31.04 |
| **May** | 9.67 | 22.86 | 16.28 | 31.59 |
| **Jun** | 13.45 | 28.36 | 20.91 | 10.68 |
| **Jul** | 16.65 | 31.61 | 24.13 | 12.63 |
| **Aug** | 16.19 | 31.12 | 23.66 | 17.18 |
| **Sep** | 11.83 | 27.24 | 19.53 | 30.76 |
| **Oct** | 4.57 | 17.91 | 12.37 | 4.10 |
| **Nov** | -1.65 | 13.00 | 5.68 | 5.88 |
| **Dec** | -5.38 | 6.31 | 0.41 | 33.90 |
| **Mean Annual Precipitation (mm)** | | | | **232.64** |



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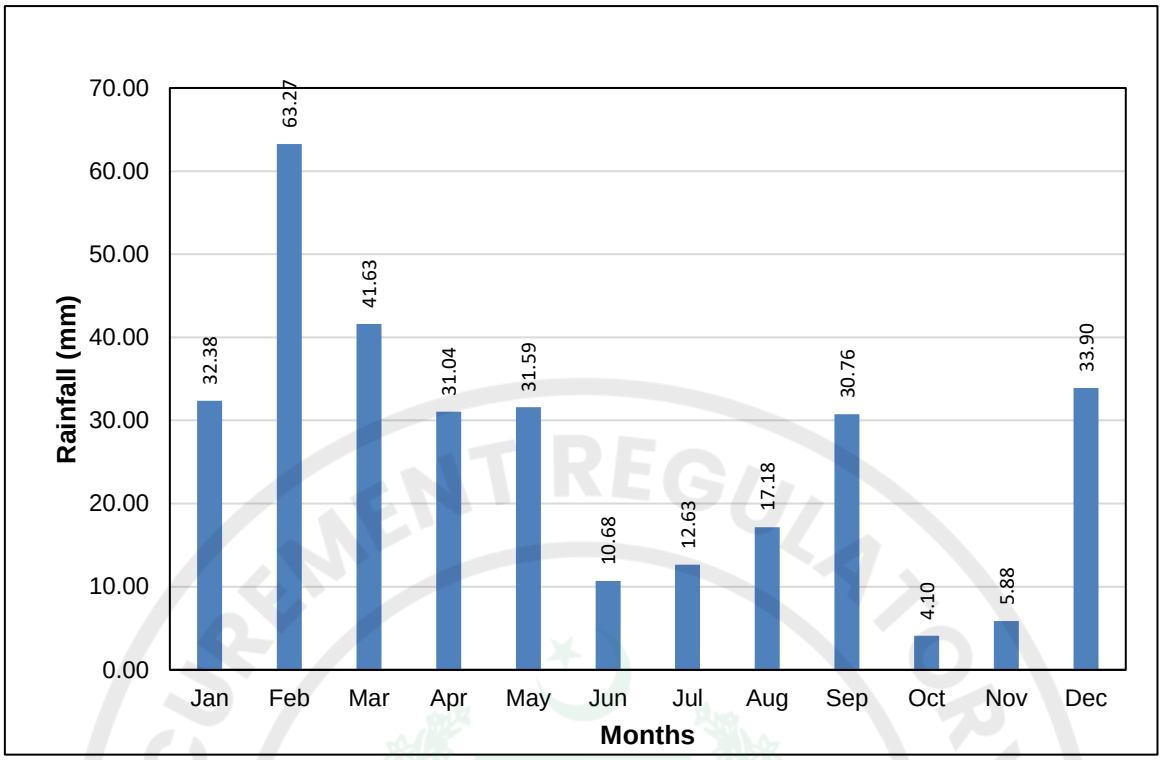


**Figure 4.2: Mean Monthly Precipitation Skardu (2007-2015)**

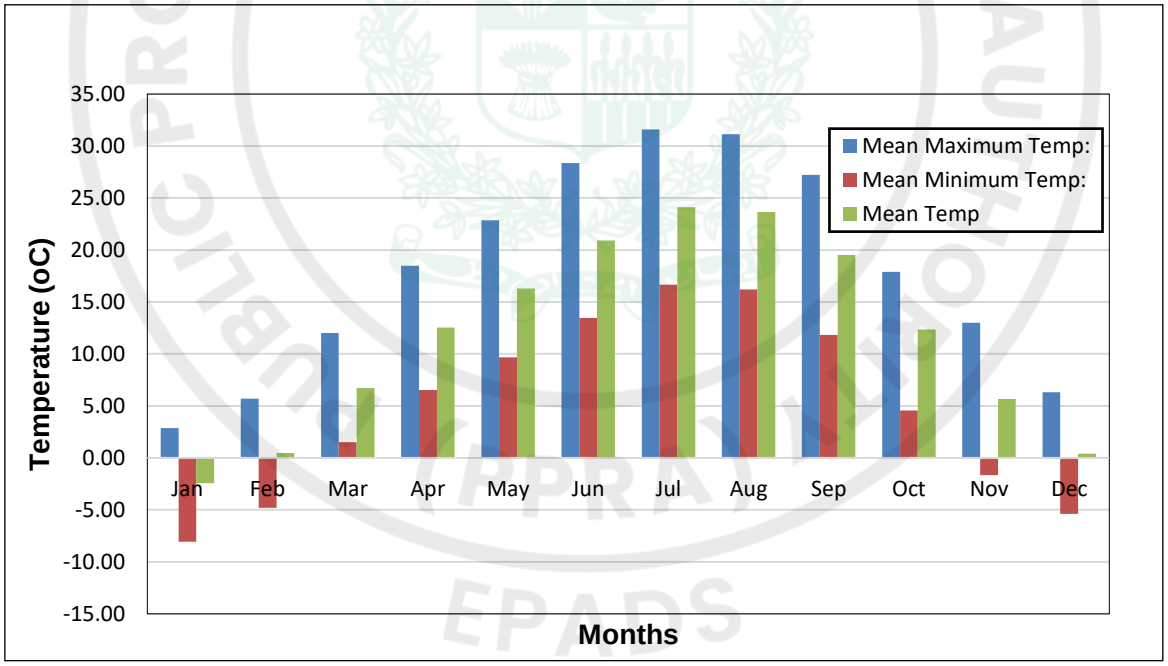


**Figure 4.3: Mean Monthly Max, Min and Mean Temperature Skardu (1952-2004)**

### 4.3.2 Climatological Data - Gilgit

Precipitation and tempreture data at Gilgit Station is collected for period of 1951-2014. Mean monthly (maximum and minimum tempretures) and precipation data are given Table 4.2 and represented in Figure 4.4.



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**Table 4.2 Mean Monthly Climatic Data at Gilgit**

| Month | Air Temperature °C (1951-2014) | | Precipitation (1951-2014) |
|---|---|---|---|
| | Max Temp (°C) | Min Temp (°C) | (mm) |
| Jan | 9.4 | 2.4 | 4.11 |
| Feb | 12.6 | 0.7 | 7.41 |
| Mar | 18.2 | 5.7 | 11.76 |
| Apr | 24.1 | 9.5 | 17.10 |
| May | 28.6 | 12.1 | 21.46 |
| Jun | 34 | 15.1 | 22.58 |
| Jul | 36.1 | 18.4 | 24.99 |
| Aug | 35.3 | 17.8 | 26.08 |
| Sep | 31.7 | 12.7 | 20.87 |
| Oct | 25.5 | 6.8 | 14.42 |
| Nov | 18.2 | 0.9 | 8.40 |
| Dec | 11.5 | -1.9 | 4.96 |
| Mean Annual Precipitation (mm) | | | 184.14 |

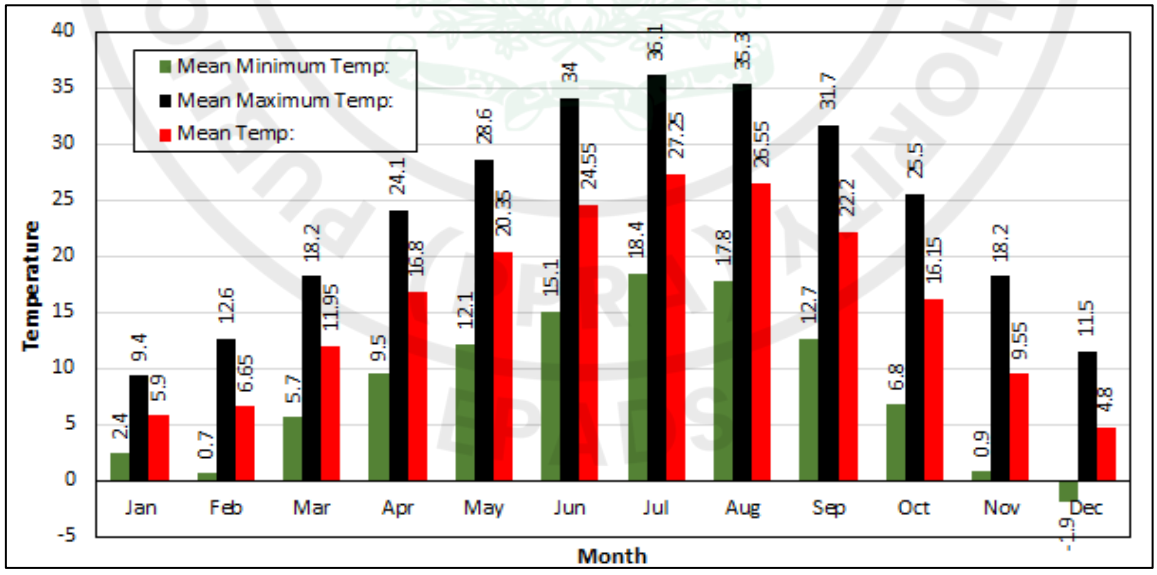


**Figure 4.4: Mean Monthly Max, Min and Mean Temperature Gilgit (1951-2014)**

## 4.4 HYDROLOGICAL STATIONS

There are a number of hydrological stations installed on main Indus River and its tributaries around project area for which flow data is available. Flow measurements have been carried out by the Surface Water Hydrology Project (SWHP) of WAPDA.




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The list of few important gauging stations surrounding the Project area is given in Table 4.3.

**Table 4.3 Availability of Data at SWHP Hydrological Stations**

| Station/River | Location | | Elev. masl | Area (km²) | Period of Available Record |
|---|---|---|---|---|---|
| | Lat. | Long. | | | |
| Kharmang/Indus | 34°56’ | 76°13’ | 2469 | 67850 | 1992 to 2007 |
| Yogo/Shyok | 35°11’ | 76°06’ | 2469 | 33670 | 1973-2014 |
| Shigar/Shigar | 35°20’ | 74°45’ | 2438 | 6610 | 1985, 1987, 1990,1992-1998, 2001 |
| Kachura/Indus | 35°27’ | 75°25’ | 2341 | 11266 | 1984 to 2007 excluding 1991 |
| **Dainyor Bridge/Hunza** | 35°55’40” | 74°22’35” | 1494 | 13157 | 1966-2015 |
| Gilgit/Gilgit | 35°55’35” | 75°18’25” | 1554 | 12095 | 1992-2007 |
| Alam Bridge/Gilgit | 35°46’03” | 74°35’50” | 2195 | 26159 | 1975, 1992-2007 |
| Partab Bridge/Indus | 35°43’50” | 74°37’20” | 1228 | 142709 | 1992-1995, 1975, 1977, 1981, 1984, 1985, 1987-1990 |

## 4.5 FLOW STUDY

Estimation of flows is an important component for design of hydraulic structures, reservoir parameters, and hydropower projects as well as for other water sector projects. Flow study is essential requirement for the estimation of water availability at Attabad Lake HPP. For this purpose, a long-term flow series are required at a site being considered for diversion of flows. Proposed project location is situated at Hunza river at upstream of Dainyor gauging station. Flows generated at Attabad Lake by using daily flows data of Dainyor Bridge at Hunza River for period of 1966-2015. The methodology adopted for developing these correlations are as follows.

### 4.5.1 Estimation of Flows - Feasibility Study 2021

Flows were estimated at proposed weir by using observed daily flows data of Dainyor Bridge at Hunza River for period of 1966-2015. That gauge was operative by SWHP, WAPDA. The catchment area of Attabad Lake estimated as 8901 $km^2$. The flows generated at weir site by using catchment ratio method. The mean monthly available flows at weir site are shown in Table 4.4.



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**Table 4.4 Monthly Flows at Weir - Attabad Lake (1966-2015)**

| Months | Mean Monthly Flows (cumecs) |
|---|---|
| Jan | 32.78 |
| Feb | 29.85 |
| Mar | 28.35 |
| Apr | 38.46 |
| May | 115.67 |
| Jun | 373.00 |
| Jul | 696.45 |
| Aug | 668.68 |
| Sep | 300.77 |
| Oct | 99.08 |
| Nov | 52.71 |
| Dec | 37.77 |
| **Average Mean Monthly** | **206.13** |

Flow duration curve was developed at the proposed weir site by using daily recorded flows of Attabad Lake for the period 1966-2015, which is presented in Table 4.5 and shown in Figure 4.5.

**Table 4.5 Flow Duration Curve - Feasibility Study**

| Time (%) | Discharge ($m^3/s$) |
|---|---|
| 10% | 613.4 |
| 20% | 376.6 |
| 30% | 205 |
| 40% | 103.3 |
| 50% | 61.3 |
| 60% | 44.3 |
| 70% | 36 |
| 80% | 30.3 |
| 90% | 26.2 |
| 99% | 20.5 |



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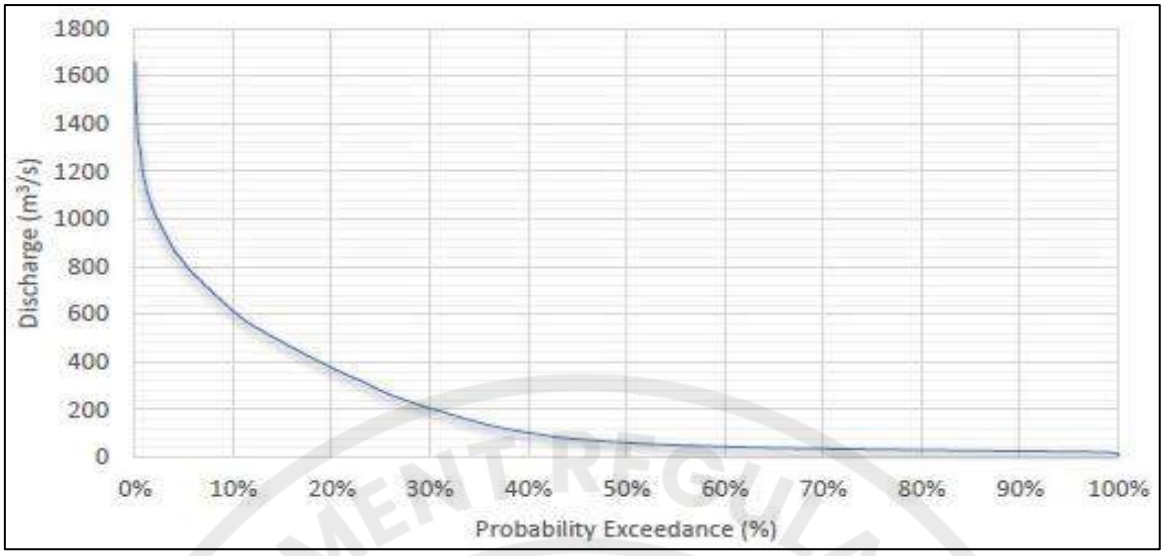


**Figure 4.5: Flow Duration Curve - Feasibility Study 2021**

### 4.5.2 Estimation of Flows - Review Study

In Present study, flows are estimated at Attabad Lake, proposed weir location by using daily flows data of Dainyor Bridge at Hunza River for period of 1966-2015. Catchment area of Dainyor Bridge at Hunza River is 13,157 km$^2$ and Attabad Lake having 8922.9 km$^2$. Flows are generated at Attabad Lake-Weir for period of 1966-2015, by using catchment area ratio (0.678) method at observed flows data of Dainyor Bridge station. Mean Monthly flows of Dainyor Station at Hunza River for period of 1966-2015 are represented in Figure 4.6 and are tabulated in Table 4.6

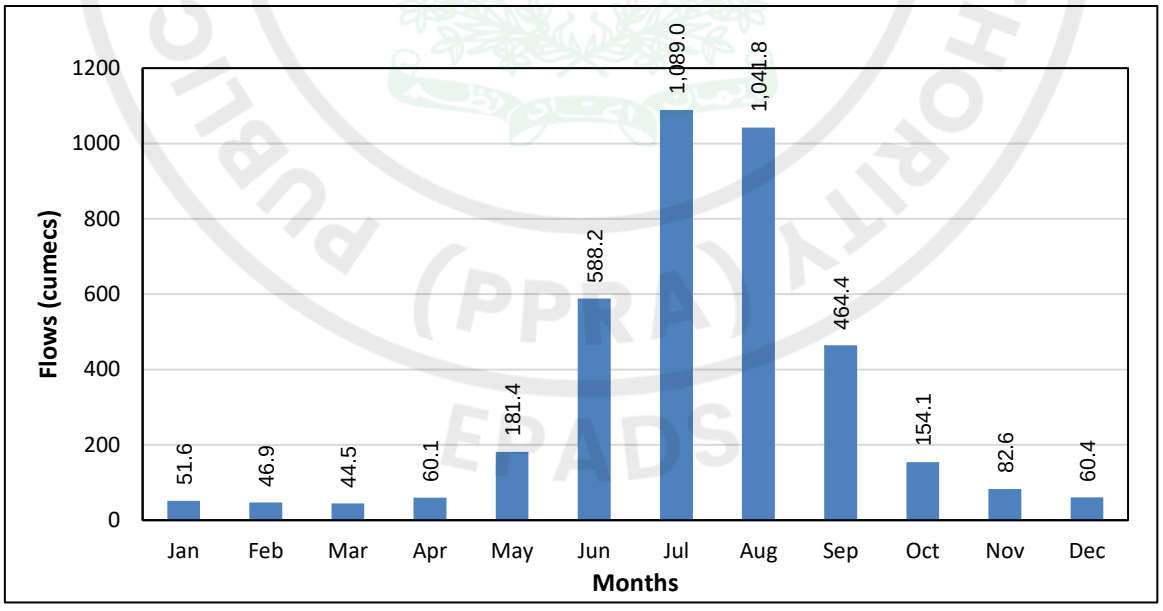


**Figure 4.6: Mean Monthly Flows Dainyor Bridge at Hunza River (1966-2015)**



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**Table 4.6: Mean Monthly Flows at Dainyor Bridge-Hunza River (1966-2015)**

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Mean Annual (cumecs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1966 | 54.4 | 49.1 | 36.3 | 48.6 | 107.6 | 774.8 | 1179.4 | 1305.7 | 623.1 | 188.5 | 75.5 | 61.5 | 373.70 |
| 1967 | 56.5 | 55.3 | 54.3 | 70.3 | 109.3 | 618.9 | 1469.0 | 1360.3 | 626.0 | 142.3 | 72.5 | 62.2 | 380.58 |
| 1968 | 42.1 | 39.3 | 36.2 | 45.6 | 125.5 | 746.9 | 1451.9 | 1519.9 | 455.4 | 135.2 | 72.1 | 58.7 | 393.91 |
| 1969 | 44.3 | 41.8 | 41.7 | 61.8 | 147.5 | 585.4 | 1443.2 | 1534.0 | 454.9 | 187.2 | 82.1 | 66.5 | 390.87 |
| 1970 | 54.0 | 46.4 | 42.7 | 77.1 | 200.8 | 759.6 | 1183.3 | 1641.4 | 893.1 | 222.8 | 76.5 | 65.0 | 428.39 |
| 1971 | 48.9 | 44.6 | 42.8 | 67.9 | 250.8 | 1266.3 | 1340.2 | 1324.4 | 473.4 | 148.9 | 78.3 | 63.3 | 428.96 |
| 1972 | 48.2 | 40.4 | 39.6 | 48.1 | 127.9 | 494.2 | 697.9 | 837.3 | 550.3 | 166.9 | 76.4 | 55.3 | 265.13 |
| 1973 | 48.1 | 42.8 | 38.9 | 68.2 | 199.0 | 1030.0 | 1798.9 | 1543.5 | 732.1 | 179.2 | 87.3 | 59.6 | 486.39 |
| 1974 | 52.1 | 48.6 | 48.5 | 60.3 | 155.6 | 448.0 | 1013.6 | 954.7 | 360.3 | 148.6 | 76.7 | 52.8 | 284.90 |
| 1975 | 45.0 | 43.3 | 40.0 | 52.4 | 139.7 | 464.4 | 940.3 | 1258.9 | 541.1 | 160.6 | 72.2 | 44.4 | 316.87 |
| 1976 | 35.2 | 35.3 | 36.6 | 45.8 | 195.5 | 485.5 | 1516.0 | 897.6 | 417.7 | 128.6 | 82.4 | 50.3 | 325.56 |
| 1977 | 45.0 | 42.4 | 39.7 | 60.4 | 168.6 | 809.8 | 1786.9 | 1287.6 | 462.8 | 161.5 | 74.3 | 46.9 | 416.23 |
| 1978 | 39.0 | 38.5 | 37.7 | 47.0 | 222.1 | 949.7 | 1889.5 | 1697.0 | 524.3 | 175.0 | 68.6 | 45.0 | 476.11 |
| 1979 | 55.5 | 49.9 | 48.1 | 60.8 | 124.3 | 617.8 | 1718.9 | 1468.5 | 439.2 | 169.1 | 86.3 | 59.7 | 410.07 |
| 1980 | 55.8 | 49.2 | 58.1 | 74.2 | 188.2 | 973.9 | 1148.7 | 954.9 | 459.4 | 170.4 | 78.2 | 57.4 | 330.54 |
| 1981 | 49.3 | 40.9 | 39.8 | 66.8 | 322.8 | 494.7 | 1236.7 | 1002.6 | 305.0 | 126.7 | 68.2 | 51.5 | 316.91 |
| 1982 | 45.5 | 42.6 | 39.5 | 61.8 | 212.6 | 479.9 | 785.9 | 1085.1 | 247.2 | 91.3 | 63.3 | 55.8 | 267.52 |
| 1983 | 51.7 | 46.6 | 37.8 | 46.4 | 200.5 | 410.8 | 888.4 | 1335.6 | 701.4 | 130.2 | 70.1 | 43.5 | 330.23 |
| 1984 | 40.8 | 37.8 | 37.4 | 43.9 | 75.6 | 623.4 | 1109.8 | 1639.6 | 425.9 | 104.2 | 73.9 | 53.3 | 347.14 |
| 1985 | 43.4 | 40.1 | 40.2 | 51.0 | 118.5 | 422.7 | 1280.4 | 1173.8 | 488.4 | 153.6 | 64.0 | 50.0 | 325.60 |
| 1986 | 42.4 | 39.3 | 37.2 | 49.8 | 126.9 | 418.9 | 1166.6 | 946.4 | 411.2 | 205.7 | 80.2 | 54.6 | 297.35 |
| 1987 | 48.7 | 41.7 | 38.1 | 44.2 | 102.7 | 355.9 | 630.9 | 821.6 | 580.0 | 164.5 | 74.3 | 62.6 | 246.94 |
| 1988 | 51.6 | 44.0 | 38.8 | 83.7 | 221.8 | 536.8 | 1248.7 | 1023.2 | 429.7 | 116.3 | 80.3 | 62.3 | 328.09 |
| 1989 | 49.5 | 43.6 | 41.2 | 44.0 | 90.0 | 389.5 | 723.0 | 688.5 | 400.2 | 153.1 | 77.6 | 60.0 | 230.02 |
| 1990 | 52.1 | 45.7 | 39.4 | 44.4 | 311.0 | 713.6 | 1147.0 | 1128.2 | 675.0 | 202.4 | 82.8 | 63.8 | 375.45 |
| 1991 | 50.9 | 46.0 | 45.7 | 53.1 | 110.4 | 454.8 | 774.6 | 855.4 | 647.4 | 116.4 | 63.5 | 54.6 | 272.74 |
| 1992 | 49.5 | 45.5 | 40.9 | 46.7 | 108.6 | 314.4 | 826.2 | 811.2 | 385.2 | 139.4 | 87.4 | 59.5 | 242.86 |
| 1993 | 44.3 | 39.8 | 35.1 | 72.1 | 146.6 | 424.7 | 788.7 | 664.2 | 422.6 | 156.4 | 81.0 | 54.4 | 244.16 |
| 1994 | 47.0 | 41.0 | 38.5 | 41.9 | 188.2 | 535.9 | 1476.7 | 1368.8 | 495.1 | 132.2 | 73.0 | 54.4 | 374.40 |
| 1995 | 45.8 | 43.0 | 37.0 | 43.8 | 151.7 | 393.1 | 1058.9 | 1014.8 | 279.8 | 105.8 | 63.3 | 50.3 | 273.95 |
| 1996 | 40.9 | 36.0 | 34.6 | 47.0 | 76.0 | 464.6 | 787.9 | 917.2 | 441.6 | 139.0 | 64.6 | 51.5 | 258.40 |
| 1997 | 49.7 | 47.1 | 41.8 | 59.4 | 107.1 | 293.7 | 655.6 | 564.9 | 303.3 | 142.3 | 71.6 | 58.2 | 199.38 |
| 1998 | 46.0 | 46.1 | 42.2 | 63.3 | 213.1 | 723.8 | 1152.7 | 813.4 | 641.4 | 168.3 | 88.2 | 63.9 | 329.45 |
| 1999 | 48.4 | 42.9 | 42.7 | 54.9 | 138.7 | 513.9 | 1021.7 | 1177.2 | 370.3 | 121.4 | 65.8 | 57.5 | 304.45 |
| 2000 | 47.6 | 38.4 | 36.2 | 57.2 | 345.0 | 568.6 | 818.9 | 768.1 | 450.9 | 118.0 | 81.3 | 51.6 | 281.81 |
| 2001 | 47.1 | 42.7 | 39.7 | 76.5 | 320.8 | 750.4 | 1310.4 | 990.1 | 382.3 | 146.6 | 70.9 | 49.7 | 362.18 |
| 2002 | 43.6 | 41.7 | 40.3 | 56.9 | 179.7 | 556.6 | 695.0 | 875.4 | 411.1 | 158.3 | 71.0 | 53.1 | 264.97 |
| 2003 | 46.8 | 41.1 | 34.8 | 66.6 | 125.3 | 579.7 | 1172.5 | 807.3 | 633.2 | 133.9 | 81.2 | 61.0 | 306.88 |
| 2004 | 76.8 | 67.7 | 63.4 | 83.4 | 251.9 | 894.7 | 643.9 | 536.4 | 226.7 | 114.1 | 100.9 | 91.7 | 245.96 |
| 2005 | 84.2 | 77.4 | 57.6 | 88.0 | 315.7 | 940.5 | 1771.6 | 758.5 | 420.2 | 153.9 | 83.4 | 73.9 | 402.13 |
| 2006 | 57.1 | 55.1 | 52.9 | 62.1 | 381.4 | 474.6 | 737.1 | 774.4 | 305.4 | 152.2 | 108.8 | 91.1 | 271.01 |
| 2007 | 77.3 | 57.3 | 53.1 | 56.6 | 311.9 | 720.4 | 629.9 | 500.2 | 288.4 | 153.0 | 85.5 | 70.9 | 250.37 |
| 2008 | 64.3 | 65.3 | 68.4 | 83.1 | 212.5 | 900.7 | 1102.6 | 966.4 | 414.9 | 126.3 | 105.0 | 78.3 | 348.23 |
| 2009 | 83.6 | 61.9 | 60.2 | 64.0 | 144.3 | 489.1 | 896.5 | 1005.5 | 433.7 | 259.7 | 160.0 | 99.7 | 309.09 |
| 2010 | 33.2 | 25.4 | 23.3 | 46.4 | 99.9 | 427.7 | 891.2 | 1238.3 | 481.6 | 170.9 | 113.4 | 68.0 | 309.86 |
| 2011 | 85.0 | 66.0 | 100.1 | 91.6 | 190.2 | 701.6 | 819.6 | 742.2 | 521.0 | 212.1 | 136.9 | 99.9 | 313.85 |
| 2012 | 69.5 | 86.5 | 63.1 | 74.3 | 180.5 | 417.1 | 887.1 | 917.3 | 553.1 | 135.2 | 83.5 | 60.2 | 293.93 |
| 2013 | 65.9 | 49.2 | 59.1 | 77.4 | 216.8 | 793.7 | 967.8 | 946.1 | 570.4 | 204.7 | 103.7 | 68.9 | 345.34 |
| 2014 | 55.4 | 51.8 | 44.6 | 50.3 | 136.2 | 366.8 | 800.8 | 818.3 | 355.4 | 163.1 | 94.8 | 64.1 | 250.12 |
| 2015 | 45.9 | 40.9 | 41.6 | 64.5 | 174.1 | 348.8 | 900.9 | 1030.1 | 306.3 | 167.2 | 104.3 | 62.1 | 273.90 |
| Mean Monthly (cumecs) | 51.6 | 46.9 | 44.5 | 60.1 | 181.4 | 588.2 | 1089.0 | 1041.8 | 464.4 | 154.1 | 82.6 | 60.4 | 322.1 |

Mean monthly flows for Dainyor bridge are minimum during March and maximum during July with values of (44.5 m³/s and 1089 m³/s) respectively. Mean annual flows are 322.1 cumecs.

- **Extended Flow Series at Weir Site**

Flows have been estimated during review studies at Attabad Lake Weir for period of 1966-2015 by using Dainyor Bridge data at Hunza River with the application of catchment area ratio method. Mean monthly maximum and minimum flows available at proposed weir site are 739.2 cumecs in July and 29.95 cumecs in March, respectively. Average mean monthly flows estimated at weir site with value of 218.48 cumecs. The mean annual flows and mean daily flows estimated as 220.07 cumecs and 219.69 cumecs, respectively. The mean monthly and mean annual flows are shown in graphically form in Figure 4.7 and Figure 4.8, respectively and in Table 4.7.



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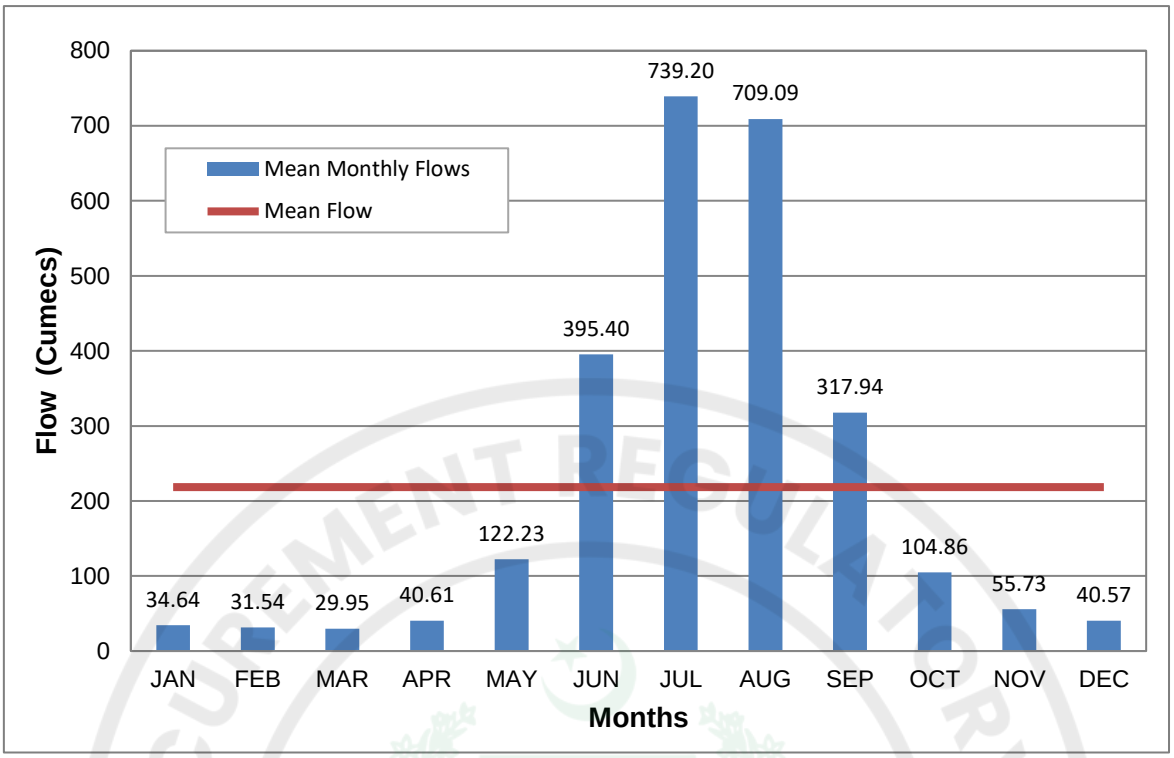


**Figure 4.7: Extended Mean Monthly Flows at Weir (1966-2015)**

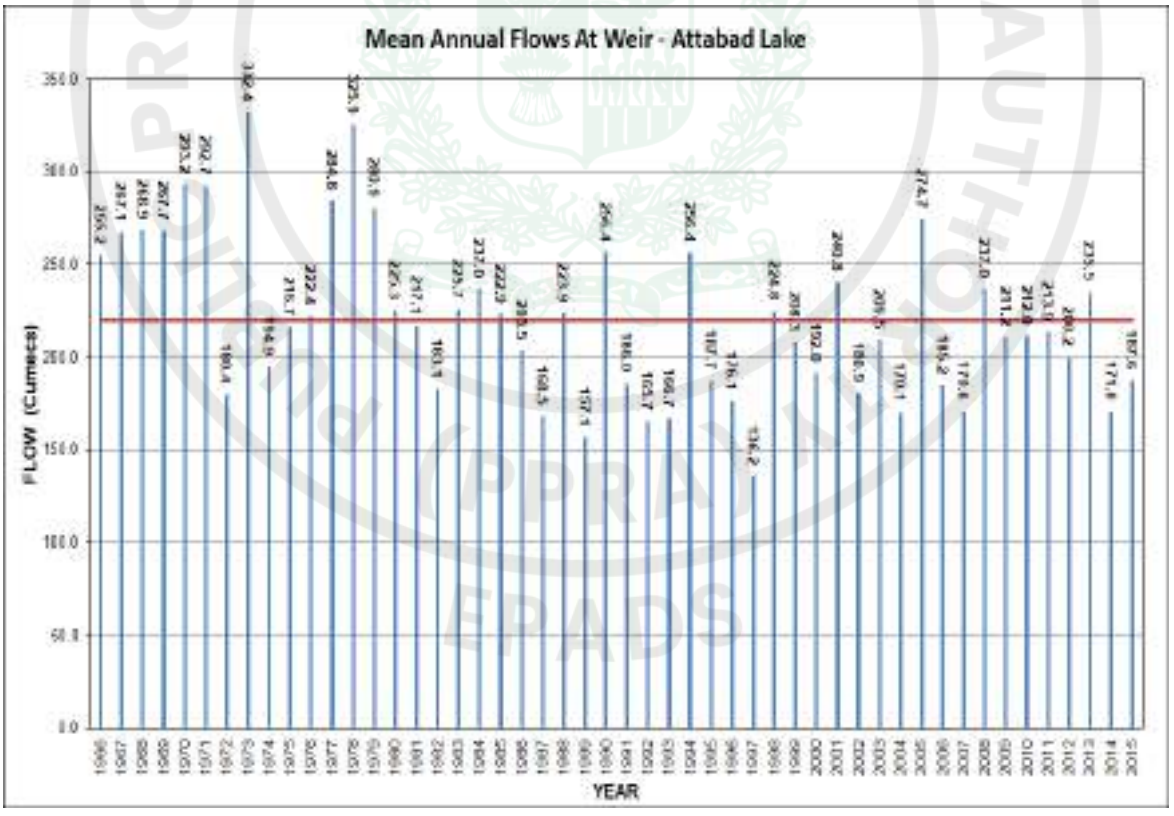


**Figure 4.8: Estimated Mean Annual Flows at Attabad Lake - Weir**



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## Table 4.7 Estimated Mean Monthly and Annual Flow at Weir

| ESTIMATED MEAN MONTHLY & ANNUAL FLOWS AT WEIR SITE (Cumecs ) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | Avg Mean Monthly | Mean Annual |
| 1966 | 36.86 | 33.28 | 24.53 | 32.94 | 72.99 | 625.45 | 799.82 | 886.49 | 422.69 | 114.27 | 51.20 | 41.73 | 253.44 | 255.20 |
| 1967 | 38.33 | 37.48 | 36.84 | 47.69 | 74.16 | 419.74 | 996.26 | 922.54 | 434.51 | 96.49 | 49.16 | 35.39 | 264.88 | 267.08 |
| 1968 | 28.56 | 26.68 | 24.55 | 30.94 | 85.14 | 506.54 | 984.67 | 1038.76 | 368.88 | 91.71 | 48.87 | 38.43 | 267.15 | 268.93 |
| 1969 | 30.02 | 28.35 | 28.29 | 41.92 | 100.06 | 397.81 | 978.79 | 1048.37 | 368.51 | 126.59 | 55.67 | 45.89 | 265.08 | 267.74 |
| 1970 | 36.64 | 31.49 | 28.97 | 52.27 | 136.18 | 515.12 | 802.48 | 1045.38 | 685.73 | 151.07 | 51.91 | 37.28 | 291.21 | 293.18 |
| 1971 | 31.83 | 30.27 | 28.87 | 46.06 | 170.11 | 858.81 | 906.91 | 888.19 | 321.09 | 100.75 | 53.13 | 42.96 | 298.92 | 301.14 |
| 1972 | 32.72 | 27.42 | 26.84 | 32.63 | 86.75 | 335.14 | 473.29 | 567.62 | 373.24 | 113.22 | 51.95 | 37.46 | 179.81 | 180.44 |
| 1973 | 32.60 | 29.06 | 26.19 | 46.26 | 134.99 | 704.66 | 1219.96 | 1048.75 | 496.49 | 121.51 | 59.19 | 40.44 | 329.86 | 332.37 |
| 1974 | 36.34 | 32.99 | 32.31 | 40.87 | 105.66 | 303.80 | 687.38 | 647.49 | 244.34 | 100.80 | 51.31 | 36.79 | 193.21 | 194.89 |
| 1975 | 30.51 | 29.39 | 27.12 | 36.63 | 94.74 | 314.97 | 637.70 | 853.78 | 366.99 | 108.56 | 48.94 | 38.14 | 214.90 | 216.68 |
| 1976 | 23.91 | 23.96 | 24.82 | 31.05 | 132.61 | 329.29 | 1028.16 | 608.71 | 283.29 | 87.22 | 42.31 | 34.14 | 220.79 | 222.49 |
| 1977 | 30.52 | 28.75 | 26.90 | 40.95 | 114.38 | 549.17 | 1211.16 | 879.98 | 313.84 | 109.53 | 50.37 | 31.81 | 282.28 | 284.54 |
| 1978 | 28.46 | 26.08 | 25.57 | 31.90 | 150.60 | 644.84 | 1267.84 | 1156.88 | 355.68 | 118.71 | 46.50 | 30.51 | 322.89 | 323.92 |
| 1979 | 37.81 | 33.83 | 32.61 | 54.80 | 84.38 | 418.96 | 1165.75 | 995.89 | 257.83 | 114.68 | 60.63 | 40.48 | 278.10 | 280.85 |
| 1980 | 37.86 | 33.39 | 38.86 | 50.33 | 127.66 | 457.86 | 779.01 | 647.43 | 311.51 | 116.66 | 53.02 | 38.96 | 231.16 | 233.36 |
| 1981 | 33.41 | 27.76 | 26.35 | 44.60 | 218.91 | 336.48 | 838.72 | 679.96 | 286.84 | 85.96 | 46.24 | 36.50 | 214.83 | 217.09 |
| 1982 | 30.84 | 28.66 | 26.78 | 41.66 | 144.16 | 325.47 | 633.01 | 736.66 | 167.62 | 61.90 | 42.90 | 37.86 | 161.43 | 163.69 |
| 1983 | 36.07 | 31.60 | 25.50 | 31.45 | 135.96 | 278.59 | 602.51 | 905.75 | 475.73 | 88.31 | 47.54 | 29.50 | 227.96 | 225.71 |
| 1984 | 27.64 | 25.71 | 25.35 | 29.74 | 51.29 | 422.80 | 762.66 | 1044.16 | 269.81 | 70.63 | 50.14 | 36.14 | 235.42 | 236.98 |
| 1985 | 29.45 | 27.21 | 27.26 | 35.21 | 80.38 | 285.67 | 854.77 | 796.04 | 331.24 | 104.20 | 43.41 | 33.54 | 229.81 | 222.92 |
| 1986 | 28.78 | 26.64 | 25.21 | 33.77 | 86.08 | 284.89 | 783.71 | 641.85 | 278.84 | 139.50 | 54.39 | 37.65 | 201.66 | 203.32 |
| 1987 | 31.69 | 28.26 | 25.87 | 29.96 | 69.67 | 341.39 | 427.88 | 557.17 | 393.33 | 111.58 | 50.39 | 42.45 | 167.47 | 168.49 |
| 1988 | 35.02 | 29.86 | 26.33 | 56.75 | 150.40 | 364.83 | 948.84 | 693.89 | 291.38 | 78.85 | 54.46 | 42.28 | 222.51 | 223.90 |
| 1989 | 33.59 | 29.52 | 27.83 | 29.82 | 61.04 | 264.16 | 400.34 | 466.96 | 271.43 | 103.85 | 52.66 | 40.70 | 156.00 | 157.86 |
| 1990 | 35.32 | 30.98 | 26.75 | 30.12 | 210.95 | 483.97 | 777.85 | 765.15 | 457.83 | 137.27 | 56.12 | 43.26 | 254.63 | 256.44 |
| 1991 | 34.51 | 31.16 | 30.89 | 36.02 | 74.68 | 308.44 | 525.34 | 590.12 | 439.07 | 78.97 | 43.03 | 37.63 | 184.97 | 186.80 |
| 1992 | 33.05 | 30.67 | 27.73 | 31.64 | 73.65 | 213.21 | 560.32 | 550.12 | 281.25 | 94.50 | 59.24 | 40.36 | 164.71 | 165.69 |
| 1993 | 30.03 | 26.96 | 23.84 | 48.91 | 89.45 | 288.91 | 534.80 | 450.44 | 286.63 | 106.07 | 54.93 | 36.10 | 165.59 | 166.68 |
| 1994 | 31.87 | 27.83 | 26.10 | 28.45 | 127.67 | 363.41 | 1001.51 | 928.29 | 335.75 | 89.63 | 49.62 | 36.91 | 253.91 | 256.42 |
| 1995 | 31.05 | 29.19 | 25.89 | 29.73 | 102.91 | 266.57 | 718.16 | 688.23 | 189.78 | 71.73 | 42.92 | 34.89 | 185.79 | 187.66 |
| 1996 | 27.72 | 24.41 | 23.45 | 31.87 | 51.54 | 315.11 | 534.34 | 622.02 | 299.42 | 94.30 | 43.81 | 34.50 | 175.24 | 176.09 |
| 1997 | 33.70 | 31.94 | 28.19 | 40.31 | 72.65 | 199.21 | 444.60 | 383.13 | 265.72 | 96.51 | 48.55 | 38.11 | 135.22 | 136.20 |
| 1998 | 31.16 | 31.24 | 28.63 | 36.14 | 144.63 | 490.30 | 781.73 | 551.63 | 367.19 | 114.81 | 59.81 | 43.33 | 223.43 | 224.84 |
| 1999 | 31.47 | 29.08 | 28.86 | 37.23 | 94.04 | 348.49 | 692.91 | 798.35 | 251.15 | 82.36 | 44.65 | 38.99 | 204.47 | 206.33 |
| 2000 | 32.31 | 26.06 | 23.52 | 38.81 | 233.94 | 386.59 | 666.36 | 620.89 | 385.88 | 80.03 | 55.18 | 36.60 | 191.12 | 193.67 |
| 2001 | 31.92 | 28.97 | 26.94 | 51.21 | 217.66 | 500.86 | 866.70 | 671.50 | 219.25 | 99.42 | 46.09 | 33.71 | 238.86 | 240.81 |
| 2002 | 29.56 | 28.29 | 27.33 | 38.57 | 119.86 | 377.49 | 471.33 | 693.65 | 278.81 | 107.28 | 48.17 | 36.63 | 179.70 | 180.88 |
| 2003 | 31.75 | 27.90 | 23.52 | 37.71 | 84.98 | 393.17 | 795.16 | 547.50 | 361.62 | 90.84 | 51.87 | 41.39 | 208.13 | 209.55 |
| 2004 | 35.22 | 32.31 | 32.84 | 49.42 | 131.79 | 296.66 | 468.34 | 490.36 | 384.61 | 96.75 | 54.85 | 41.69 | 169.42 | 170.39 |
| 2005 | 57.11 | 52.47 | 39.89 | 60.36 | 214.13 | 637.87 | 1201.45 | 514.42 | 284.98 | 104.13 | 56.59 | 50.63 | 272.72 | 274.67 |
| 2006 | 38.70 | 37.39 | 35.86 | 42.11 | 258.63 | 321.86 | 499.90 | 525.17 | 287.11 | 103.24 | 73.81 | 61.76 | 183.79 | 185.24 |
| 2007 | 52.41 | 39.85 | 36.81 | 38.40 | 211.55 | 488.55 | 427.20 | 339.22 | 155.56 | 103.75 | 57.96 | 48.11 | 169.80 | 170.80 |
| 2008 | 43.59 | 44.31 | 46.41 | 56.37 | 144.10 | 610.86 | 747.74 | 648.62 | 281.36 | 85.64 | 71.90 | 53.68 | 236.16 | 237.81 |
| 2009 | 43.17 | 41.96 | 40.62 | 43.61 | 97.84 | 318.13 | 607.99 | 661.89 | 294.18 | 176.11 | 108.61 | 61.50 | 208.62 | 211.30 |
| 2010 | 22.49 | 17.19 | 15.83 | 31.50 | 87.75 | 290.86 | 672.25 | 639.62 | 326.59 | 115.28 | 76.67 | 46.89 | 218.15 | 219.85 |
| 2011 | 57.64 | 44.79 | 57.89 | 62.11 | 129.01 | 475.80 | 555.65 | 503.35 | 353.35 | 143.05 | 92.02 | 67.76 | 212.65 | 213.87 |
| 2012 | 47.14 | 59.63 | 42.78 | 50.37 | 122.40 | 282.86 | 601.59 | 622.10 | 375.18 | 91.67 | 56.60 | 40.83 | 199.34 | 200.39 |
| 2013 | 44.71 | 33.40 | 40.89 | 52.49 | 147.05 | 538.30 | 669.97 | 641.65 | 386.86 | 138.84 | 70.34 | 46.72 | 234.20 | 235.55 |
| 2014 | 37.55 | 35.11 | 30.22 | 34.11 | 92.35 | 248.75 | 543.07 | 554.98 | 241.02 | 110.59 | 64.32 | 43.50 | 169.63 | 170.95 |
| 2015 | 31.13 | 27.71 | 28.19 | 43.75 | 118.08 | 236.58 | 610.99 | 698.59 | 267.75 | 113.39 | 70.75 | 42.14 | 185.75 | 187.39 |
| **Mean** | **34.64** | **31.54** | **29.95** | **40.61** | **122.23** | **395.40** | **739.20** | **709.09** | **317.94** | **104.86** | **55.73** | **40.57** | **218.48** | **220.08** |



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- **Daily Flow Duration Curve at Weir Site**

Daily flow duration curve for the period of 1966-2015 is developed by using daily estimated flows at proposed weir site are tabulated below in Table 4.8 and shown graphically in Figure 4.9. The flow duration curve represented the required discharge of 60 cumecs is available at 52 % of time availability.

**Table 4.8 Daily Flow Duration Curve at Weir Site**

| % of Time | Flow ($m^3/s$) | % of Time | Flow ($m^3/s$) |
|---|---|---|---|
| 1% | 1244.43 | 55% | 54.13 |
| 5% | 877.51 | 60% | 47.02 |
| 10% | 660.62 | 65% | 41.75 |
| 15% | 522.35 | 70% | 38.22 |
| 20% | 408.61 | 75% | 35.08 |
| 25% | 306.85 | 80% | 32.45 |
| 30% | 222.77 | 85% | 30.15 |
| 35% | 158.58 | 90% | 28.04 |
| 40% | 112.19 | 95% | 25.93 |
| 45% | 81.43 | 100% | 12.79 |
| 50% | 64.91 | | |

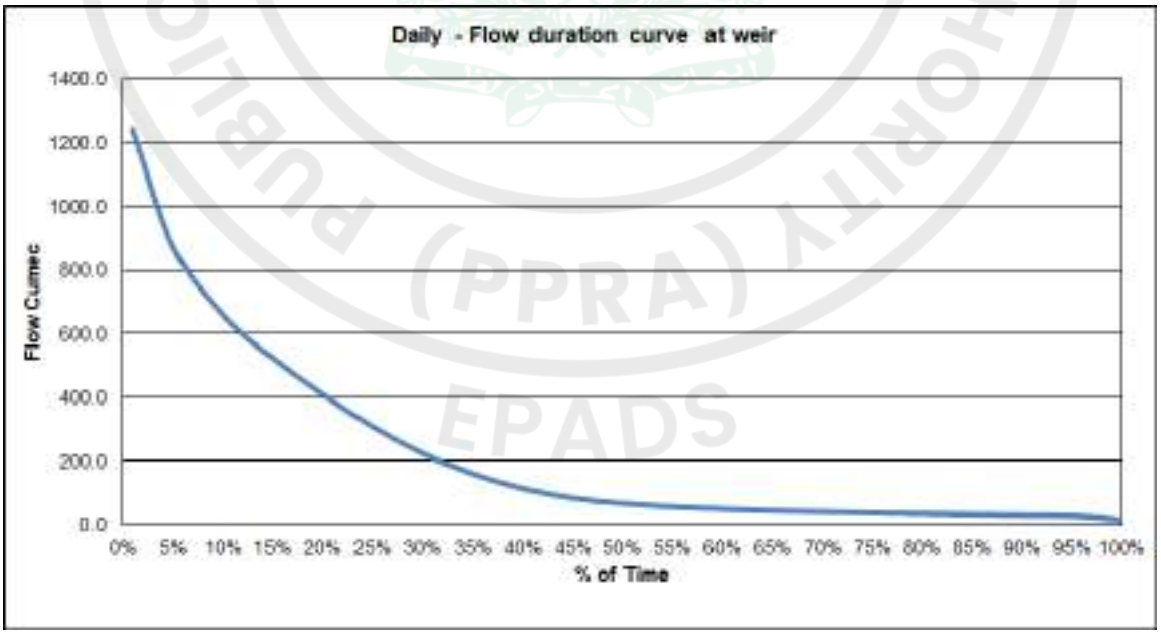


**Figure 4.9: Net Daily Flow Duration Curve at Weir Site**




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### 4.5.3 Water Availability and Reservoir Operational Study - Review Study

Mean annual water availability at weir site is 220.08 cumecs and in volume 6940 MCM. Desired design discharge is 60 cumecs for the installed capacity of 54MW. Three turbines are suggested each of 20 cumecs design discharge capacity. Weir crest elevation as suggested in feasibility study is 2414 a.m.s.l and having gross storage capacity of 147 MCM against 2414 a.m.s.l according to elevation area capacity curve (EAC). But in feasibility study, gross storage capacity of Attabad Lake is taken as 125 MCM. So, in present study consider same gross storage capacity as reported in feasibility study.

Turbines run with full desired discharge capacity of 60 cumecs from May to October. There is a shortage from November to April and these shortages will be reducing by the utilization of stored water in reservoir. It means reservoir start ponding in May and store water of 125 MCM up to gross storage level in the same month.

From May to October reservoir storage remain constant. Reservoir storage of 125 MCM will be utilize for six months from November to April according to month wise water demand for power generation. Three turbines of each 20 cumecs design discharge capacity to be suggested to fulfill the required design discharge capacity of 60 cumecs. Turbine run with full design discharge capacity at 20 cumecs availability of flow for that turbine, otherwise turbine will be functional at certain limit of low flows availability depend upon turbine design requirement. It may be 40% to 50% of Turbine design discharge as per design parameters and below this flows limit, turbine will not be functional. So, also need for consideration of minimum flow requirement to keep turbines in functional and operative position.

Invert level of Power Intake is at 2404m with storage capacity of 101.87MCM and weir crest level 2414m with storage capacity of 147MCM as per EAC. Live storage (147MCM-101.87MCM=45.13MCM) would be utilized during lean period to reduce shortages. The detail Water availability and Reservoir Operational System for power potential is tabulated below in Table 4.9.



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## Table 4.9 Water Availability and Reservoir Operation for Power Potential

| WATER AVAILIBILTY AT ATTABAD LAKE | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Months | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | Mean Annual |
| Available Flows in Cumecs | 34.64 | 31.54 | 29.56 | 40.61 | 122.23 | 385.40 | 739.20 | 709.09 | 317.94 | 104.86 | 55.73 | 40.57 | 228.08 |
| Available Flows in Volume MCM | 92.8 | 76.3 | 80.2 | 105.3 | 327.4 | 1034.9 | 1979.9 | 1899.2 | 824.1 | 280.9 | 144.5 | 108.7 | 6949 |
| SHORTAGES FOR UTILIZATION OF 60 CUMECS DESIGN DISCHARGE FOR INSTALLED CAPACITY OF 54 MW | | | | | | | | | | | | | |
| Shortages in Cumecs | 25.36 | 28.46 | 30.08 | 19.39 | | | | | | | 4.27 | 19.43 | 21.16 |
| Shortages in Volume (MCM) | 67.92 | 69.86 | 80.58 | 50.26 | | | | | | | 11.06 | 52.03 | 338.63 |
| RELEASES AFTER UTILIZATION OF 60 CUMECS DESIGN DISCHARGE FOR INSTALLED CAPACITY OF 54 MW | | | | | | | | | | | | | |
| Releases in Cumecs | | | | | 15.56 | 335.40 | 679.20 | 649.09 | 257.94 | 44.86 | | | |
| Releases in Volume (MCM) | | | | | 41.7 | 869.4 | 1819.2 | 1738.5 | 668.8 | 120.2 | | | |

MONTHLY RESERVIOR OPERATION FOR POWER POTENTIAL ON THE BASIS OF WATER AVAILIBILITY

| MONTH | Available Live Storage in MCM | Storage Utilization in MCM | Remaining Storage in Reservior MCM | No of Turbines in Operational | No of Turbines Non Operational | Remarks |
|---|---|---|---|---|---|---|
| NOV | 45.13 | 11.06 | 34.07 | 3 | 0 | Three Turbines run with full design discharge capacity |
| DEC | 34.07 | 34.07 | 0.00 | 3 | 0 | Two Turbines run with full design discharge capacity of 20 cumecs and one with low flow 13 cumecs |
| JAN | 0.00 | 0.00 | 0.00 | 2 | 1 | One Turbines run with full design discharge capacity and other with low flow of 14 cumecs |
| FEB | 0.00 | 0.00 | 0.00 | 2 | 1 | One turbine run with full design discharge of 20 cumecs and other run with low flows of 11.54 cumecs |
| MAR | 0.00 | 0.00 | 0.00 | 2 | 1 | One turbine run with full design discharge of 20 cumecs and other run with low flows of 9.95 cumecs |
| APRIL | 0.00 | 0.00 | 0.00 | 2 | 1 | Two Turbines run with full design discharge capacity of 20 cumecs |
| May | Available Reservior Storage in MCM | Reservior start Pending and fill up to Gross Sotrage in MCM | Remaining Storage in Reservior MCM | No of Turbines in Operational | No of Turbines Non Operational | |
| | 0.00 | 125.00 | 125.00 | 3 | 0 | After diverting of 60 cumecs required discharge, reservior start to be Filling and full with storage capcity of 125MCM and remaining flow of 15.56 cumecs spill |
| | Available Reservior Storage in MCM | Storage Utilization in MCM | Remaining Storage in Reservior MCM | No of Turbines in Operational | No of Turbines Non Operational | |
| JUNE | 125.00 | 0.00 | 125.00 | 3 | 0 | Three Turbines run with full design discharge capacity, flows Spill 335.4 cumecs |
| JULY | 125.00 | 0.00 | 125.00 | 3 | 0 | Three Turbines run with full design discharge capacity, flows Spill 679.2 cumecs |
| AUG | 125.00 | 0.00 | 125.00 | 3 | 0 | Three Turbines run with full design discharge capacity, flows Spill 649 cumecs |
| SEP | 125.00 | 0.00 | 125.00 | 3 | 0 | Three Turbines run with full design discharge capacity, flows Spill 257.9 cumecs |
| OCT | 125.00 | 0.00 | 125.00 | 3 | 0 | Three Turbines run with full design discharge capacity, flows Spill 44.86 cumecs |



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### 4.5.4 Comparison of Flows Study (Feasibility Study vs. Review Study)

The comparison of flows study b/w Feasibility Study 2021 and Review Study 2022 is shown graphically in Figure 4.10, Figure 4.11 and Figure 4.12.

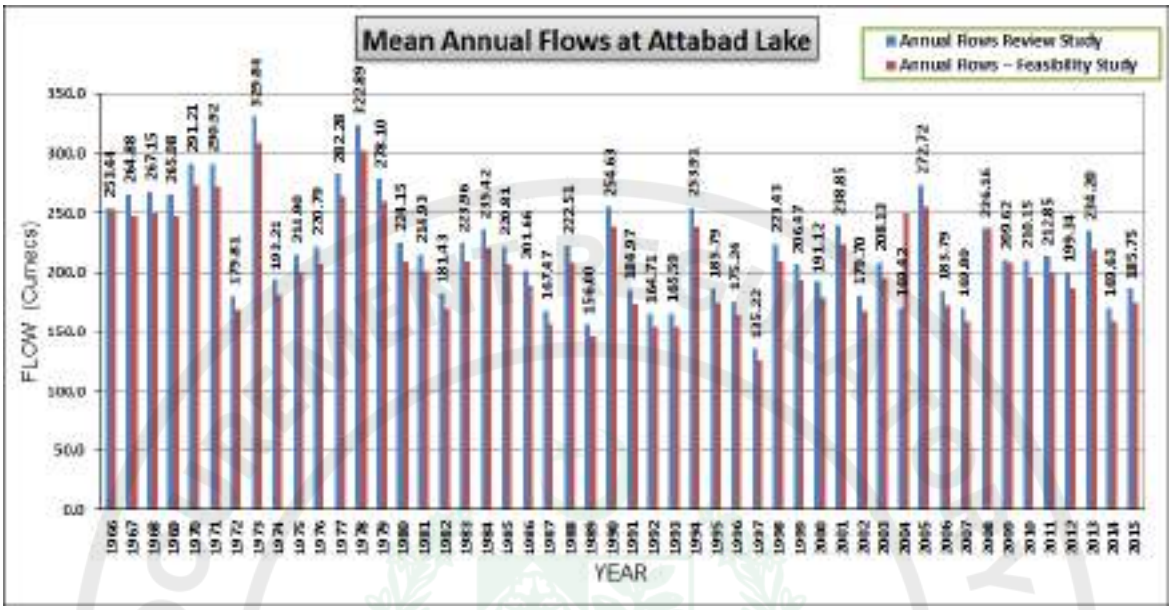


**Figure 4.10: Comparison of Annual Flows (Review Study vs Feasibility Study)**

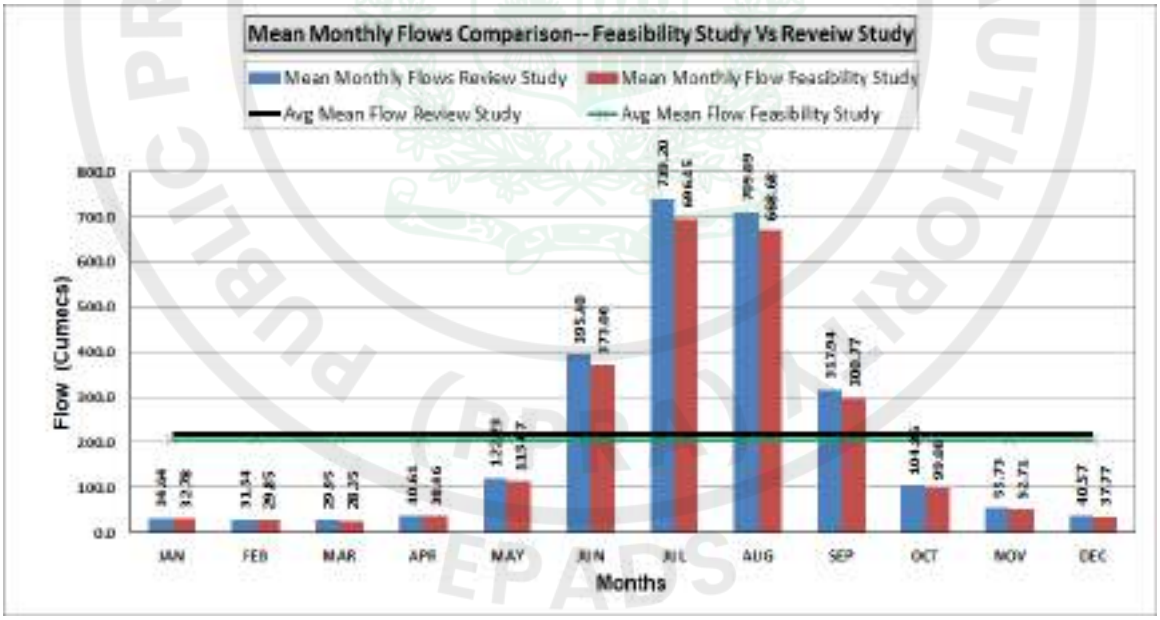


**Figure 4.11: Comparison of Monthly Flows (Review Study vs Feasibility Study)**




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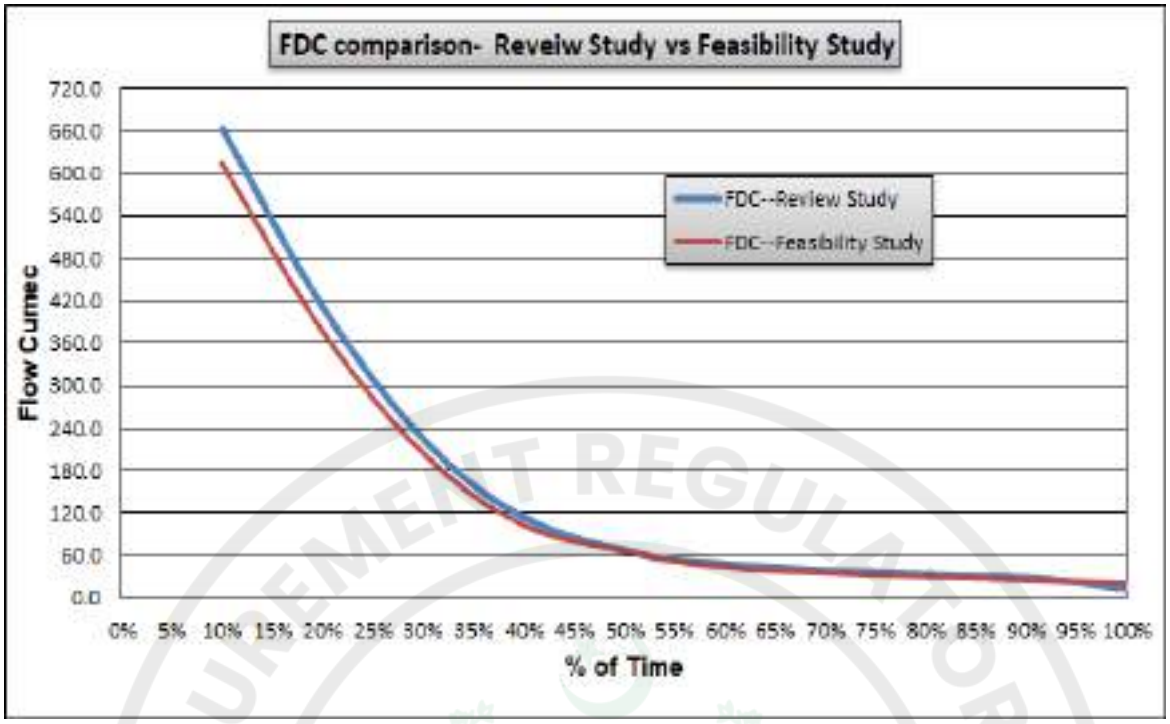


**Figure 4.12: Comparison of FDC (Review Study vs. Feasibility Study)**

## 4.6 Flood Study

Flood Frequency Analysis can be performed where maximum annual instantaneous flow values are available to estimate flood magnitudes for various return periods.

### 4.6.1 Flood Estimation - Feasibility Study 2021

In Study 2021, flood estimated by using two approaches as mentioned below.

- Flood Estimation by Flood Frequency Analysis
- Flood Estimation by USACE HEC-SSP Model

Flood Frequency Analysis (FFA) had been carried out to estimate the flood at different return periods. Three types of distribution series namely Gumble, Normal and Log Pearson Type-III Distribution series have been used to estimate the flood. Flood has also been estimated using the statistical model. The US Army Corps of Engineers (US-ACE) HEC SSP Model is used for this purpose. The results of flood estimated against different return periods at Attabad Lake by using two approaches are tabulated below in Table 4.10. It was recommended to adopt design flood of 10,000 years return period at weir site. Design flood of (3,250 m³/s) at weir site had been assumed for the calculations of design of structures.



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**Table 4.10 Flood Estimation Results - Attabad Lake**

| Flood Estimation | Flood Frequency Analysis -Results | | | HEC-SSP Model Result | |
|---|---|---|---|---|---|
| Return Period (years) | Gumble Distribution ($m^3/s$) | Normal Distribution ($m^3/s$) | Log Pearson Type-III ($m^3/s$) | Computed Flood from Curve ($m^3/s$) | Expected Probable Flood ($m^3/s$) |
| 2 | 1,142 | 1,232 | 1,155 | 1,154 | 1,154 |
| 5 | 1,411 | 1,426 | 1,428 | 1,431 | 1,436 |
| 10 | 1,589 | 1,579 | 1,596 | | |
| 20 | | | | 1,759 | 1,781 |
| 25 | 1,813 | 1,767 | 1,796 | | |
| 50 | 1,980 | 1,910 | 1,939 | | |
| 100 | 2,145 | 2,073 | 2,077 | 2,098 | 2,153 |
| 200 | | | | 2,238 | 2,314 |
| 1,000 | 2,691 | 2,520 | 2,518 | 2,559 | 2,698 |
| 10,000 | **3,237** | **2,984** | **2,915** | 3,016 | **3,292** |

### 4.6.2 Flood Estimation - Review Study

Flood has been estimated from the available record. The maximum peak daily discharges of Dainyor Bridge station at Hunza Rivers for every year recorded. The instantaneous peaks will definitely be higher than the measured daily flows. Instantaneous peak flows of Dainyor Bridge station for the period 1966 to 2015 have been calculated and generated one day maximum peak Instantaneous flow for every year at proposed weir site. The estimated instantaneous peak flow for the period of 1966-2015 at Attabad Lake is graphically represented in Figure 4.13.

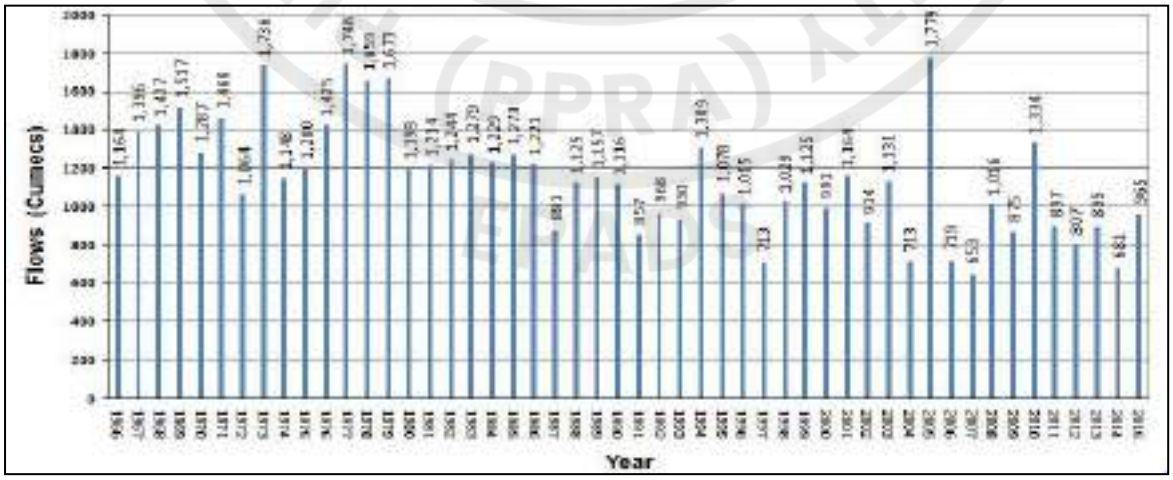


**Figure 4.13: Instantaneous Peak Flows at Attabad Lake (1966-2015)**



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- **Flood Estimation at Attabad Lake - Weir**

Flood has been estimated at propose weir site by using Peak Instantaneous flows of Attabad Lake for period of 1966-2015. Flood Frequency Analysis (FFA) has been carried out by using different distribution (Gumble, Lognormal & Pearson type 3). Flood frequency results against different return periods are tabulated and represented below in Table 4.11 and Figure 4.14 through Figure 4.16.

**Table 4.11 Floods against Different Return Period - Attabad Lake Weir**

| Flood Estimation at Weir by Flood Frequency Analysis | | | |
|---|---|---|---|
| **Return Period (years)** | **Gumbel (cumecs)** | **Lognormal (cumecs)** | **Log-Pearson type 3 (cumecs)** |
| **10000** | **3320** | **2840** | **2580** |
| 2000 | 2910 | 2550 | 2370 |
| 1000 | 2740 | 2420 | 2270 |
| 500 | 2570 | 2300 | 2170 |
| 200 | 2340 | 2130 | 2040 |
| 100 | 2160 | 2000 | 1930 |
| 50 | 1990 | 1870 | 1820 |
| 20 | 1750 | 1680 | 1660 |
| 10 | 1570 | 1540 | 1520 |

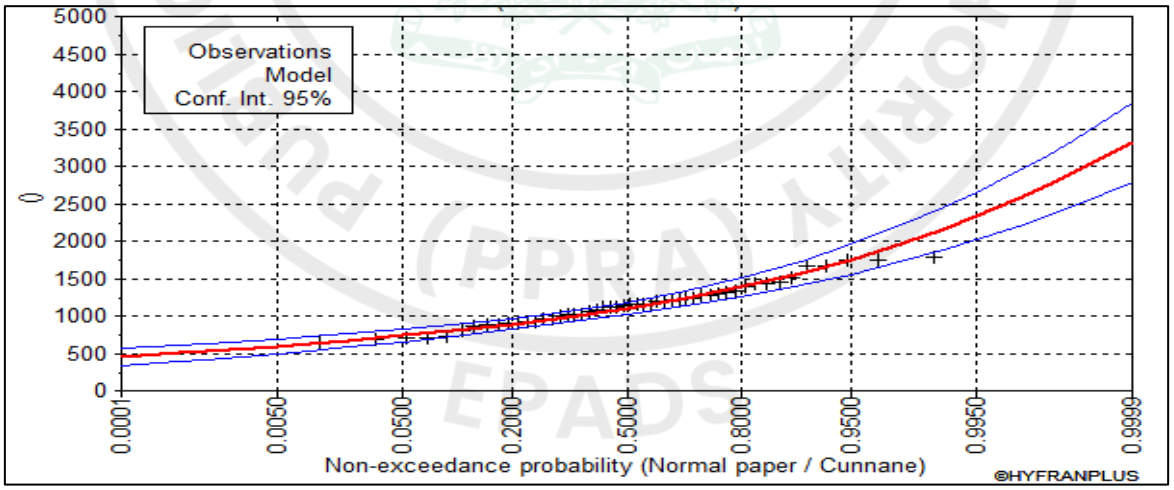


**Figure 4.14: Flood Frequency at Weir - Gumble Distribution**




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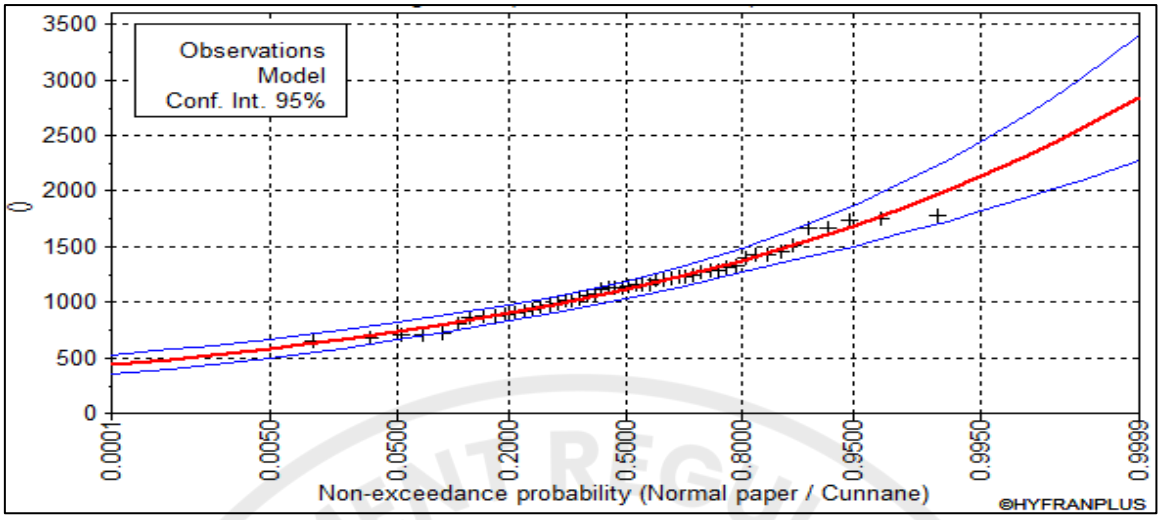


**Figure 4.15: Flood Frequency at Weir - Lognormal Distribution**

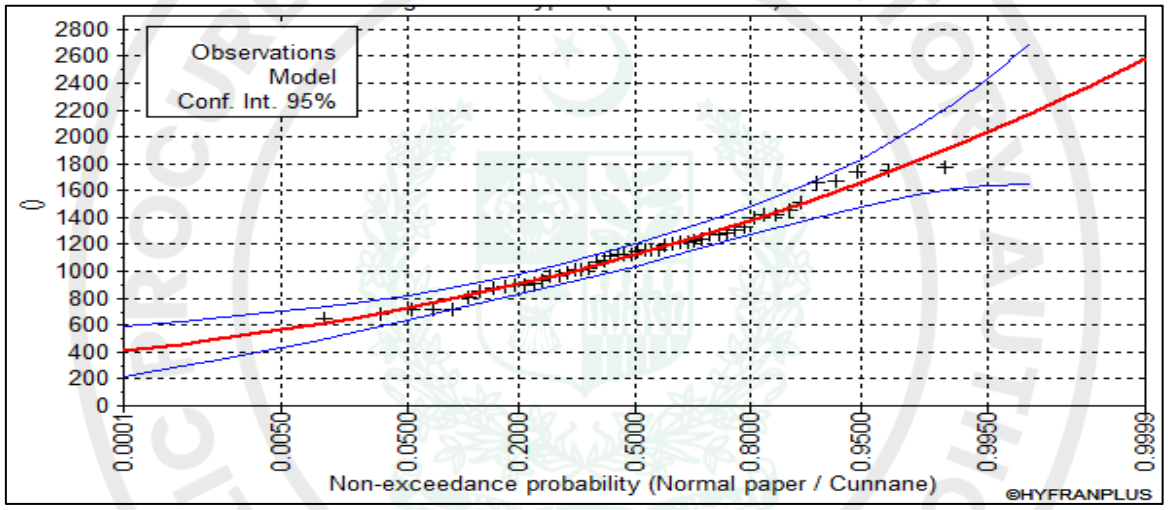


**Figure 4.16: Flood Frequency at Weir - Pearson Type 3 Distribution**

- **Recommended Design Flood**

Keeping in view the flood estimation against returns periods by using different distributions, it is recommended to adopt Gumble Distribution against 10,000 years of return period for the selection of design flood at proposed weir site.

***Finally, Design Flood of 3320 m³/s at weir site has been selected for the design of hydraulic structures.***

## 4.7 HYDROLOGICAL FLOOD ROUTING

Flood routing is a mathematical procedure for predicting the changing magnitude, speed, and shape of a flood wave as a function of time (i.e., the flow hydrograph) at one or more points along a waterway. Although, the lake has not much storage capacity but still it can lag and attenuate the peak generated by floods to minimize the adverse impacts on the downstream structures and areas. The temporarily stored water is then released through an outlet or spillway after the peak has passed.



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### 4.7.1 Flood Routing - Feasibility Study 2021

To setup the HEC-HMS model, Storage-Discharge relationship had been developed for the reservoir. The hydrograph with the peak of 3,250 m³/s had entered in the lake as inflow and attenuated peak of 3,085 m³/s was attained after 4 hours of the inflow peak. The attenuated peak was attained at an elevation of 2421.3 masl. The inflow hydrograph of 3,250 m³/s , the rating curve of overflow spillway and flood routing of Attabad Lake are presented in Figure 4.17, Figure 4.18 and Figure 4.19.

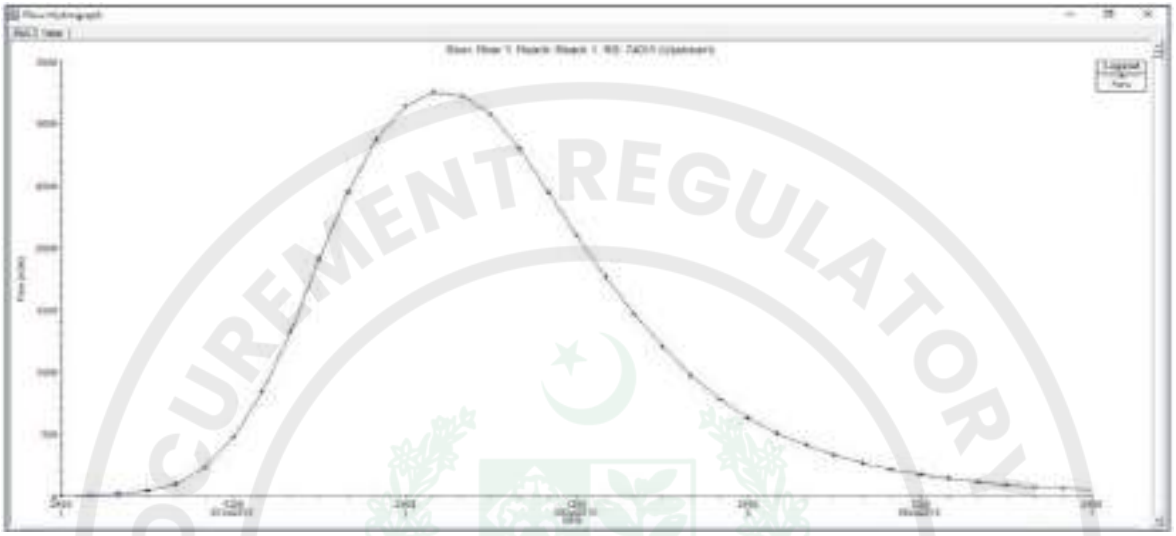

**Figure 4.17: Flow Hydrograph of 3250 Cumecs**

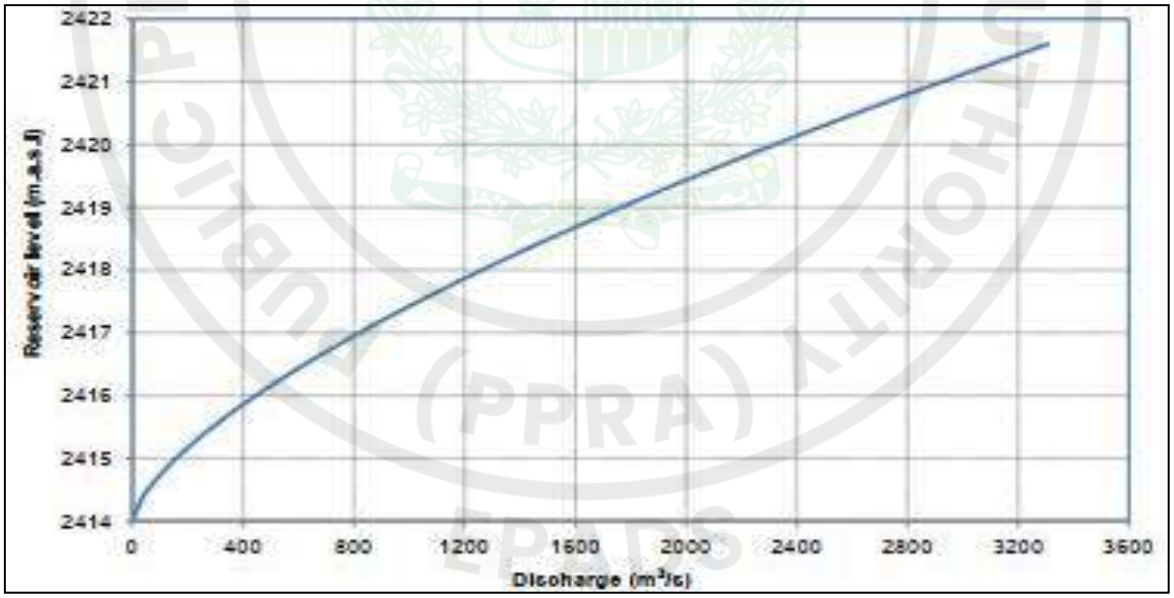


**Figure 4.18: Rating Curve of Spillway**



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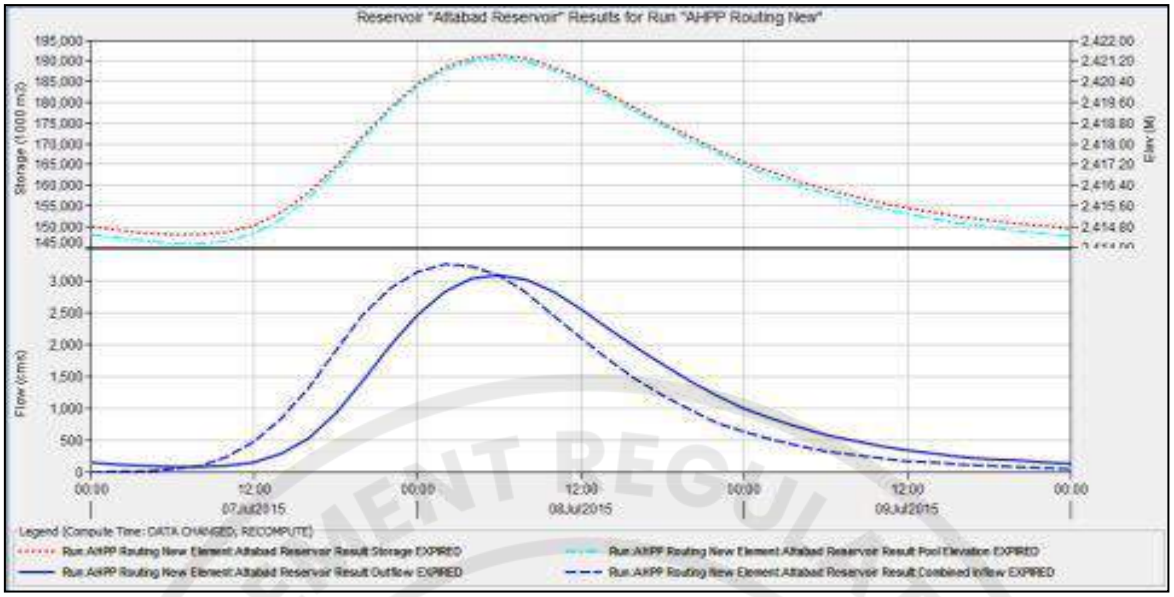


**Figure 4.19: Attabad Lake Flood Routing Feasibility Study**

### 4.7.2 Flood Routing - Review Study

In present study, for developing HEC-HMS Model, the model input parameters (Capacity Storage relationship and Elevation Area Capacity Curve) keeping same as in feasibility study. Taking catchment area 8922.9 sq.km and peak inflow 3320 m³/s. Assuming spillway crest level as 2414 m a.m.s.l. The inflow hydrograph of (3250 m³/s as in Feasibility Study) is converted into Unit Hydrograph by unity method and generated Inflow Hydrograph of 3320 m³/s on the basis of Unit Hydrograph. Unit hydrograph and Inflow Hydrograph of 3320 cumecs are as given in Figure 4.20 and Figure 4.21.

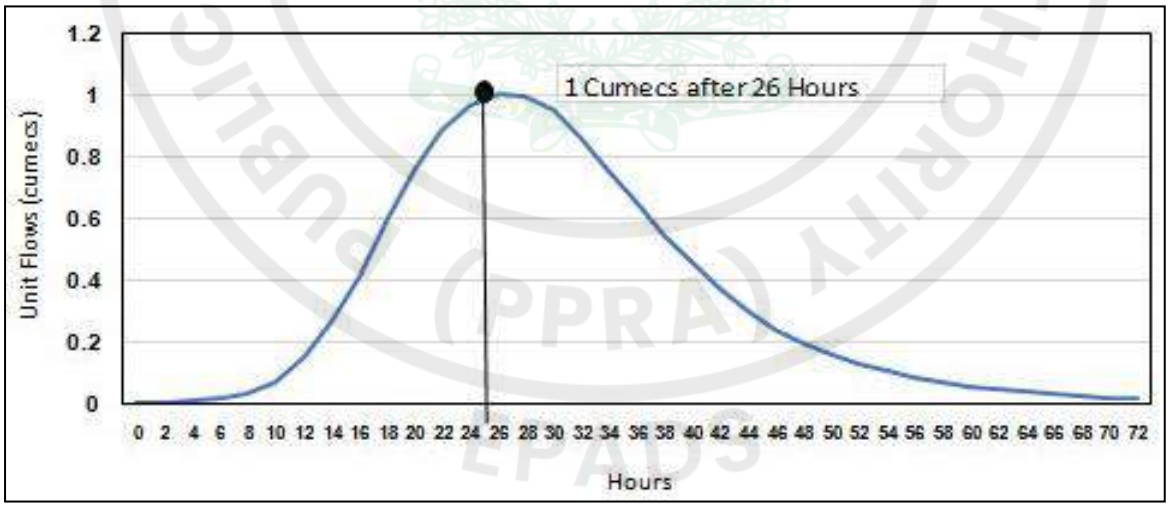


**Figure 4.20: Unit Hydrograph**



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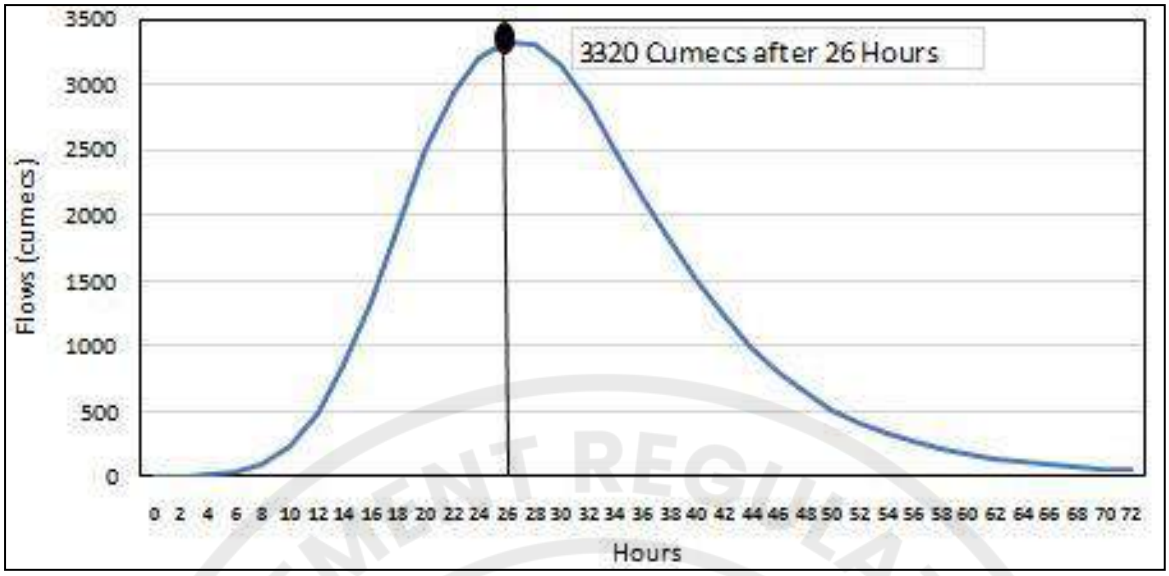


**Figure 4.21: Flow Hydrograph of 3320 Cumecs**

HEC-HMS, model run by considering inflow hydrograph with the peak of 3,320 m³/s has been entered in the lake as inflow and attenuated peak of 3,152.8 m³/s is attained after 4 hours of the inflow peak. The attenuated peak is attained at an elevation of 2421.4 m a s l. HEC-HMS results are shown below in Figure 4.22.

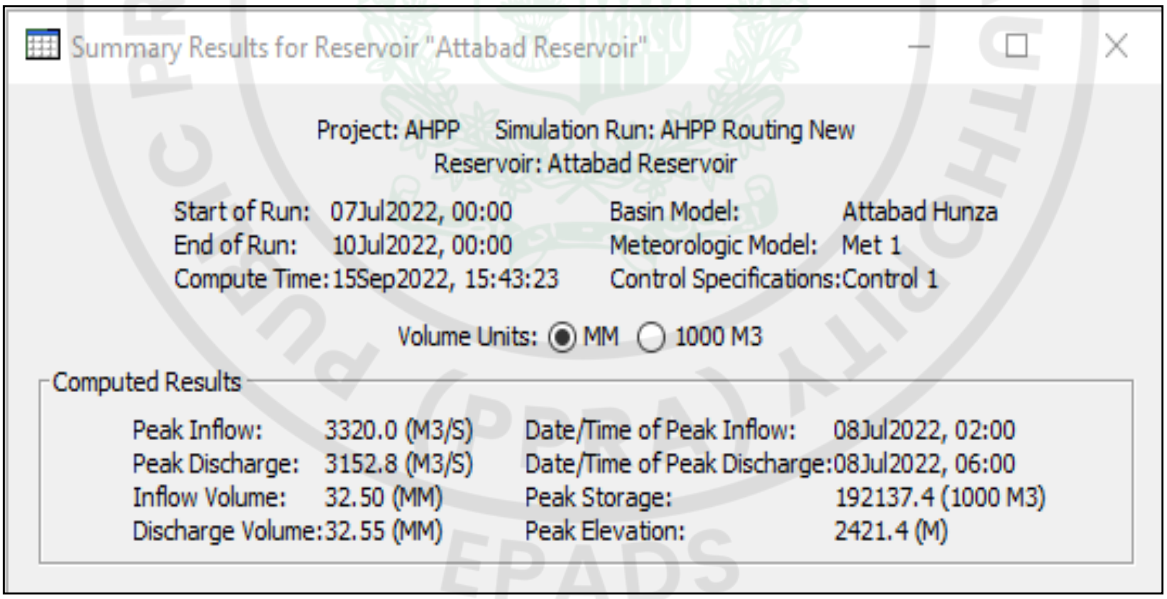


**Figure 4.22: HEC HMS Model - Simulation Results**

Attabad Lake Flood Routing results are given in Figure 4.23 and tabulated in Table 4.12.



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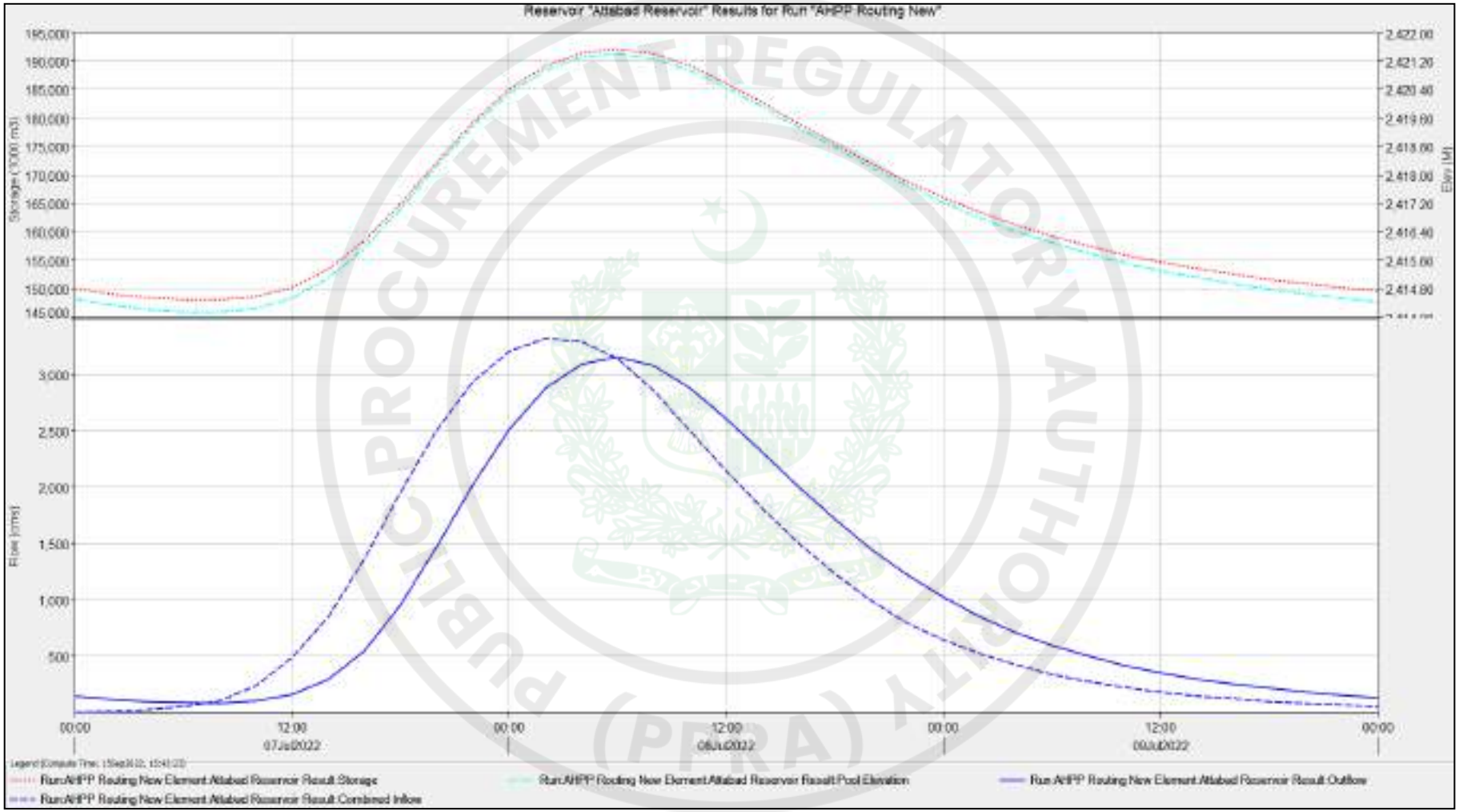


**Figure 4.23: Attabad Lake Flood Routing - Review Study**




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## Table 4.12 Flood Routing Results - Attabad Lake

Project: AHPP Simulation Run: AHPP Routing New
Reservoir: Attabad Reservoir

Start of Run: 07Jul2022, 00:00 Basin Model: Attabad Hunza
End of Run: 10Jul2022, 00:00 Meteorologic Model: Met 1
Compute Time: 15Sep2022, 15:43:23 Control Specifications: Control 1

| Date | Time | Inflow (M3/S) | Storage (1000 M3) | Elevation (M) | Outflow (M3/S) |
|---|---|---|---|---|---|
| 07Jul2022 | 00:00 | 0.0 | 150000.0 | 2414.5 | 142.4 |
| 07Jul2022 | 02:00 | 3.9 | 149094.6 | 2414.3 | 112.9 |
| 07Jul2022 | 04:00 | 17.0 | 148433.5 | 2414.2 | 91.5 |
| 07Jul2022 | 06:00 | 44.3 | 148041.1 | 2414.2 | 78.8 |
| 07Jul2022 | 08:00 | 96.3 | 147986.4 | 2414.1 | 77.0 |
| 07Jul2022 | 10:00 | 229.9 | 148541.3 | 2414.2 | 95.0 |
| 07Jul2022 | 12:00 | 481.8 | 150216.4 | 2414.5 | 151.4 |
| 07Jul2022 | 14:00 | 849.9 | 153429.0 | 2415.1 | 288.0 |
| 07Jul2022 | 16:00 | 1353.2 | 158372.5 | 2415.9 | 542.0 |
| 07Jul2022 | 18:00 | 1948.2 | 164910.0 | 2417.0 | 943.5 |
| 07Jul2022 | 20:00 | 2502.0 | 172256.3 | 2418.2 | 1466.1 |
| 07Jul2022 | 22:00 | 2928.9 | 179261.0 | 2419.4 | 2019.1 |
| 08Jul2022 | 00:00 | 3205.3 | 185036.7 | 2420.3 | 2510.8 |
| 08Jul2022 | 02:00 | 3320.0 | 189134.9 | 2420.9 | 2876.1 |
| 08Jul2022 | 04:00 | 3291.6 | 191458.6 | 2421.3 | 3090.0 |
| 08Jul2022 | 06:00 | 3139.7 | 192137.4 | 2421.4 | 3152.8 |
| 08Jul2022 | 08:00 | 2853.8 | 191294.7 | 2421.3 | 3074.8 |
| 08Jul2022 | 10:00 | 2494.0 | 189126.1 | 2420.9 | 2875.3 |
| 08Jul2022 | 12:00 | 2137.5 | 186080.9 | 2420.5 | 2602.0 |
| 08Jul2022 | 14:00 | 1800.6 | 182609.9 | 2419.9 | 2300.3 |
| 08Jul2022 | 16:00 | 1495.2 | 179001.5 | 2419.3 | 1997.9 |
| 08Jul2022 | 18:00 | 1225.5 | 175442.3 | 2418.8 | 1711.5 |
| 08Jul2022 | 20:00 | 989.5 | 172036.6 | 2418.2 | 1449.5 |
| 08Jul2022 | 22:00 | 792.1 | 168853.5 | 2417.7 | 1216.3 |
| 09Jul2022 | 00:00 | 637.0 | 165964.7 | 2417.2 | 1015.3 |
| 09Jul2022 | 02:00 | 514.4 | 163407.0 | 2416.8 | 846.6 |
| 09Jul2022 | 04:00 | 414.7 | 161163.7 | 2416.4 | 705.7 |
| 09Jul2022 | 06:00 | 334.4 | 159198.8 | 2416.1 | 589.2 |
| 09Jul2022 | 08:00 | 269.7 | 157476.2 | 2415.8 | 493.4 |
| 09Jul2022 | 10:00 | 217.5 | 155971.2 | 2415.5 | 411.9 |
| 09Jul2022 | 12:00 | 175.6 | 154653.9 | 2415.3 | 347.1 |
| 09Jul2022 | 14:00 | 141.8 | 153498.3 | 2415.1 | 291.3 |
| 09Jul2022 | 16:00 | 114.3 | 152489.0 | 2414.9 | 245.2 |
| 09Jul2022 | 18:00 | 92.1 | 151599.0 | 2414.8 | 208.4 |
| 09Jul2022 | 20:00 | 74.5 | 150814.5 | 2414.6 | 176.1 |
| 09Jul2022 | 22:00 | 60.4 | 150133.6 | 2414.5 | 148.0 |
| 10Jul2022 | 00:00 | 49.0 | 149536.8 | 2414.4 | 127.3 |



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## 4.8 SEDIMENTATION STUDY

Sedimentation study is prerequisite for the design of any hydropower project. Sediment transport studies are essential to estimate total sediment inflow at the weir site, sediment load and the life of the reservoir with and without flushing or sluicing options and all other aspects related to sedimentation.

### 4.8.1 Sedimentation Study - Feasibility Study 2021

Suspended sediments at Attabad Lake were estimated by using sediment data of Dainyor Bridge station. Relationship developed between suspended sediment and discharge data of Dainyor Bridge. Sediment rating curve developed with that correlation and generated suspended sediment yield at proposed weir site with the application of developed sediment rating curve. Average annual suspended sediment estimated as 20.06MMT.

Average Volume of fresh sediment deposits for Attabad Lake HPP is estimated as: (20.06 MMT x 1000 kg/MT) / (1122.4 kg/m$^3$ x 1234 m$^3$/acre-feet x 106) ~ 14,483 Acre-Feet/year. Bed load had been considered as 20% of the total suspended load. Total Sediment load at weir site worked out to be 24.06 M Tons. Without flushing, reservoir would be filled with sediments in 10 years.

### 4.8.2 Sedimentation Study - Review Study

- **Estimation of Suspended Sediment at Weir**

Estimation of suspended sediment at weir site by using two approaches

- Observed Dainyor Bridge Sediment Data
- Development of Sediment Rating Curve

**1$^{st}$ Approch: Observed Sediment Data of Dainyor Bridge**

Observed annual suspended sediment data of Dainyor Bridge at Hunza river is collected from SWHP-WAPDA, for the year of 1966-2005 is tabulated below in Table 4.13.

**Table 4.13 Observed Suspended Sediment at Dainyor Bridge**

| Suspended Sediment Yield at Hunza River (Dainyor Bridge) - SWHP WAPDA | | | |
|---|---|---|---|
| **Year** | **Sediments (m.s.t)** | **Year** | **Sediments (m.s.t)** |
| 1966 | 74.1 | 1986 | 34.2 |
| 1967 | 76.2 | 1987 | 23.3 |
| 1968 | 81.2 | 1988 | 39.6 |
| 1969 | 78.2 | 1989 | 5.59 |
| 1970 | 85.3 | 1990 | 12.9 |
| 1971 | 86.9 | 1991 | 7.73 |
| 1972 | 32.2 | 1992 | 11.2 |
| 1973 | 111 | 1993 | 10.2 |
| 1974 | 40.6 | 1994 | 14.1 |
| 1975 | 31.2 | 1995 | 15.5 |
| 1976 | 31.3 | 1996 | 20.5 |



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| Suspended Sediment Yield at Hunza River (Dainyor Bridge) - SWHP WAPDA | | | |
|---|---|---|---|
| **Year** | **Sediments (m.s.t)** | **Year** | **Sediments (m.s.t)** |
| 1977 | 56.1 | 1997 | 10.8 |
| 1978 | 59 | 1998 | 19.7 |
| 1979 | 47.7 | 1999 | 18.3 |
| 1980 | 33.3 | 2000 | 19.2 |
| 1981 | 31.4 | 2001 | 20.4 |
| 1982 | 29.2 | 2002 | 12.8 |
| 1983 | 33.7 | 2003 | 17.5 |
| 1984 | 46.4 | 2004 | 11.04 |
| 1985 | 39.3 | **Avg** | **36.64** |

The average annual suspended sediment at Dainyor Bridge estimated from the above table is 36.64 MTons. As Attabad Lake is located at upstream of Dainyor Bridge on Hunza river, average annual suspended sediment estimated at Attabad Lake by using catchment area ratio method. Thus, average annual suspended sediment at proposed weir site is worked out to be **24.85 MTons.**

### 2nd Approch: Development of Sediment Rating Curve

Observed daily suspended sediment data w.r.t discharges of Dainyor Bridge gauging station have been collected from SWHP-WAPDA, for the period of 1966-2015. Best correlation developed between suspended sediments with discharges for the period of 1967-1988 as represented in Figure 4.24.

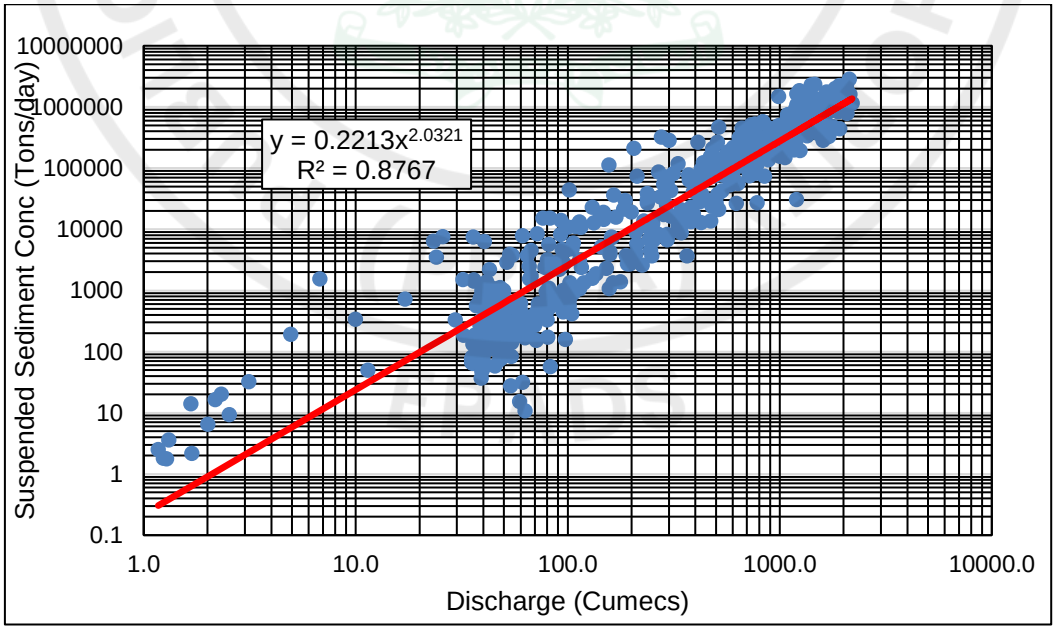


**Figure 4.24: Correlation between Suspended Sediment and Discharge - Dainyor Bridge**




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The best fit relationship thus obtained was:

$$y = 0.221x^{2.032}$$

For the safety and life of project, appropriate estimation of sediment yield at weir site is needed. Therefore, keeping on safer side, select the years having above average estimated inflows at Attabad Lake. Putting the value of estimated available flows at weir site (x) in the above equation will give the suspended sediment (y) at weir. The mean monthly and mean annual suspended sediment at Attabad Lake are represented below in Figure 4.25 & Figure 4.26.

Average monthly suspended sediments at weir site are varying from 7721 Tons in March to 8,256,082 Tons in July. Average annual suspended sediment estimated at weir site is **20.30 MTons**.

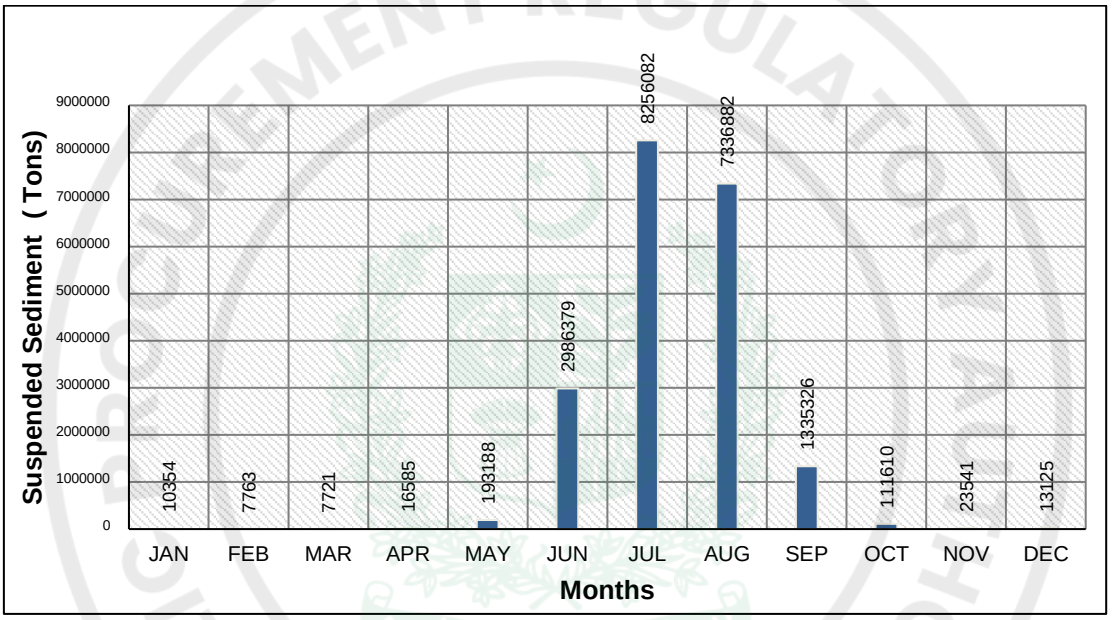


**Figure 4.25: Monthly Suspended Sediment at Attabad Lake**

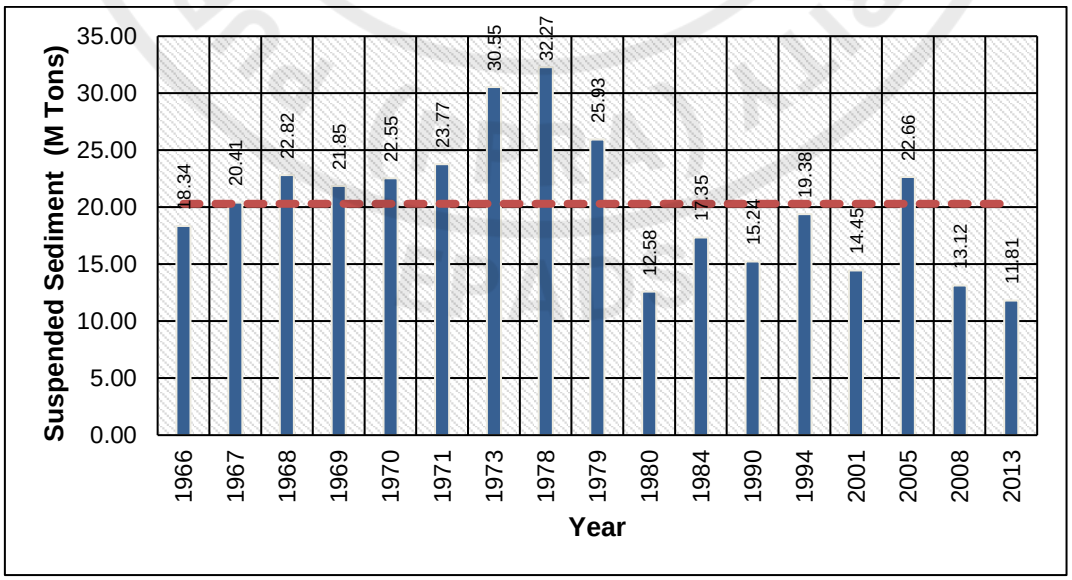


**Figure 4.26: Annual Suspended Sediment at Attabad Lake**




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Average annual suspended sediment yield at weir site estimated with values of 24.85 MTons and 20.30 MTons against 1st and 2nd approach respectively. Keeping in view the above two approaches, finally estimated annual suspended sediment yield at Attabad Lake is taking average of above two values (24.85 MTons and 20.30 MTons). The resulted average annual suspended sediment at weir site is 22.5 MTons.

- **Estimation of Total Sediment Load**

Total annual sediment load at Attabad Lake is addition of suspended sediment load and Bed load at weir site. Bed load is considered as 20% of suspended sediment load. Annual suspended sediment load at weir site is 22.5 MTons. Bed load is 20% of Suspended load and Bed load worked out to be 4.51 MTons. **Total annual sediment load in Attabad Lake is estimated with value of 27.08 MTons.** Density of sediment is 62 lb/ft³. Total annual sediment load in volume is **27.71 MCM** or **22,466 Ac FT**.

## 4.9 SUMMARY OF REVIEW STUDY

Comparative summary of Review w.r.t Feasibility Study is as shown below in Table 4.14.

**Table 4.14 Comparative Summary of Feasibility vs. Review Study**

| Sr. No. | Description | Feasibility study 2021 | Review Study 2022 |
|---|---|---|---|
| 1 | Catchment area | 8901 km² | 8922.9 km² |
| 2 | Climatic Data | Gilgit | Gilgit & Skardu |
| 3 | Flows Data | Daily flows Dainyor Bridge data 1966-2015 | Daily flows Dainyor Bridge data 1966-2015 |
| 4 | Mean annual flows at Attabad Lake | 209 cumecs | 220.08 cumecs |
| 5 | Mean Annual flow in Vol | 6591 MCM | 6940 MCM |
| 6 | Mean Monthly Flow | 206.13 cumecs | 218.4 cumecs |
| 7 | Design Discharge | 60 cumecs | 60 cumecs |
| 8 | Flow duration curve | 60 cumecs at 50% of time | 60 cumecs at 52% of time |
| 9 | Weir crest level (m) | 2414 a.m.s.l | 2414 a.m.s.l |
| 10 | Design Flood against 10,000 yrs. return period | 3250 m³/s | 3320 m³/s |
| 11 | Peak Discharge after lake routing | 3085 m³/s | 3152 m³/s |
| 12 | Max flood level | 2421.3 a.m.s.l | 2421.4 a.m.s.l |
| 13 | Annual suspended sediment | 20.06MTons | 22.5MTons |
| 14 | Total annual sediment inflow | 24.06MTons | 27.08MTons & in Vol 22466 Ac Ft |



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## 4.10 ANALYSIS ON ADDITIONAL AVAILABLE DATA

Flow study review for the same period (1966-2015) of observe daily flows data of Hunza River at Dainyor Bridge station as used in Feasibility study. The analysis and comparative (Hydrology & Sedimentation study) as discussed above in detail.

The additional daily flows data of Hunza river at Dainyor Bridge for period of three (03) years (2016, 2019 & 2020) along with suspended sediment data of two years (2019-2020) had been acquired from SWHP-WAPDA. The data was studied and its findings are as follow.

- Missing daily flows data for the period of 2016.
- Discontinuous years of data availability.

For the analysis of flows pattern and water availability, continuous years of data required. In the current scenario, flows study done for the period of 1966-2015. The additional data was available for the period of 2019-2020, and reflected three years missing data (2016-2018). In the light of above observations, hydrological study could not be updated.

The comparative analysis of two years daily flows data of Dainyor Bridge for period of (2019-2020) w.r.t (1966-2015) is represented in Figure 4.27 and avgerage mean monthly flows are 275 cumecs in 2019-2020 & 322 cumecs in 1966-2015, respectively.

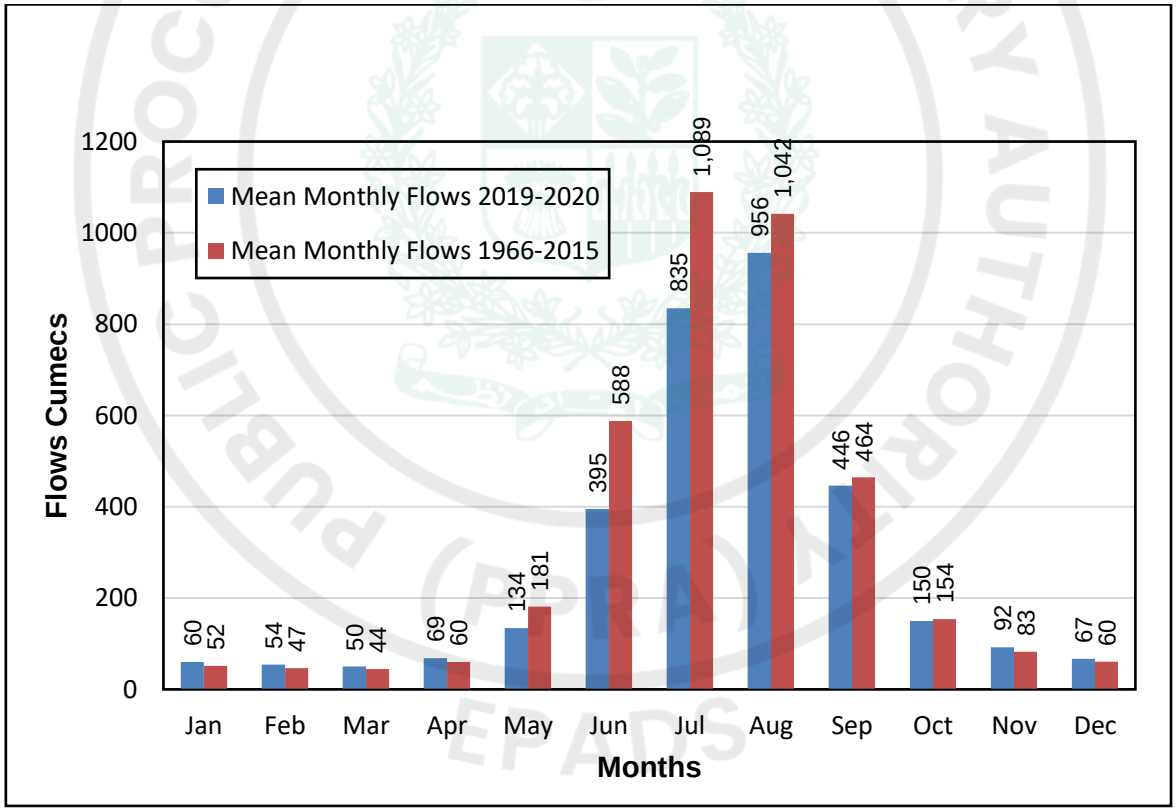


**Figure 4.27: Comparison of Mean Monthly Flows - Hunza River at Dainyor Bridge**

The flows generated at proposed weir location for the period of (2019-2020) by using Dainyor Bridge data with the application catchment area ratio method. The flows comparison study of Attabad lake for two (02) periods of durations (1966-2015) and (2019-2020) are represented below in Figure 4.28.



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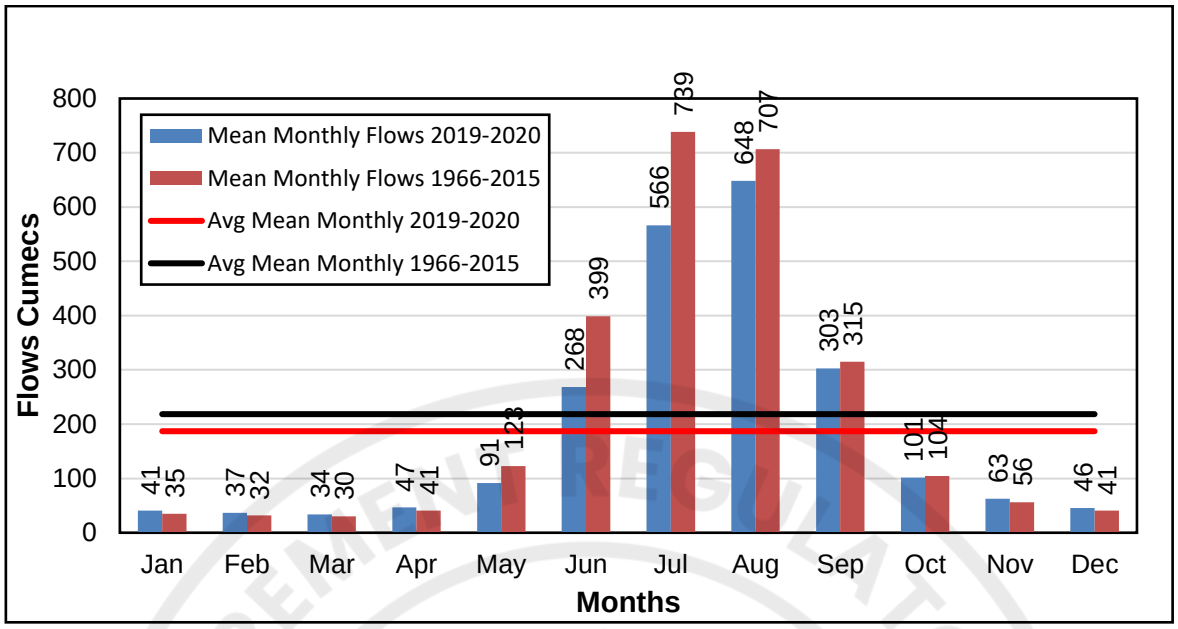


**Figure 4.28: Comparison of Mean Monthly Flows - ATTABAD LAKE**

The average mean monthly flows at proposed weir for period of (2019-2020) are 187.7 cumecs and for period of (1966-2015) are 218.4 cumecs, respectively. Above figure highlighted flows patter for both duration periods are similar but on other hand, flows availability reduce in period of 2019-2020.

Flows study need to be updated in detail design stage to get the effective estimated values of flows and all other hydrological parameters.

## 4.11 RECOMMENDATIONS

As part of the TORs, Detail Design of Attabad Lake shall be carried out by EPC Contractor. Following recommendations for EPC Contractor regarding Hydrology and Sedimentation Study are as under.

- Stream gauging station should be installed at project site for ascertaining the authenticity of water availability at project site (especially low flows during winter months).
- Flow study need to be revised/updated during detail design stage by EPC contractor. In present study, flows were estimated for the period of 1966-2015 with mean annual flows available at weir site as 6940 MCM.
- GLOFS study will be under taken during detail design stage by EPC Contractor.
- Detailed studies for design flood estimation need to be carried out by the EPC Contractor. In the Detailed Design, the Contractor shall select appropriate return periods for estimating the design floods for weir and power house site. However, the check flood not to be less than 10,000 years return period or GLOF value.
- It is suggested that GLOF value and recently flood occurrence in 2022 also be considered for estimation of flood at weir site. Design floods to be selected to ensure safety of structures and based on analysis of flood risks and consequences.
- Detailed studies for the estimation of sediment load should also be undertaken during the detail design study by EPC Contractor.



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# 5 REVIEW OF GEOLOGY AND GEOTECHNICAL STUDIES

## 5.1 GENERAL

Geology and Geotechnical Studies of Attabad Lake Hydropower Project have been reviwed to ascertain the quantum and dependency of available data for further Detail design studies to be carried out by EPC Contractor. The field investigations, in-situ testing, samples collected and laboratory testing data has been reviewed to cover the available inventory of documented geotechnical investigations.

The review findings are given in forthcoming sections of this chapter along with further recommendations.

## 5.2 REVIEW OF GEOLOGICAL STUDIES

Attabad Lake Hydro Power Project (ALHPP) is proposed on Hunza River, a left tributary of Gilgit River. A large landslide occurred on January 4, 2010. Valley slope comprising a very steep side mountain suddenly collapsed. The slope failure was so massive and instantaneous that blocked the water flows. Vertical face of the landslide scarp as estimated by GSP (Geological Survey of Pakistan) was about 100 m high and the blocked segment of the valley was about 2 km (ISSMGE Bulletin: Volume 4, Issue 3 Page 21) that formed a natural dam and ceased the flow of Hunza river resulting in an upstream reservoir. WAPDA Authority planned to utilize the potential of hydropower due to this lake. Initially, Govt. of GB carried out Feasibility Study by engaging Local consultants in March, 2017. The study was deficient in many aspects including geotechnical investigations, laboratory testing, layout planning, impacts of right bank sliding, Neo-tectonic study and environmental issues. Therefore, Govt. of GB requested WAPDA to carryout detailed Feasibility Study and Hydro Planning Organization (HPO), WAPDA updated the Feasibility Study in June, 2021.

The geological and geotechnical investigations include Surface Geological Mapping, drilling of boreholes and Test pits at the proposed sites of weir, sediment flushing channel/under sluice, headrace tunnel, powerhouse area, and identification of borrow area for construction material. Samples collected during geotechnical investigations have been tested to ascertain geotechnical properties at Central Material Testing Laboratory (CMTL), Lahore. This chapter includes review of all geological and geotechnical investigations and studies which were carried out at Feasibility stage.

### 5.2.1 Review Scope of Geological Studies

The purpose of the review is to evaluate the available project information as documented in the feasibility report, (Volume I, Main report chapters) about site geology, geotechnical and foundation characteristics with respect to standard practice for a typical medium sized hydropower project located in valley largely incised by the fluvio-glacial geomorphic agents. The project site comprises the valley section located near the massive landslide which is a tectonically highly disturbed area marked by a pronounced seismic activity.

The review process activities involved the following:

- Review of Project Feasibility Report and accompanied Drawings (March, 2017).
- Review of Project Feasibility Report and accompanied Drawings (June, 2021).
- Review of geological and geotechnical investigations in terms of their adequacy for the interpreted geological model of the project.



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- Review of subsurface geology particularly of the proposed weir site, power tunnel and powerhouse area.
- Registering the geological and geotechnical hazards and involved risks
- Review of suitability of recommended construction materials for various uses particularly recommendation of using the local available construction materials for the sake of improving the project economics and getting other desired benefits.
- Based on the integrity of the technical evidence, investigations and the syntheses of the analyses, the gravity and soundness of the conclusions and recommendations provided in feasibility report are adequate and/or sound enough to proceed further for the execution of the project.

The review has been completed in perspective of the following:

- Critical review of feasibility report, regional and project geological maps, relevant project documents and Google Earth satellite image.
- Critical review of the geological interpretation of the geotechnical investigations along with project layout in perspective of the terrain characterization and geohazards.
- Preparation of Feasibility Study (June, 2021) Review Report.

### 5.2.2 Regional Geology and Regional Faults

Regional geologic and tectonic conditions were evaluated using available geologic maps and relevant technical literature. The regional geological and tectonic Map of Pakistan published by Geological Survey of Pakistan (GSP). Geological map has been modified by Pecher et al.2008 after collecting data of different resources and the Regional Tectonic Map is compiled by Ali H.Kazmi & Riaz A. Rana under the supervision of Asrarullah Director General, Geological Survey of Pakistan in 1982.The modification of this Map has done by Chaudry and Ghazanfer in1986 and Ahsan et al, 2008. was used at Feasibility stage for the purpose of regional geological and tectonic assessment. In detail design studies, latest and elaborated regional geological maps/data/information should be used by the EPC contractor for extracting more regional geological information for the project area.

### 5.2.3 Site Geology

The recent deposits are the most widely spread soil units that overlies the bedrock. The slopes are covered with surficial deposits having variable thickness. Terrace deposits comprise mixtures of clay, sandy silt, boulders and gravel in varying proportions.

Soil units present in the Project Area are described below.

- **Angular Boulder Gravels with Sand and Appreciable Amount of Fines (ABGM)**
  Most of the slopes are covered by material comprising of ABGM. This is colluvial material broken from the rock units, rolled down slope and settled at the foothill or along the slopes. These deposits are mainly associated with crushed/brecciated rock units, originated/caused by brittle deformation due to tectonic compression resulting in faulting/shearing. ABGM material is present in the sediment flushing channel, surficial deposits in power tunnel alignment and in part of tailrace channel.
- **Rounded Boulder Gravels with Sand and Appreciable Amount of Fines (RBGM)**
  River bed is mainly occupied by RBGM material. Some exposures are also present at power house site Due to the formation of lake, the bed of the river is mostly covered with



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silt and sand. RBGM is present in the main weir area, part of sediment flushing channel and part of power tunnel.

- **Terrace Deposits**
  Terrace Deposits consist mainly of unconsolidated mixtures of clay, silt, sand and gravels with occasional boulders and own re-worked origin being mostly derived from loose material of (RBGM, ABGM, Morainic and Brecciated deposits). Terrace deposits are present at a relatively higher elevations in the project area.

- **Morainic Deposits**
  It consists mainly of material ranging in size from large boulders to clay size particles, angular to sub-angular, poorly sorted, elongated and have flat surface, powerhouse area is covered by moraine deposits with clayey silt to silty clay.

Rock units present in the Project Area are described below.

- **Granitic Gneiss**
  It is light grey to grey in color on fresh surface and weathers to light brown, coarse to very coarse grained, moderately to highly jointed, highly sheared up to higher elevation due to geological faults, sparse to moderately weathered, moderately hard to hard. Part of power tunnel and tunnel outlet is in Granitic Gneiss.

- **Granodiorite**
  It is dark grey to blackish grey, weathers to brownish grey, medium to coarse grained, moderately weathered, moderately hard to hard, moderately jointed and is intruded by pegmatites and granitic gneiss. It is crushed, mylonised, and sheared at places. It is well exposed at the banks of Hunza River where it is intruded by many pegmatite dykes. Some shear zones are also present in this unit. Part of power tunnel and intake area are in Granodiorite.

### 5.2.4 Geological Structures

The whole project area bears the drastic imprints of two regional, seismically active and capable fault systems i.e., MKT and Karakorum Strike Slip Fault (KSSF). As the project area has undergone multiple episodes of tectonic events, many regional as well as local faults and their branch faults and off-shoot splays have formed. There are many faults present in the vicinity of proposed ALHPP. These faults owe their origin to the tectonic regimes associated with MKT and KSSF and transverse in between these two fault systems. Some of these faults have been observed during Surface Geological mapping and reported as following:

- **Attabad-Hispar Valley Fault**
  This fault crosses the Hunza River and forming a junction point with Hunza River and Attabad Fault in Attabad village. It is a thrust fault striking N30°E and dipping 40°SE and is well exposed at the left side slope near the project area. Granitic gneiss along its alignment is sheared / brecciated, forming fault breccia at many places. Due to high degree of shearing, many active landslides and rockfalls have been originated along its trace.
- **Attabad Fault**
  This Thrust Fault is striking N60°W and dipping 52°NE, exposed in area rear of Attabad village. It is relatively a small fault and terminates along junction point of three faults. A large brecciated and sheared rock is present along this Thrust Fault. Sheared and brecciated rock can be seen on outcrops at right bank slope.

- **Attabad River Fault**



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The exposure of this fault is present at right bank slope of Hunza River. The breccia is well exposed at right side, just downstream of Sarat Suspension Bridge. The intensity of brecciation increases towards Salamanabad village. In fact, Salamanabad village is developed on brecciated rockmass.

### 5.2.5 Geomorphology

Geomorphologic studies were not conducted during the Feasibility stage.

The reviewer has made the geomorphologic assessment of the project area and its closed vicinity using satellite images and remote sensing techniques as shown in Figure 1. The segment of Hunza valley wherein the various components of the project are situated reflects very high relief conditions marked by relatively steeply inclined extensive mountain slopes along right side of the valley as compared to the left bank mountain slopes.

The mountain slopes are mostly marked by erratic slopes instabilities along with relatively less extensive segments of casuistic slopes. The mass wasting regimes active in the project area are drastically influenced by a broad spectra of variables such as geomechanical conditions, moisture distribution and dynamic loading. Most abundant slope hazards include but not limited to Rockfall/Debris flows, rolling slopes in unconsolidated loose overburden and mud/debris flows in sub-parallel rectilinear secondary drainage.

In perspective of the aforementioned volatile slope conditions, it is recommended that during detail design, prior to the initiation of specific and specialized investigations, a comprehensive and overall baseline terrain characterization based on geologic, geotectonic, geomorphologic, seismic geohazard and prevailing climatic conditions should have been conducted. Simplified Geomorphological Map of project area is shown in Figure 5.1.



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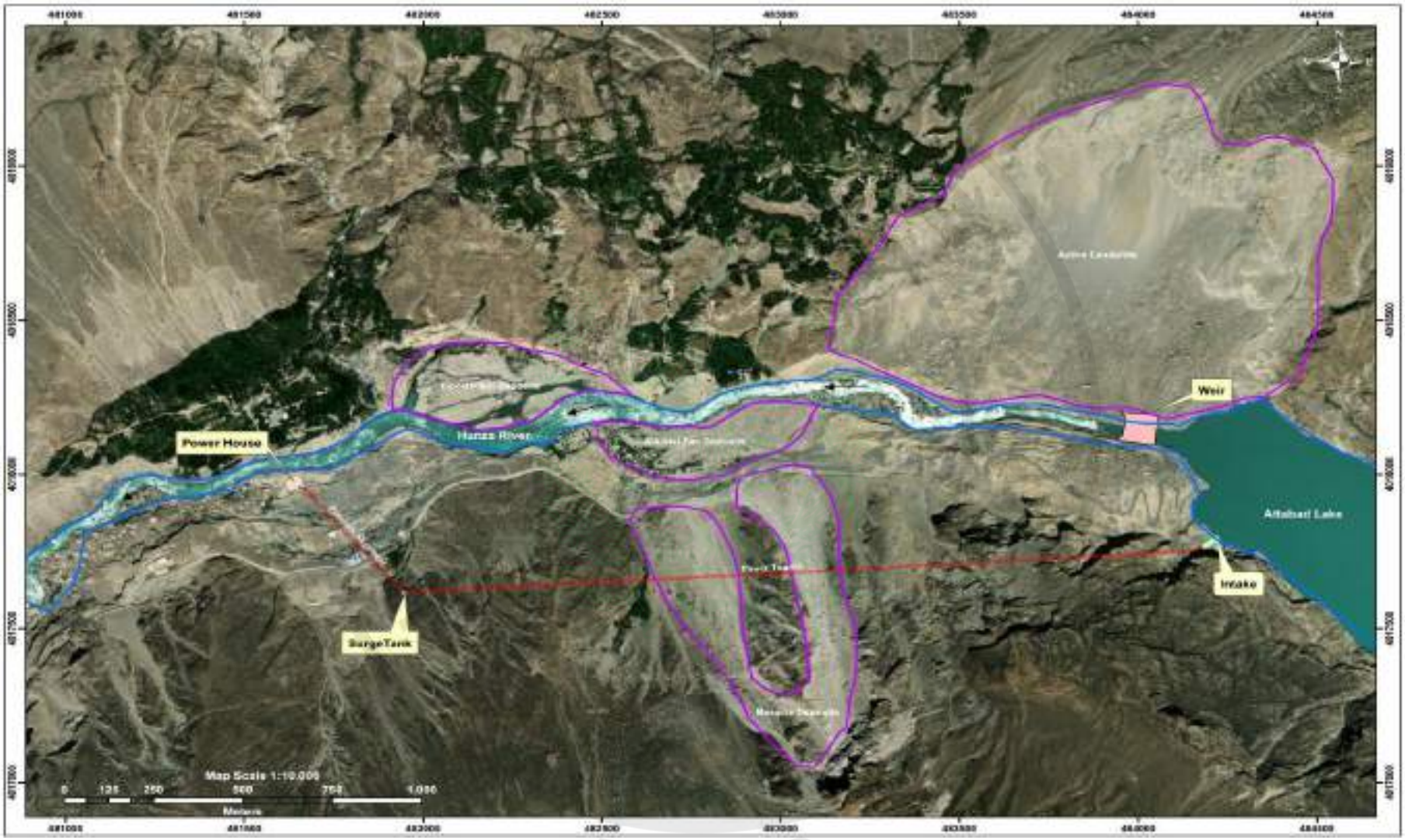


**Figure 5.1: Simplified Geomorphological Map of Project Area**



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### 5.2.6 Review of Surface Geological Investigations

- **Geological Mapping**

The Surface geological mapping of the project area has been carried out on 16 topographic sheets prepared by Survey Division Peshawar, HPO, WAPDA on scale 1:1 000 with contour interval of 2 m, with the help of Total Station, Plane Table and Brunton compass and presented at scale of 1:2000.

The EPC contractor will verify the geological mapping conducted during the Feasibility Study and necessary amendments in the geological map will be made, where required. Moreover, additional geological studies will also be carried out focusing geomechanical properties and rockmass characterization.

The EPC Contractor shall perform the geologic mapping during detail design stage with an appropriate scale to capture the ground information for safely hosting the proposed structures. For engineering purpose, the mapping will define geologic conditions potentially affecting the project appurtenant structures. Emphasis, therefore, will be given on the physical properties of soil and rock masses as they may affect proposed foundations excavation, slope stability at abutment slope excavation and construction methods. The physical properties or geologic factors include the occurrence and properties of soil units, rock outcrop patterns, rock strength, weathering, permeability and condition of structural discontinuities (jointing, bedding, foliation, schistosity, faults, shear zones, etc.). The geologic materials (soils, rocks) will be described and classified following the accepted guidelines as used in other activities for soil or rock descriptions, classification and logging. Execution of the detailed geological mapping during the detail design stage will be done using Satellite Images/ Drone images.

The EPC Contractor shall perform the geologic mapping of the soil cover area/ quaternary deposits, using Unified Soil Classification System (USCS) will be conducted as required particularly focusing on (i) factors affecting water-tightness, (ii) occurrence of major faults and lineaments, and (iii) identification and characterization of significant geological hazards that might pose threat to the safety of safe operation of the project.

- **Scanline Survey**

To determine the geomechanical properties of the rockmass, scanline surveys at the critical locations plays a vital role for the assessment of the mode of failures present in the project area. However, no such studies have been conducted during the Feasibility study.

The EPC contractor should perform scanline surveys in accordance to the ISRM standards 2007and compile scanline data in tabulated form which should include joint type, dip/strike, interval, aperture, roughness, infilling and Uniaxial Compressive Strength (UCS). The collected dip/strike discontinuity data should also be plotted on software like DIPS or other structural geology software to define characteristics of major sets of discontinuity and mode of failures (planner, wedge and toppling) at the slopes as shown in a typical Kinematic Analysis in Figure 5.2.



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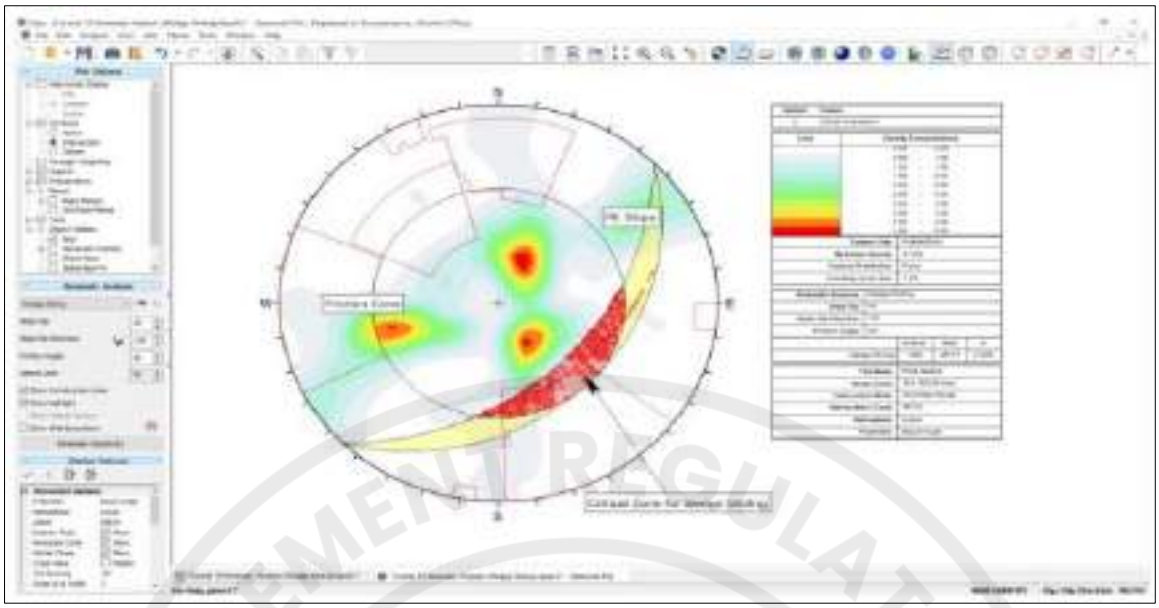

**Figure 5.2: Interface of RocScience DIPS Software Showing Kinematic Analysis**

- **Neotectonincs**

During the Feasibility stage, neotectonic study has been carried out in sufficient details. The area under study has been covered 40km upstream and 50km downstream of slided mass. However, during the detail design stage EPC contractor shall verify and confirm the local faults, shears, lineaments, scars and tectonic distortion trends specific to the project area and its 50 km radial vicinity.

## 5.3 REVIEW OF GEOTECHNICAL STUDIES AND SUBSURFACE INVESTIGATIONS

Field investigations for Feasibility study 2021 included drilling of six (06) boreholes, excavation of ten (10) test pits, field testing in boreholes and sampling for laboratory testing. Comprehensive field investigations plan of Feasibility study 2021 marked on satellite image is shown in Figure 5.3.



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**Figure 5.3: Field Investigation Plan of Feasibility Study 2021**



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Summary of drilled boreholes with locations, drilled depths and conducted water pressure tests is given in Table 5.1. Total drilling of 401 m have been executed for foundation evaluation of different structures, bore holes of varying depths have been drilled accordingly to estimated geological conditions prevailing in subsurface. Permeability tests have been performed using constant head method in overburden material at 3 m interval whereas water pressure tests (Lugeon tests) in bed rock have been performed at interval of 5 m or at change of strata. Rock cores and soil samples have been collected from all the bore holes at various depths for lab testing.

Summary of excavated test pits with depths is given in Table 5.2. A total ten (10) number of test pits having cumulative depth of 30m were excavated to study the surficial material present at different locations.

The review of subsurface investigation data revealed following:

- Low core recovery and RQD values recovered at shallow depths.
- Core recovery and RQD values increases with depth.
- Lack of discontinuity data recording in the core logs as only one (01) borehole i.e., BH-04 was drilled 74m into the bedrock.
- Lack of bedrock information.
- Lack of details of preserved rock samples in the borehole logs.
- Non availability of core box photographs.
- Details of permeability test have not been provided.
- Description of material encountered is lacking and confusing, like information about sand/fines, roundness or angularity of gravels etc.
- Sufficient Investigations at many important structures like pressure tunnel intake, surge tank, penstock, and right abutment of main weir were not done.



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## Table 5.1 Boreholes and Summary of Analysis

| Area | BH No. | Depth (m) | Inclination | Material Encountered | Permeability Range (cm/sec) | Water Pressure Test |
|---|---|---|---|---|---|---|
| Weir L/S | BH-01 | 90 | 90° | Angular Boulder Gravels of slided mass, light grey to grey in color, mostly of Granodiorite and Granitic gneiss. | 0-4m depth, K=0.04618,<br>13-16m depth, K=0.002858,<br>16-19m Depth, K=0.012294 | |
| Sediment Flushing Channel (Inlet) | BH-02 | 60 | 90° | Angular Boulder Gravels of slided mass, light grey to grey in color, mostly of Granodiorite and Granitic gneiss | 0-3m depth, K=0.06037,<br>3-6m depth, K=0.01327 | |
| Sediment Flushing Channel (outlet) | BH-03 | 61 | 90° | Light grey to grey, fine to medium grained sand with angular gravels variegated origin | 25-28m depth, K=0.001226,<br>28-32m depth, K=0.007040,<br>32-37m depth, K=0.003243,<br>37-42m depth, K=0.002813,<br>42-46m depth, K=0.001832,<br>46-49m depth, K=0.002621,<br>49-52m depth, K=0.001082,<br>52-56m depth, K=0.001436,<br>56-59m depth, K=0.000724 | |
| Power tunnel Alignment | BH-04 | 80 | 90° | Cobbles Granodiorite & Granitic Gneiss, Mylonised Granitic Gneiss, Granitic Gneiss, foliated & fresh, moderately jointed, moderately strong to strong | | Maximum Value=3.77 at 5Bar<br>Minimum Value=0.01 at 3Bar |
| Powerhouse | BH-05 | 50 | 90° | Angular to Sub- Angular pebble, cobble and boulders of Granitic | 12-15m depth, K=0.0277, | |



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| Area | BH No. | Depth (m) | Inclination | Material Encountered | Permeability Range (cm/sec) | Water Pressure Test |
|---|---|---|---|---|---|---|
| | | | | Gneiss, Grey to brownish grey, Fine Clayey Silt, Fine to Very Fine Silty Sand | 15-19.5 depth, K=0.00945, 19.5-22.5m depth, K=0.00685,<br>22.5-25.5m depth, K=0.006359,<br>25.5-28.5m depth, K=0.004969 | |
| Powerhouse | BH-06 | 60 | 90° | Grey to Brownish grey, fine to very fine grained, clayey silt, Cobbles and Boulders comprising of granitic gneiss, granodiorite and silty sand | 10.4-16m depth, K=0.00241,<br>16-20m depth, K=0.00289,<br>20-23m depth, K=0.00392,<br>24-26m depth, K=0.00286,<br>29-32m depth, K=0.00338,<br>35-53m depth,<br>K=0.00279, K=0.00781,<br>53-57m depth, K=0.00298 | |



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**Table 5.2 Test Pits and Summary of Analysis**

| Area | TP No. | Depth (m) | Inclination | Water Table Depth (m) | Material Encountered |
|---|---|---|---|---|---|
| Shishkat Bridge (Sand Aggregate) | TP-01 | 3 | 90° | 1.3 | Sand with Subordinate gravels |
| Powerhouse Area (Aggregate) | TP-02 | 3 | 90° | Nil | Boulder, Cobbles and pebbles of variegated origin, embedded in sand, Clayey Silt, grey to brownish grey |
| Power House Area (Fine Aggregate/Clay) | TP-03 | 3 | 90° | Nil | Clayey Silt, Light Grey to brownish grey in color, fine to very fine grained |
| Power House Area ( Fine Aggregate) | TP-04 | 3 | 90° | Nil | Light grey to grey, medium to fine grained sand, grey to brownish grey, fine to very fine grained clayey sandy silt |
| Outlet of Sediment Flushing channel alignment | TP-05 | 3 | 90° | Nil | Clayey silty sand with gravels |
| Flushing Channel Slope Alignment (Left Side) | TP-06 | 3 | 90° | Nil | Gravelly Sand and ABGM, it consists of boulder, gravels of mostly granodiorite with subordinate clay and silt |
| Inlet of Sediment Flushing Channel Alignment (left Side) | TP-07 | 3 | 90° | Nil | Silty Sand with RBGM, grey colored silty sand with subordinate gravels and ABGM |
| Slope Area Above Spillway (Right Side) | TP-08 | 3 | 90° | Nil | Gravelly Sand and ABGM, it consists of boulder, gravels of mostly granodiorite with subordinate clay |



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| Area | TP No. | Depth (m) | Inclination | Water Table Depth (m) | Material Encountered |
|---|---|---|---|---|---|
| | | | | | and silt, some crushed rock ground to silty/ sandy material |
| Slope Area Above Spillway (Right Side) | TP-09 | 3 | 90° | Nil | Gravelly Sand and ABGM, it consists of boulder, gravels of mostly granodiorite with subordinate clay and silt, some crushed rock ground to silty/ sandy material |
| Slope Area Above Spillway (Right Side) | TP-10 | 3 | 90° | Nil | Clayey Silt, Light brown to brownish grey, fine to very fine grained |

### 5.3.1 Review of Field Testing Data

- **Permeability and Water Pressure Testing**

Summary of permeability and water pressure tests is given in table 5.1. Permeability and water pressure tests performed in feasibility study are limited and insufficient to use in the detail design.

During the detail design stage, the EPC Contractor has to drill appropriate number of additional boreholes at the project appurtenant structures and have to perform Lugeon at regular interval to assess Lugeon values under the weir, powerhouse and other structures of the project. These additional geotechnical investigations will be supervised by an experienced Engineering Geologist.

- **Determination of Lugeon Pattern**

The EPC contractor has to plot the values of ‘Flow’ verses ‘Pressure’ to assess the Lugeon pattern that will help in evaluating the discontinuities pattern in the test section as shown in Table 5.3 represents the proposed Lugeon interpretation procedure using the flow loss vs. pressure.



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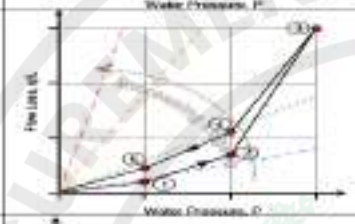
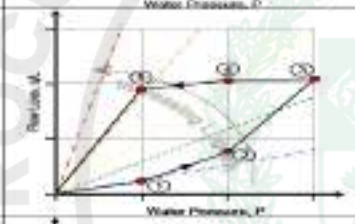
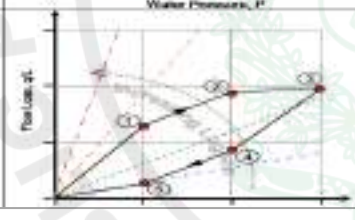
**Table 5.3 Proposed Lugeon interpretation procedure using the flow loss vs. pressure**

| BEHAVIOR | WATER LOSS VS PRESSURE PATTERN | DESCRIPTION | REPRESENTATIVE LUGEON VALUE |
|---|---|---|---|
| LAMINAR | | All Lugeon values about equal regardless of the water pressure | Average of Lugeon values for all stages |
| TURBULENT | | Lugeon values decrease as the water pressures increase. The minimum Lugeon value is observed at the stage with the maximum water pressure | Range of Lugeon values observed at water pressures expected during operation. If water pressure expected during operation is unknown use the value corresponding to the medium water pressure (2nd or 4th stage) |
| DILATION |  | Lugeon values vary proportionally to the water pressures. The maximum Lugeon value is observed at the stage with the maximum water pressure | Range of Lugeon values observed at water pressures expected during operation. If water pressure expected during operation is unknown use the value corresponding to either low or medium water pressures (1st, 2nd, 4th, or 5th stage) |
| WASH-OUT |  | Lugeon values increase as the test proceeds. Discontinuities' infillings are progressively washed-out by the water | Highest Lugeon value recorded (5th stage) |
| VOID FILLING |  | Lugeon values decrease as the test proceeds. Either non-persistent discontinuities are progressively being filled or swelling is taking place | Use final Lugeon value (5th stage), provided that presence of non-persistent discontinuities and/or occurrence of swelling is confirmed by observation of rock core. |

- **Processing of Lugeon Test Result**

Graphs of depth and Lugeon values for all the existing and new Lugeon tests have to be prepared as shown in Figure 4 for clarification of the relation between depth and permeability, as well as detecting abnormally high permeable zones in deep portions. This will help in evaluating the requirements of any grouting measures required in the foundations of the appurtenant structures.

The occurrence of unconsolidated and loose quaternary deposits such as ABGM, RBGM, Terrace and Morainic deposits at various project structures indicates that such materials may need to be treated for stability of the works and slopes.

### 5.3.2 Review of Laboratory Testing Data

A total of 10 rock core samples from BH-04 (Power tunnel alignment) have been selected for evaluation of geotechnical parameters for design purpose. A total of 15 samples, i.e., 3 block sample, 3 samples from borrow area, and 9 test pit samples have been selected for investigations. Samples from all Test Pits have been selected by cone and quarter method and different type of tests have been performed to check their engineering properties and confirm their suitability as aggregate material.



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- **Petrographic Analysis**

Petrographic Analysis was performed on a total of 05 samples to confirm the mineral assemblage in the particular rock unit. For this purpose, 2 samples were collected through excavation of test pits, 2 samples from different locations were collected during surface geological mapping, and 01 drilling core sample was collected from power tunnel alignment.

**Table 5.4 Results of Petrographic Analysis**

| Sr. No. | Borehole No. | Rock Name | Major Minerals | | | | | Minor Minerals | | | | | Remarks / Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Quartz | K-Feldspar | Oligoclase | Biotite | Amphibole | Magnetite | Chlorite | Epidote | Muscovite | Carbonate | |
| 1 | Rock Samples | Foliated Granite | 24 | 18 | 17 | 21 | 1 | 2 | 2 | 6 | 7 | 1 | ASR Potential exists |
| 2 | | Granite | 32 | 26 | 14 | 6 | 3 | 2 | 4 | 1 | 3 | 3 | ASR Potential exists |
| 3 | | Granodiorite | 24 | 11 | 20 | 15 | 16 | 2 | 3 | 5 | 2 | 2 | ASR Potential exists |
| 4 | | Granodiorite | 26 | 12 | 25 | 14 | 11 | 2 | 3 | 3 | 2 | 2 | ASR Potential exists |
| 5 | BH-04 | Granitic Gneiss | 30 | 13 | 28 | 17 | 4 | 1 | 3 | 1 | 2 | 1 | ASR Potential exists |

However, as revealed from test results reproduced herein Table 5.4, it is suggested that more petrographic analyses are required on samples collected from various locations of additional investigations. For the assessment of ASR, the limited number of tests are not enough to describe the rock conditions existing in the project area.

- **Direct shear test**

Direct Shear Test is performed on Granitic Gneiss Sample. One sample from BH-04 was selected for Direct Shear Test from depth of 56 to 56.35m. The result shows that cohesion “c” has 0.595 MPa with angle of shear resistance “ϕ” is 21.8 deg. Only one test is insufficient for detail design of a hydropower project. Therefore, it is recommended that more direct shear tests should be performed by EPC Contractor during the detail Design stage at various project structures.

- **Rock Core Modulus**

Rock Core Modulus was determined for 2 core samples and 3 bulk samples. The core samples were of Granitic gneiss rock. The results are reproduced in Table 5.5.

**Table 5.5 Results of Rock Core Modulus Determination**

| Sr. No. | Bore Hole | Location | Depth (m) | | Test Results (MPa) | | |
|---|---|---|---|---|---|---|---|
| | | | From | To | Young's Modulus | Modulus of Deformation | Mode of Failure |
| 1 | BH-04 | Power Tunnel Alignment | 48.0 | 48.25 | $2.29*10^4$ | $1.15*10^4$ | Axial |
| 2 | | | 61.0 | 61.30 | $1.83*10^4$ | $9.16*10^3$ | Axial |
| 3 | Bulk Samples | Passu Area | - | - | $7.52*10^4$ | $3.76*10^4$ | Diagonal & Axial |
| 4 | | Powerhouse Area | - | - | $4.16*10^4$ | $2.08*10^4$ | Diagonal & Axial |
| 5 | | Slided Mass | - | - | $4.96*10^4$ | $1.88*10^4$ | Diagonal |

It is recommended that more tests are required during detail design stage. EPC Contractor should conduct more tests on samples collected from additional investigations.

- **Point Load Strength Index Test**

Point Load Strength Index test is performed on 3 core samples, one sample of Mylonised Granitic Gneiss and 2 samples of Granitic Gneiss, and 4 bulk samples. The results are reproduced in Table 5.6.



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**Table 5.6 Results of Point Load Strength Index Test**

| Sr. No. | Bore Hole No. | Location | Depth (m) | | Test Results | | |
|---|---|---|---|---|---|---|---|
| | | | From | To | Is (Mpa) | Is 50 (Mpa) | Failure |
| 1 | BH-04 | Power Tunnel Alignment | 21.00 | 21.15 | 4.04 | 3.93 | Diametrically |
| 2 | | | 31.21 | 31.52 | 5.39 | 5.23 | Diametrically |
| 3 | | | 43.25 | 43.55 | 3.14 | 3.05 | Diametrically |
| 4 | Bulk Samples | TP-08 | - | - | 1.81 | 1.66 | Diametrically |
| 5 | | Passu Area | - | - | 4.11 | 4.30 | Diametrically |
| 6 | | Powerhouse Area | - | - | 3.97 | 4.15 | Diametrically |
| 7 | | Slided Mass | - | - | 5.68 | 5.94 | Diametrically |

As required, any additional tests may be conducted on the core samples.

- **Uniaxial Compressive Strength Test**

Uniaxial Compressive Strength test is performed on 3 rock core samples of Granitic Gneiss, 3 samples from Test Pits and 3 Bulk samples from borrow areas. The results are reproduced in Table 5.7.

**Table 5.7 Results of Uniaxial Compressive Strength Test**

| Sr. No. | Bore Hole / Test Pits | Location | Depth (m) | | Test Results | |
|---|---|---|---|---|---|---|
| | | | From | To | UCS (MPa) | Failure Mode |
| 1 | BH-04 | Power Tunnel Alignment | 38.14 | 38.43 | 49.2 | Diagonal |
| 2 | | | 56.00 | 56.39 | 45.2 | Diagonal |
| 3 | | | 68.00 | 68.23 | 38.5 | Diagonal |
| 4 | TP-7 | Slided Mass (Left side) | - | - | 52.40 | Diagonal |
| 5 | TP-8 | Slided Mass (Right side) | - | - | 71.91 | Diagonal |
| 6 | TP-9 | Slided Mass (Right side) | - | - | 34.63 | Diagonal |
| 7 | - | Passu Area | - | - | 47 | Diagonal |
| 8 | - | P/H Area | - | - | 88 | Diagonal & Axial |
| 9 | - | Slided Mass | - | - | 59 | Diagonal & Axial |

Core samples are from only one borehole and all samples are of same lithology. More sampling and testing is required for the better assessment of results and prediction of actual rockmass conditions prevailing in the project area during the detail design stage.

- **Indirect Tensile Strength Test**

Indirect Tensile Strength test is performed on Granitic Gneiss rock. (ITS) Test has been carried out on core samples collected from BH-04, at depth from 43.25 to 43.55m. The (ITS) Test is mostly estimated as 10 to 15% of Uniaxial Compressive Strength (UCS). The labortory test value is 6.46 MPa which indicates that rock is moderately hard.

- **Hoek Triaxial Compressive Strength Test**

Hoek Triaxial Compressive Strength test is performed on 2 rock core samples of Granitic Gneiss. The values of cohesion “C” and angle of internal friction “Ø” calculated by (HTCS) Test, indicates that the shear strength of the rock core samples is low to moderate. The results are reproduced in Table 5.8.



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**Table 5.8 Results of Hoek Triaxial Compressive Strength Test**

| Sr. No. | Borehole No. | Depth | | Cohesion "C" MPa | Angle (Ø) deg. |
|---|---|---|---|---|---|
| | | From | To | | |
| 1 | BH-04 | 52.60 | 53.00 | 2.18 | 27.749 |
| 2 | | 63.00 | 63.35 | 0.60 | 15.543 |

The review of laboratory testing data revealed following.

- The number of test performed on rock samples are not adequate
- Rock samples collected from only 01 borehole i.e., BH-04 is not truly representing the sub surface engineering properties of rocks for whole of the project area
- Test results obtained from rock and soil samples are limited and presenting unexpected variations.
- In case of direct shear test only one sample is not enough to describe the Cohesion and Shear resistance values of a rock type furthermore this test should be performed on all types of rock units existing is the project area.
- The number of test performed are not enough to describe Young Modulus and Modulus of Deformation. The testing should be performed on samples of all rock types.
- For UCS test core samples are from only one borehole and all samples are of same rock type i.e., Granitic Gneiss. Adequate number of tests/ samples and testing is required for the better assessment of results and prediction of actual rockmass conditions prevailing in project area.
- Direct shear test and Uniaxial compressive strength test is performed on the sample taken from the same depth of same borehole (56-56.35m)
- Property Index tests (NMC, Specific Gravity, Porosity, Dry Density, Water absorption) are performed on the samples on which rockmass testing is already performed.

Considering the previously available data, and the project requirement, the subsurface deep investigation and refining/ conforming the information plenty of standardized laboratory testing of site specific rock samples is essentially required by the EPC Contractor for the assessment of rockmass parameters for detailed design.

## 5.4 ADDITIONALLY PROPOSED FIELD AND LABORATORY INVESTIGATIONS

Apart from this limitation of previous stage, for detail design by the EPC Contractor shall require drill holes at the sites of missing structures as well as to drill additional holes at already investigated sites for refining/ conforming the information for use in EPC design. Considering the previously available data, and the project nature, the deep subsurface investigations vertical and inclined both are essentially required by the EPC Contractor for the detailed design. It is recommended to perform the additional geotechnical investigations following the terrain characterization of the project area and prior to the finalization of the project layout plan.

In order to complete the set of data obtained from the ground surveys drilling of some additional boreholes to evaluate the geotechnical and geological conditions at the project components are recommended for Detail design studies by EPC Contractor. These boreholes should be located on the right bank of the weir where no previous borehole present, water intake, surge tank and penstock alignment, in the present powerhouse location (can be used for tailrace structure) and new proposed location of powerhouse.

The locations of the proposed boreholes is given in Table 5.9 and shown in Figure 5.4 and Figure 5.5. This proposal is subject to finalization of project layout during detail design studies.



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**Table 5.9 Coordinates and Locations of Proposed Boreholes for Detail Design**

| Sr. No | Borehole | Northing | Easting | Depth (m) | Location |
|---|---|---|---|---|---|
| 1 | BH-7 | 4018180 | 484021 | 60 | Weir Site (Right abutment) |
| 2 | BH-8 | 4017758 | 484168 | 90 | Power Intake |
| 3 | BH-9 | 4017615 | 481944 | 70 | Surge Tank |
| 4 | BH-10 | 4017720 | 481859 | 80 | Penstock |
| 5 | BH-11 | 4017836 | 481762 | 60 | Proposed Power House Area |
| 6 | BH-12 | 4017961 | 481648 | 60 | Power House Area |

It is proposed to perform laboratory tests in order to define the grain size, permeability and grain size of the slopewash material during the opening of the borehole on the right bank of the weir location.

Lugeon tets should be done during the drilling of boreholes in the intake and surge tank. Also UCS with elastic moduli, unit weight, porosity, point load, UCS and triaxial tests should be perfomed on samples taken from these boreholes.

Menard pressuremeter test is proposed in the location of the penstock and powerhouse.



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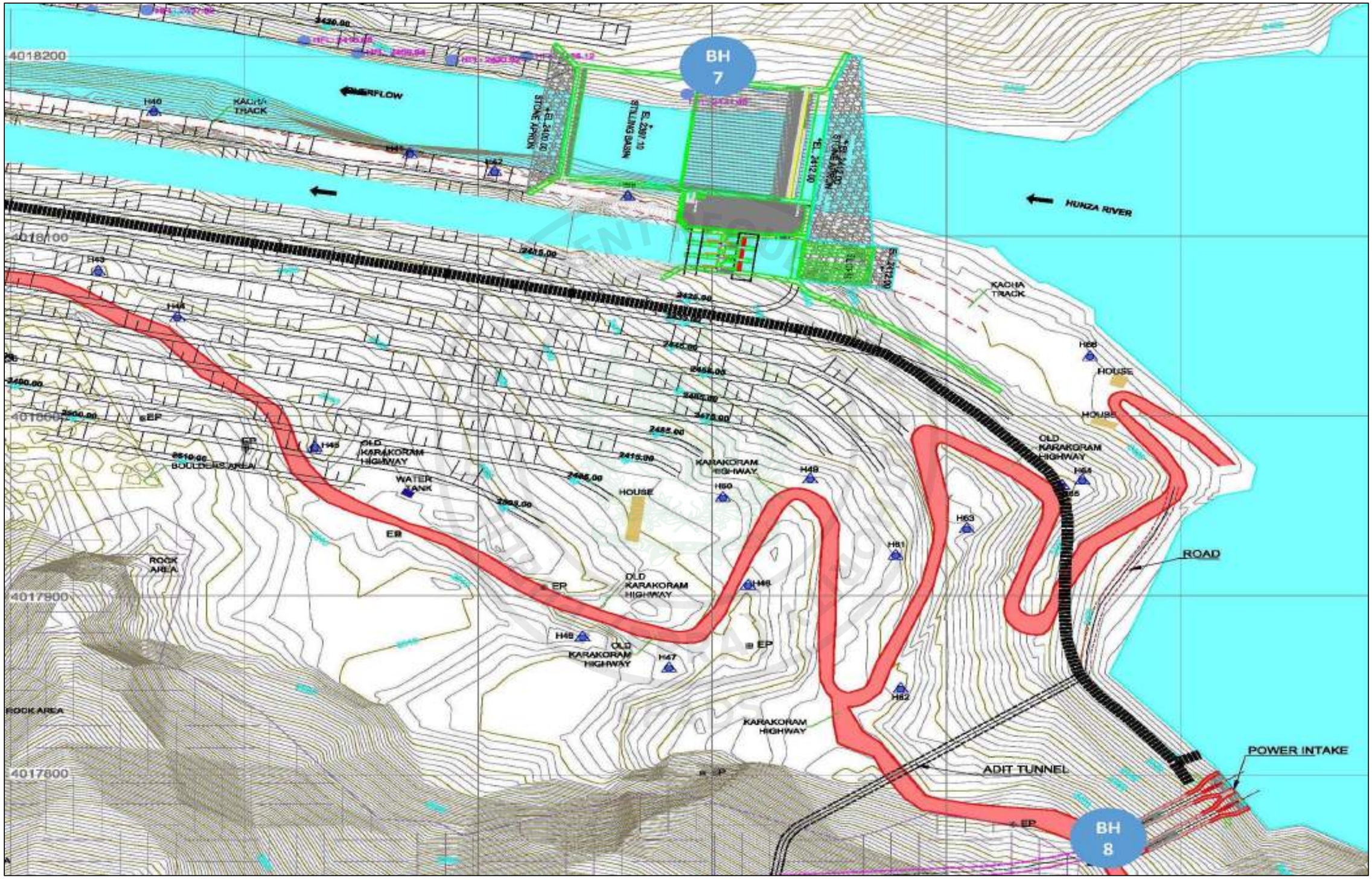


**Figure 5.4: Proposed Borehole Locations of the Weir and Intake Area**



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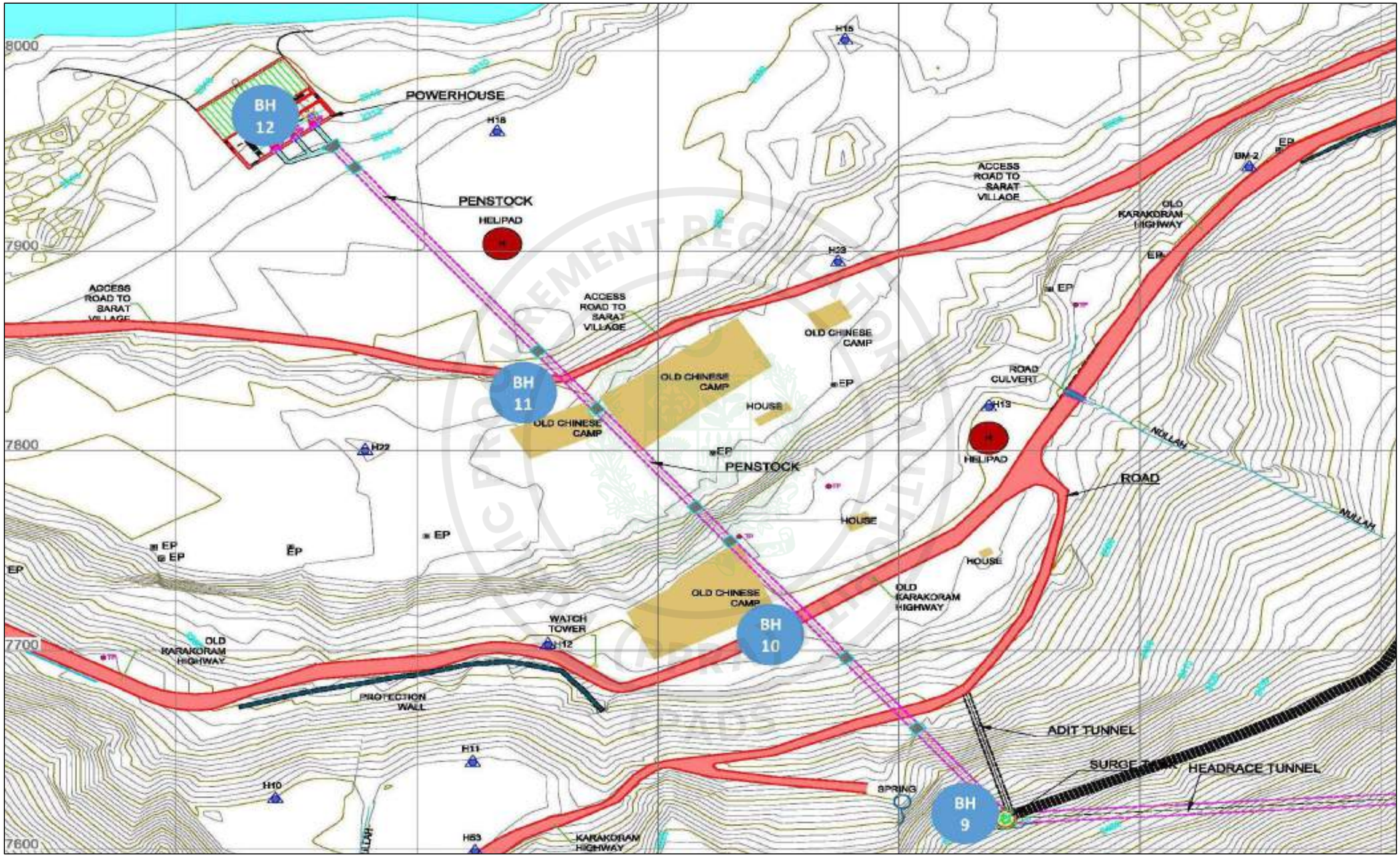


**Figure 5.5: Borehole Locations between Surge Tank and Powerhouse**



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## 5.5 REVIEW OF FOUNDATION EVALUATION

The available documentation reviewed in this regard includes in-situ foundation evaluation as reported under Sub-Section 5.11and further foundation treatments and specific considerations under Sub-Section 10.11, both from Volume-I: Main Report of the Feasibility Study 2021. The FEM models and concept have also been presented in figures as included in Volume-VII: Appendices to the Feasibility Study. Additionally, the project drawings from Volume-II studied for the review include the surface geological cross section of weir and under sluice area as shown in drawing AFS-GE-313 along with the arrangement, plan, cross-section and longitudinal section of these structures as presented in Feasibility study 2021 drawings AFS-GE-408 to AFS-GE-411.

### 5.5.1 Review Findings

The following aspects have been noted from the available documentation:

- **Weir and Under sluice Area**

- BH-1, BH-2 and BH-3 drilled in the slided mass at the location of these structures show that the underlying strata consists of loose, highly pervious ABGM (slided mass), having large size boulders and cavities with no rock till the depth of 90m.
- The foundation of weir is proposed to be laid on this slided mass after foundation treatment.
- It is recommended in Feasibility study to replace a maximum of 14m deep slided mass material with stabilized soil layer as weir foundation treatment.
- Silty clay hauled from the powerhouse area mixed with 2% cement will be placed as foundation material under 60m wide weir.
- Moreover, 2 cutoff walls were also proposed beneath the main structure of the weir and under sluices.
- Permeability of weir area is very high as BH-01 drilling is showing 100% water loss and water head was not maintained/built during the permeability test.
- Geological rock units with which weir has to be abut, includes granodiorite, intruded by pegmatite veins at right side. On left side, weir has to be abut with ABGM formed by slided mass (DWG No: AFS-GE-297 & 298). This statement given in section 5.12 of Attabad Lake HPP Main Feasibility Report is contradictory to the geological maps and geological cross sections.

- **Intake**

- Surface geological section of intake is presented in drawing AFS-GE-314. It is proposed to be excavated in the granodiorite rock which is strong to moderately strong. Granodiorite rock is exposed at steep angle where it is hard, massive, strong to moderately strong, and sparsely to moderately jointed. But at higher elevation, the rock is highly jointed and sheared, having vertical open joints which must be treated for stability and safety.(DWG No: AFS-GE-295 & 298). Intake area slopes alongwith Tunnel Portal slopes stability analysis was not conducted during the Feasibility study.

- **Power tunnel**

- Geological cross-section of power tunnel is missing from the Volume: II Drawings.
- It is proposed to be excavated through grandiorite with subordinate Granitic gneiss.
- BH-4 shows that the rock has high RQD values with low permeability which seems good for tunnel excavation.



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- Data obtained during the feasibility study for tunnel design is not upto the mark for the safe design of the Power Tunnel.

- **Surge Tank**

- It is proposed in moderately hard, highly jointed and sheared granitic gneiss rock.

- Borehole location map AFS-GE-316 shows that no borehole has been drilled at the proposed location.

- **Penstock**

- The Penstock will be supported by piers according to Section 5 “Geology and Geotechnical Studies” whereas according to Section 15 “Construction Planning” the penstock will be laid over concrete in the excavated trench. Moreover, in the “Penstock Plan and Longitudinal Profile” DWG NO. AFS-ST-430, piers and its foundations cannot be observed instead anchor blocks can be observed at the joints.

- The foundation of piers is proposed to be laid on overburden material (sandy gravel and boulder) after removal of clayey silt.

- **Powerhouse**

- The powerhouse layout, plan, cross-section and longitudinal section are presented in Dwg. No. AFS-PH-(431, 432, 435 and 436) respectively.

- BH-05 and BH-06 had been drilled in the proposed power house area. According to the field log BH-05 detects boulders and gravel material at a depth of 30 m whereas BH-06 detects similar material at a depth of 15 m.

- It is proposed to remove the whole thickness of clayey silt layer due to high swelling potential and then lay the foundation of powerhouse on gravels and boulders.

- **Cofferdam**

- The layout and cross-section of coffer dam are provided in drawing AFS-WE-412 and AFS-WE-413.

- The staged construction sequence of cofferdam will comprise the construction of upstream coffer dam along with under sluice channel in stage-I, afterwards, Stage-II cofferdam will be constructed on the upstream of weir site till the completion of weir construction. Diversion flood is selected as 1750 cumecs corresponding to 20-year return period.

- Coffer dam is proposed to be made of silty sand, sandy silt and gravelly sand available at river bed and slided mass. The large boulders present in the slided mass are proposed as riprap material. The foundation of coffer dam will consist of impervious cutoff off provided by intersecting columns of jet grouting.

### 5.5.2 Technical Considerations for Foundations

The following aspects necessitate specific technical considerations regarding foundations of the project structures as described above:

- **Weir and Under sluice Area**

- The longitudinal sections shown in drawing AFS-GE-410 are not clearly consistent with the cross-sections shown in drawing AFS-GE-411, in depicting the proposed treatment of stabilized clay blanket and the depth of cutoff walls. The concept proposed and indicated through the Figures 2.11 and 2.17 along with the respective FEM Models for analysis as shown in Figures 2.12 and 2.18 are also in contrast with the drawings.

- The specific properties of silty clay material from the powerhouse area in-situ and treated have not been lab tested for comparative assessment of utility. Tests like dispersion,



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swelling, shrinkage shear test parameters etc. must be evaluated prior to a recommendation of such a proposal.

- The strata at the weir location seems very critical due to presence of loose ABGM, therefore any excavation through large boulders seems impractical and likely to slide at or during the time of execution.
- Secondly, the clayey blanket is proposed to be placed on the highly pervious and loose slided mass. As clay is always placed in the form of thin compacted layers. The placing and compaction of clay on the slided mass material also seems hazardous and impractical as finer material particles of the clay have the potential to migrate or erode in absence of adequate filters over its foundation. The presence of large cavities further complicates this issue.
- Structural stability of the weir has not been addressed to evaluate its safety in bearing, sliding and overturning scenarios.
- The type of cutoff wall is not finalized rather both options of cement slurry and plastic piles have been indicated. The equipment requirements, execution methodologies and material specifications for each of these options are different and necessitate specific deliberations in context.
- The slide slopes are proposed to be stabilized through benching which seems impractical in such loose material having boulders as large as 25m. The estimated volume and extents of the excavation has the potential to increase considerably out-of-proportion. Due to the critical nature of strata, the excavation is hazardous and attempts to excavate may possibly trigger further land sliding. Moreover, the care and handling of excavation equipment in such area is not feasible.

- **Intake**

- Since, no borehole is drilled at this site so it needs further subsurface investigations.
- It is also reported that the rocks at higher elevation are highly jointed and sheared having vertical open joints which needs to be analyzed and treated for safety and stability.

- **Power Tunnel**

- It is mentioned in Volume-I, the rocks at end of the tunnel are highly sheared and the rock units are crushed which needs to be analyzed and evaluated for the stability of the proposed power tunnel.

- **Surge Tank**

- Surge Tank Plan and Section DWG No. AFS-ST-428 Section A-A shows that Surge Tank is almost 61 meters embedded below the NSL. Due to absence of investigative boreholes the subsurface strata are unknown at this location. Subsurface investigations shall be conducted before evaluating the stability of Surge Tank structure.

- **Penstock**

- Section 5 “Geology and Geotechnical Studies” contradicts with DWG NO. AFS-ST-430 “Penstock Plan and Longitudinal Profile” as piers are proposed to support the Penstock alignment in prior whereas anchor blocks can be observed in later.
- Subsurface investigations along he proposed Penstock length are important for analysis.

- **Powerhouse**

- The underlying strata of powerhouse consists of clayey silt material followed by sandy gravels and boulders. The layers of deposited material may vary as the field logs show different depth of clayey silt material.



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- Cross Section for Powerhouse DWG. AFS-PH-435 shows the depth of the base of the Powerhouse 16 m below the natural surface level. Removal of the whole thickness of clayey silt layer thereby also implies depths greater than the powerhouse base.
- No further details related to powerhouse foundation have been specified in the feasibility report. As such the complete removal of the cover layer (clayey silt) and the proposed foundations for the powerhouse require re-consideration in terms of further clarity.

- **Cofferdam**

- It is reported in the feasibility study that the coffer dam will be constructed for 2-year period but the stability and protection of cofferdam in such slide prone area is not considered in feasibility study. Further, the provision of grouting columns in the slided mass material seems impractical due to presence of large cavities. Also, the quantification of material available at the indicated sites for the construction of dam body is not specified.

### 5.5.3 Recommendations for Foundation Evaluations

- **Weir**

- The EPC Contractor shall perform the detailed engineering geological mapping during detail design stage with a scale of 1:500 to capture the ground information for safely hosting the weir. Moreover, additional geological and geohazard studies shall also be carried out focusing geomechanical properties, terrain characterization and rockmass categorization.
- Additional design stage geotechnical investigations should be performed by EPC Contractor on both left and right abutments and also into the middle part of the Weir foundation/gabion mattress.
- Permeability tests in soil and rock, collection of samples from overburden strata and rock coring for appropriate laboratory testing, must be done for these boreholes.
- A comprehensive cut slope stability analysis should be performed by the EPC Contractor for detailed design of cut slopes in both soil and rock conditions. Suitable slope stability measures shall be then adopted according to the results of analyses including shotcrete, wiremesh, and rock bolts etc.
- Permeability parameters for seepage analysis must be evaluated for near to actual depiction of site conditions in numerical model so that seepage control measures can be adopted. This shall be done by means of appropriate geotechnical investigations and permeability testing in river bed by EPC Contractor.

- **Intake**

- Accurate location of the Intake shall be finalized after terrain characterization and geohazard studies
- Scanline survey and geomechanical properties of the rockmass shall be evaluated by the EPC Contractor during the detailed design stage.
- For stability assessment and detailed design of cut slopes, appropriate geotechnical investigations shall be performed by EPC Contractor at the location of Intake.
- Specialized laboratory testing for evaluating relevant shear strength constitutive model for stability analysis and Uniaxial Compressive Strength (UCS) tests
- Detailed design of bedrock slopes, cut slopes and tunnel portals/ intake area shall be prepared by the EPC Contractor. Selection of type/ layout of protection/ stabilization Measures shall also be prepared by the EPC Contractor.

- **Power Tunnel**



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- The EPC contractor should perform the geologic mapping during detail design stage with a scale of 1:500 along the power tunnel alignment corridor to capture the ground information. Moreover, additional geological and geohazard studies shall also be carried out focusing geomechanical properties, terrain characterization and rockmass categorization.
- Accurate alignment of the tunnel should be finalized after terrain characterization, geological and geohazard studies
- Scanline survey and geomechanical properties of the rockmass shall be evaluated by the EPC Contractor during the tunnel alignment mapping in detailed design stage
- Appropriate geotechnical investigations with vertical and inclined boreholes shall be conducted during the tunnel design.
- Laboratory testing of selected samples should be conducted for evaluating the relevant geotechnical parameters.
- Detailed discontinuity survey/Scanline survey is required across the tunnel alignment for the assessment of rock quality.
- Assessment of rock quality is required by the empirical methods like Rock Mass Rating and Q-Method and evaluate the support across the power tunnel alignment.
- Support of power tunnel alignment is required to check through numerical modeling in computer programs.

- **Surge tank and Penstock**

- The EPC Contractor should perform the geologic mapping during the detail design stage with a scale of 1:500 along the Surge Tank and Penstock alignment to capture the ground information. Moreover, additional geological and geohazard studies shall also be carried out focusing geomechanical properties, terrain characterization and rockmass categorization.
- Any alternations/ adjustments in the locations of Surge Tank and Penstock alignment shall be finalized after terrain characterization and geohazard studies
- Piers will support the penstock alignment, as proposed. In this section, the piers are laid down on overburden material and the presence of clayey silt may create problem and might be excavated prior to establish the foundation for piers.
- Appropriate confirmatory geotechnical investigations shall be performed by EPC Contractor for Surge Tank and Penstock location to assess the strength and other geotechnical parameters of soil and rock.
- For Surge tank Structure, detailed foundation design analysis is required for checking the stability.
- Slope stability analysis is required for the slopes of Surge tank proposed area.

- **Powerhouse and Tailrace Channel**

- The EPC Contractor shall perform the geologic mapping during the detail design stage with a scale of 1:500 in power house area to capture the ground information. Moreover, additional geological and geohazard studies shall also be carried out focusing terrain characterization.
- More refinements, in the proposed and optional locations of Power house should be considered after detailed terrain characterization, geohazard studies and on the basis of the Design stage Investigations if required.
- Appropriate geotechnical investigations and laboratory testing is required for the determination of geotechnical parameters.



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- Detail foundation design analysis are required during the detailed design stage by the EPC Contractor.

## 5.6 REVIEW OF CONSTRUCTION MATERIAL STUDIES

Appropriate selection of the material sources for construction of a project put major impacts on its durability, performance, cost and quality. In the context, a systematic investigation will be required to identify suitable sources for various construction materials. Sources of construction materials will be identified and confirmed for its suitability as per project requirements in the closest vicinity of the project to save time and cost.

Feasibility studies of the proposed hydro power project was carried out in June 2021. Construction materials study conducted during the Feasibility stage including test pit logs and laboratory test results etc. are reviewed and found generic and lacking in many aspects.

### 5.6.1 General Review

- Quantification of construction material suitable sources is not done. It is very important to quantify the suitable sources with respect to the material requirement in the project.
- For qualitative analysis, few mandatory tests for finalization of the suitability of construction materials are missing which are mentioned below in material specific review comments.
- To conclude whether any source has ASR potential, accelerated mortar bar test (ASTM C1260) along with Petrographic examination (ASTM C295) should be done.
- No established rock quarries in the vicinity are studied in this report. Neither any information regarding available established rock quarries is documented. Previous studies of the materials utilized in the construction of three tunnels (left bank of Attabad Lake) can also be useful for the current project.
- For cement, steel, bitumen, concrete admixtures and others manufactured materials, general information is given in the report. Specific studies related to the availability of production of cement types, steel grades-wise and others, are missing in the report and is recommended to be carried out before the preparation of BOQs.
- Attabad Lake itself is the biggest possible source of mixing water used in concrete, which is also not investigated through detailed testing in accordance with ASTM C1602, in this report.
- Fill material requires more investigation and testing to check and finalize the sources. Selection of fill material keeping in view the permeability requirement with respect to each component, is of significant importance. To prevent from seepage, different soil types are required and should be studied separately and sources should be located accordingly in the closest vicinity.
- At least one location map should be prepared showing all the construction material sources discussed in the relevant section.

### 5.6.2 Material Specific Review

- **Fine Aggregate**

Refer section 7.2.1 of the Feasibility report. One sand quarry with only one test pit (TP-1) is studied at Feasibility stage. This is a river bed quarry located in the tail of Attabad Lake. Quantification was not done. Petrography was also not done. Without doing petrographic test, Alkali Silica Reaction potential cannot be concluded. Sieve analysis was done showing percentage of Sand, Silt and Gravel (USCS classification). No fineness modulus was mentioned which is a mandatory requirement for sand size confirmation. Gradation analysis was given in the form of graph and sieve analysis



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details was not given. Soundness test and other deleterious tests (guidelines of ASTM C33) are also missing in the Feasibility Report.

- **Silt and Clay Quarry**

Refer section 7.2.2 of the feasibility report, 3 test pits were done to analyze the fill materials availability in the project area. TP-2 & TP-3 were done in helipad/powerhouse area and TP-10 near Kiln area, near Ganesh Bridge. These natural soils were not classified as per fill material type requirement. Quantification was also not done.

- **Coarse Aggregate**

Refer section 7.3 of the feasibility report, three sources (Slided mass, power house area/river bed and Passu areas) were selected and sampling and testing were carried out accordingly during Feasibility stage for coarse aggregate. Quantification is not done for above three sources.

Passu area quarry is located 35 km upstream of Attabad Lake near Passu village. Rock is marble and have economic importance and generally not permitted to be used as coarse aggregate for concrete (need to check the laws of mineral department, Govt. of Gilgit Baltistan). Petrographic result shows no ASR potential. Remaining two exhibit ASR and cannot be used with ordinary Portland cement. Both sources have significant quantity of fine materials which are not noted. More than 20% deleterious quartz as indicate in their respective petrographic examination make it highly susceptible to ASR potential. Slided Mass (TP-7) shows higher Loss Angeles Abrasion and cannot be used as coarse aggregate in concrete.

### 5.6.3 Recommendation for Construction Material Studies

- Missing testing is recommended for Fine Aggregate to be done with more samples collection from the source to finalize the suitability of the said source. New sand quarries are also recommended to be located for fine aggregate utilization in the project.
- It is recommended to classify silt and clay soils as per ASTM soil classification system.
- As already discussed, that established rock quarries should be studied and documented accordingly. More rock quarries in the vicinity are recommended to be investigated to finalize the suitability of the coarse aggregate.



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# 6 REVIEW OF NEOTECTONICS STUDY AND SEISMIC HAZARD ANALYSIS

## 6.1 GENERAL

A review of the available report/data related to seismological studies was carried out, the following report/data have been reviewed in this regard;

- "Feasibility Report-2021, Volume-IV, Neotectonic and Seismic Hazard Analysis, Attabad Lake Hydropower Project, WAPDA".
- Additional data via email dated September 22, 2022 titled "Attabad HPP: Data requirement for Review of Neotectonics & Seismic Hazard Study".
- Letter with additional data titled "Attabad LHPP-clarification regarding review of Seismic Hazard Study dated October 11, 2022".

## 6.2 REVIEW FINDINGS

On the basis of review of the above mentioned reports/additional data, the findings are as under;

- As a part of Feasibility Study (2021), the seismic hazard evaluation was carried out for selecting the seismic design parameters. The following seismic design parameters were recommended;
  i. Safety Evaluation Earthquake (SEE) = 0.44g for Dam/Weir & 0.38g for Spillway
  ii. Operating Basis Earthquake (OBE)= 0.24g

Overall the work done (seismic design parameters) during feasibility stage needs to update/finalize before or during Detail Design stage due to the following reasons;

- No Ground Motion Prediction Equation (GMPE) for the deep seismic source zone (Hindukush) is used in calculation of seismic design parameters.
- Above mentioned selected seismic design parameters should be comparable with the findings of PSHA (Total Hazard Curves, Response Spectra) and/or DSHA (Table 6.2-1 & 6.2-2 of Feasibility Study).

## 6.3 RECOMMENDATIONS

It is recommended to carry out following surveys/studies before or during Detail Design stage;

- Detailed site specific seismic hazard assessment should have been conducted to authenticate & finalized the seismic design parameters.
- Geologic mapping of faults is also recommended, specifically to confirm the local faults as mentioned in the report.
- Necessary geophysical surveys in support of seismic hazard assessment, where required.



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# 7 REVIEW OF PROJECT LAYOUT STUDIES

## 7.1 GENERAL

Two alternate layouts were studied at Feasibility stage 2021. One was with project components on left bank and one on right bank. A comparative study was done at Feasibility stage for these alternates. Both studies alternates are described in following sections.

## 7.2 ALTERNATIVE-I: PROJECT LAYOUT ON THE LEFT BANK

In the Feasibility study, it is stated that the left bank alternative with Weir and Under sluices, 2.3 km headrace tunnel, surge tank, embedded penstock and a surface power house is favorable alternate and considered suitable to propose a Project. Review of Feasibility study implies that selecting the left bank option is a legitimate decision in terms of topographic conditions and ease of access.

## 7.3 ALTERNATIVE-II: PROJECT LAYOUT ON THE RIGHT BANK

Alternative-II, which is the right bank option, is a less favorable option for Attabad Lake HPP in terms of access, stability of slopes, and ease of construction and same assessment was done during Feasibility study.

The water intake structure planned in alternative-II is far away from the Weir body. For this reason, it is not possible to flush the sediment that will be deposited in front of the intake.

## 7.4 SELECTED LAYOUT AT FEASIBILITY STAGE 2021

The project layout studies were refined during Feasibility study after selection of left bank alternate and further following two alternates were studied on left bank option in detail.

a. Alternate-1A, Headrace Tunnel Option.
b. Alternate-1B, Headrace with Embedded Pressure Pipe.

The selection of the Project Layout (Alternative-I A) on the left bank with identified weir site, 2.3 km long headrace tunnel, 550 m embedded penstock and surface powerhouse in the Feasibility study was more beneficial layout plan for this project in terms of geology, cost/kWh for design discharge, ease of construction and technical reasons.

The selected Project Layout (Alternative-I A) from Feasibility study is reproduced in Figure 7.1.



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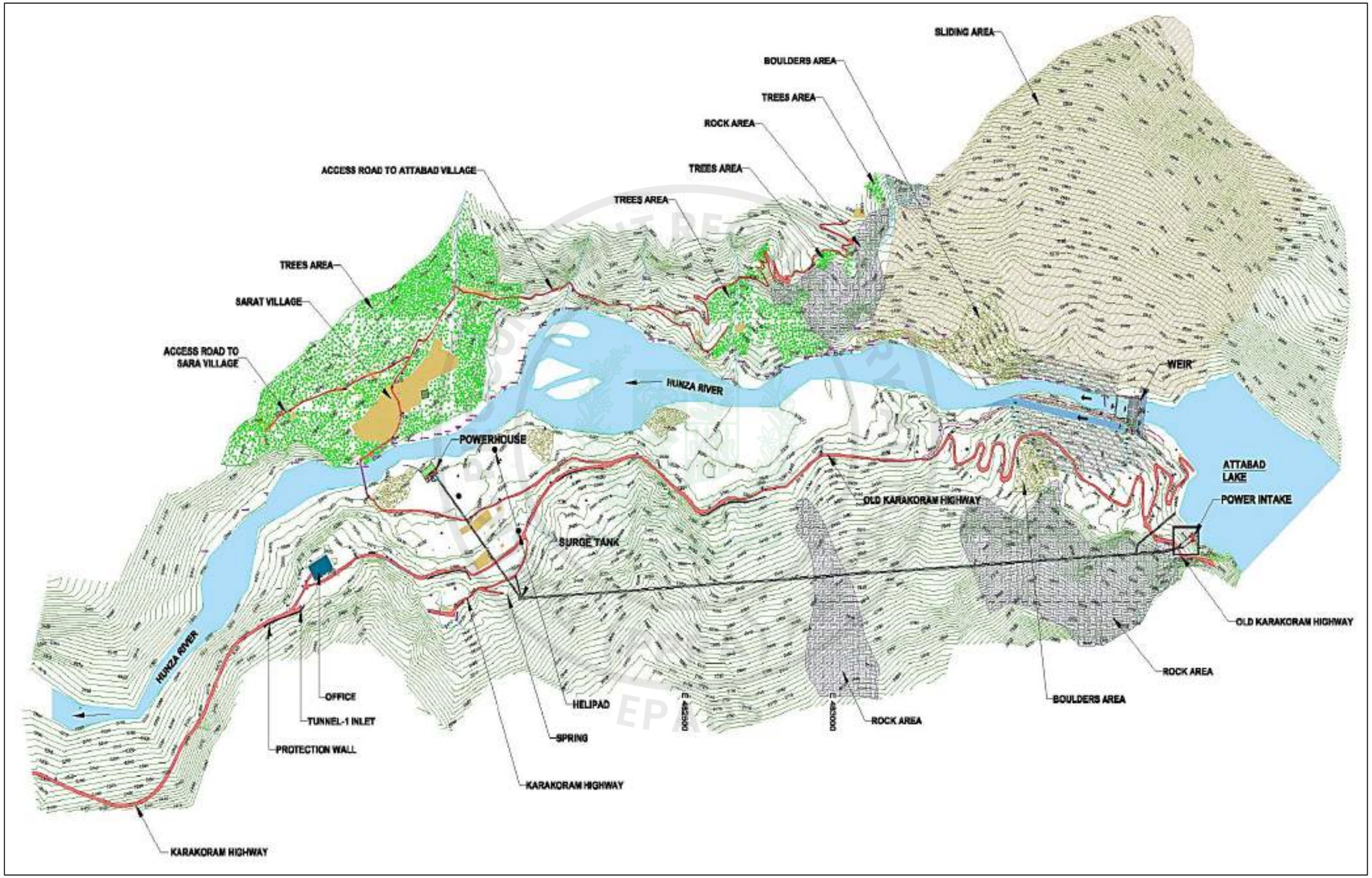


**Figure 7.1: Feasibility stage Project Layout Alternative-1A**



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## 7.5 PROJECT LAYOUT STUDIES AT REVIEW STAGE

The natural Dam created due to landslide resulted in formation of a Lake behind it at Attabad. It not only possess a threat but at the same time an opportunity for making use of the head due to this Earthen Dam. Due to lake formation, there is potential drop of more than 100 m in 2.5 km river reach. The mean annual flow of Hunza River at Attabad Lake is 204 $m^3/s$. The Project Layout is to be configured considering the power demand and demand pattern of regional grid. Attabad Lake storage can be used for daily peaking. A design discharge with peaking storage facility is to be selected to generate the installed capacity 95% time of the year in peak hours. From the available flow data and estimated flow series at Project Area, a discharge of 60 $m^3/s$ has been taken as design discharge.

The Management Consultants have carried out comprehensive review of Project layout and have thoroughly reviewed the technical aspects of all Project components proposed for the Feasibility study 2021 Alternate-I A. Reconnaissance site visit was also conducted to get acquainted with the proposed sites and to give recommendations for EPC Contractor detail design.

### 7.5.1 Site Visit Observations and Feasibility Review Findings for Project Layout

Following sections describe the site visit observations of proposed sites of project components. These site observations are supported by Review findings of Feasibility study 2021.

- **Weir / Spillway and Under Sluice Area**

The slided mound area proposed for the main Weir / Spillway and Under Sluice structures was visited. Landslide material was observed on both banks. Feasibility stage Geotechnical Investigations in this area did not report the bedrock even as deep as 90 m. The overburden was reported to comprise of ABGM of slide mass (in BH-01 and BH-02) or sandy gravels (in BH-03). Although the description may also vary as gravels, cobbles and boulders embedded in silty sandy matrix of mix origin, the physical presence and extent of this strata especially the boulders was realized with this site visit. Excavation for abutments and foundations is risky under such conditions and might be in higher volumes than proposed in Feasibility.

Feasibility stage Weir and Under Sluices layout and longitudinal section is reproduced in Figure 7.2 and Figure 7.3.



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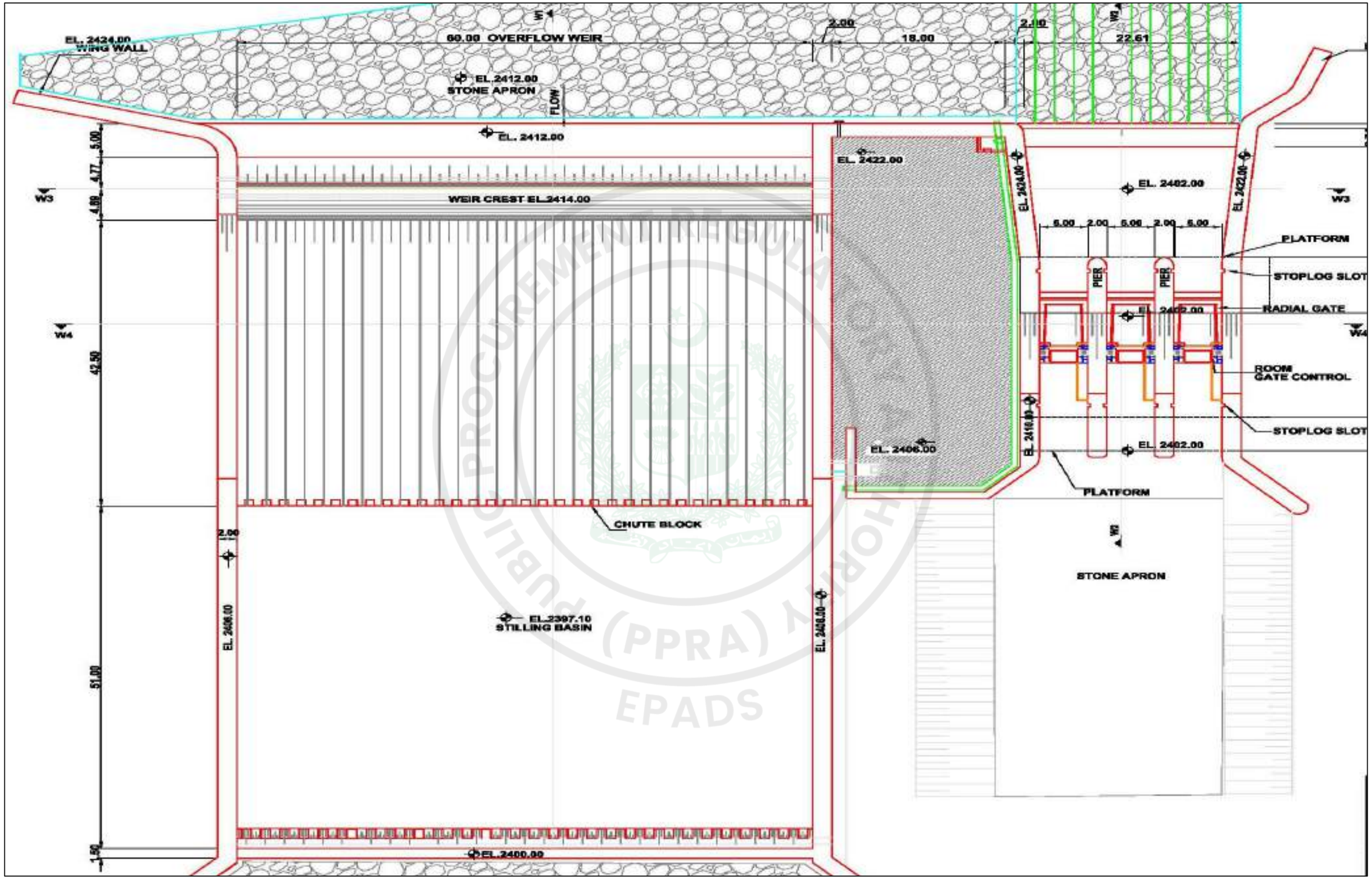


**Figure 7.2: Weir and Under Sluices layout plan from Feasibility Study**



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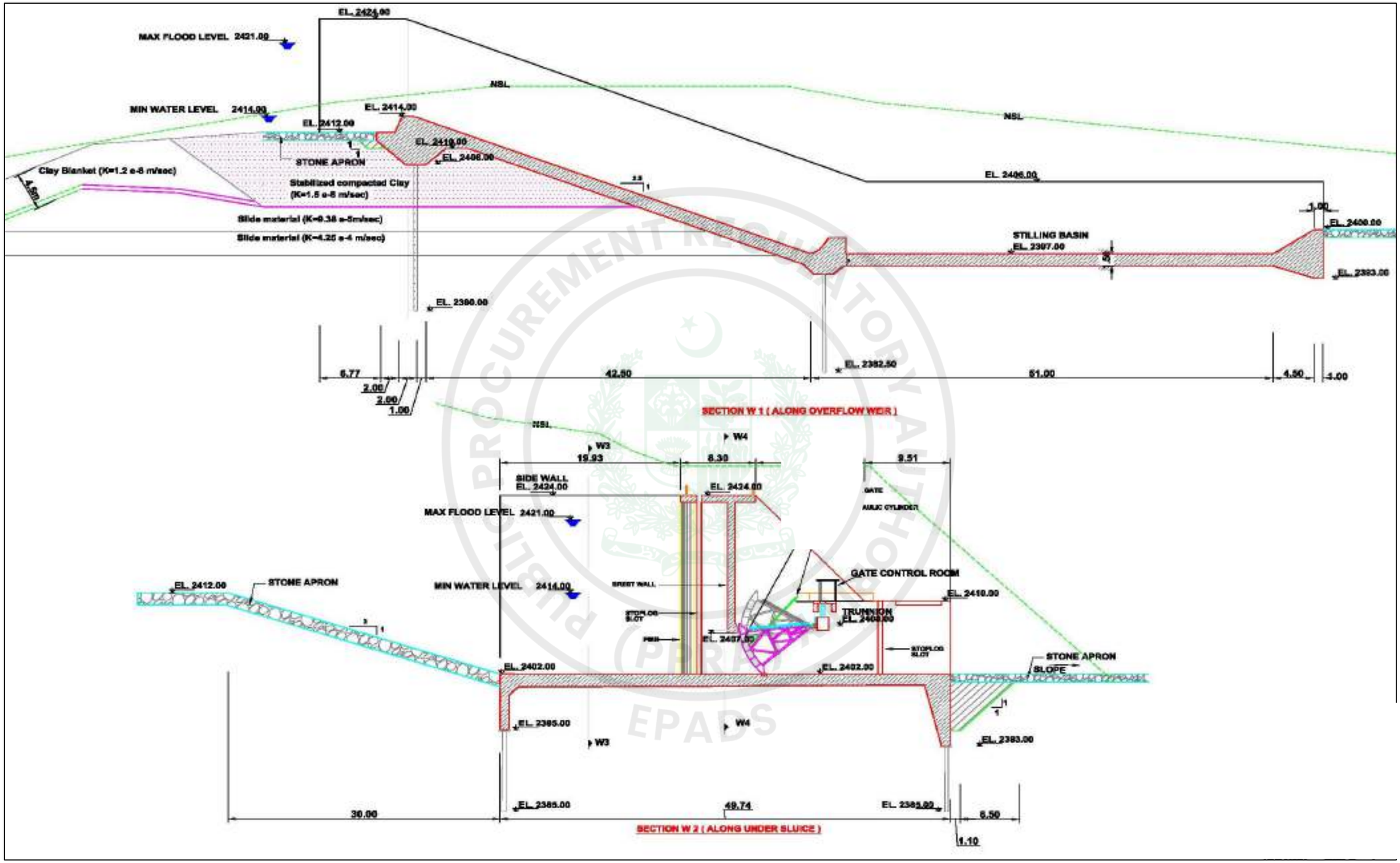


**Figure 7.3: Weir and Under Sluices longitudinal section from Feasibility Study**



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Although, the location of the crest of the proposed Weir and the approach channel were visible, the spillway chute area was inaccessible due to collapse of a portion of the track that runs along the edge of the spillway excavated by FWO. This only reinforces the need for stabilizing the embankment, particularly, in the region of proposed weir.

Weir and Under sluices area needs special care on foundation treatment and seepage under the structures as well as through the banks / abutments. Specific considerations in this regard include the requirement and effectiveness of measures to be adopted for seepage control, practicality of the methods to be utilized for required excavations in slopes and foundations, measures required for stabilizing and / or reinforcing the required excavations, along with the equipment mobilization and installation constraints. Construction of piles / seepage cutoff proposed in Feasibility might be difficult due to presence of boulders. Bentonite mixtures for excavation stability might also be ineffective. Concrete diaphragm or sheet piles will also be difficult. For these reasons, MC initial proposal for ensuring the stability and the seepage of the Weir site is the consolidation grouting using sand mixed grouting with hardening accelerating admixtures. The depth and pattern of the consolidation grouting to be defined in the next design stage (by EPC Contactor).

River bed also needs stabilization to avoid differential settlements of the proposed gated structures. The variability of slide material along with large size boulders present in the slide mass also necessitate a sensitivity / back analysis for justification of the geotechnical parameters to be considered.

The slow erosion of fines from the slide mass from both sides, in contact with the flowing waters of the river was another point of concern. The muddy water was observed due to migration of fines on edges reflected inherent instability of the loose mass to an extent which was alarming while considering this stratum for founding the sensitive structures with hydro-mechanical fixtures like gates, slots etc.

Some of the photographs of Feasibility stage proposed Weir and Under sluices site as taken during reconnaissance site visit are shown in Figure 7.4 through Figure 7.10.

**Figure 7.4: Weir site view from Attabad Lake**



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**Figure 7.5: View from Just Upstream of Weir Axis**

**Figure 7.6: Upstream View from Weir Axis, Muddy water & migrated fines on banks**



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**Figure 7.7: Excavated Spillway view from Weir Axis**

**Figure 7.8: Right Abutment view from Left Abutment, Slide Mound of ABGM**



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**Figure 7.9: Left Abutment view on side track, Large size Boulders from slide material**

**Figure 7.10: Left Abutment, Fresh Slide area and completely damaged walkway / path towards chute area**

- **Intake Area**

The intake area is inaccessible except by boat. The intake appears to be located in relatively sound rock (as good as any seen in the area) and the location is geologically appropriate. However, its construction should pose significant challenge. It is anticipated that there are likely to be structural issues regarding the design of coffer dam and the access chamber for intake gate, trash racks and stop logs. Further, the Hydrology, Sedimentation and Hydraulic



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model data is being reviewed to assess these structural issues. Photograph of Feasibility stage proposed Intake site as taken during reconnaissance site visit is shown in Figure 7.11.

**Figure 7.11: Intake Area view from Upstream of Weir, Sound Rock Exposed**

- **Power Tunnel and Surge Shaft Area**

Geology of Power Tunnel and Surge Shaft area seems appropriate with Granitic Gneiss as also presented in the surface geological maps from Feasibility. The location of surge shaft was flagged to assist in visualizing the alignment of the Penstock to the Powerhouse. The access to surge shaft and headrace tunnel can approached through old KKH.

Four (04) highway tunnels exist in the general area in which the Power Tunnel is to be constructed, so its construction might not pose any problem. The details for the existing highway tunnels of KKH, i.e. the actual alignments marked on plan and profile, the geological mapping information during their construction phase, etc were requested by MC to Client to support and validate geological conditions along the proposed Tunnel. Client arranged construction and as-built drawings of these existing KKH tunnels with alignment, profile and geological data. These support documents were studied by MC to validate the alignment and geological conditions.

The closest part of the headrace scheme to the KKH Tunnel is at surge tank. At this point, the surge tank bottom elevation is 2385 m, whereas the KKH tunnel invert elevation is 2376 m. The perpendicular distance between the outer walls of the structures is 65 m. Since the geological formation is defined as moderately weathered gneiss in the as-built drawings of the KKH tunnel, the interaction between the structures is regarded as safe.

The measures to be taken at the fault zone that is assumed to be present at the middle section of tunnel during site visit which the low pressure tunnel is passing through shall be clarified and incorporated in the tender design. On the other hand, the as-built drawing of KKH tunnel no 2 states that the section that is parallel to the low pressure headrace tunnel is completely in moderately weathered gneiss and a fault zone is not mentioned.

Photograph of Feasibility stage proposed Surge shaft site as taken during reconnaissance site visit is shown in Figure 7.12.



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**Figure 7.12: Flagged Surge shaft Area, Sheared and Jointed Rock Exposed**

- **Penstock**

A single Penstock leads from the surge shaft to the Powerhouse in the feasibility study proposed by WAPDA. Except for the upper reach, the proposed Penstock alignment traverses through relatively easy terrain

In the upper reach, there may be some slope stability issues, although, it appears that the rock line is near the ground surface. Further towards lower elevations, the rock line appears to recede away from the natural ground with fine material on surface with sand and gravel lenses.

It is proposed to drill two boreholes under the anchor blocks in order to have information to be used for the design of anchor blocks. These boreholes can be used also for the powerhouse.

- **Powerhouse Area**

The Powerhouse, as proposed in the Feasibility report, is located on flat terrace along left bank of Hunza River. The site was flagged and marked so it could be identified clearly quite adjacent to the left bank of the river Hunza.

It looks as if rock may not be available under the Powerhouse footprint. However, the area looks satisfactory for construction of the Powerhouse and other appurtenant structures. There also appears to be no slope stability issues at the proposed site.

Photographs of Feasibility stage proposed Powerhouse site as taken during reconnaissance site visit are shown in Figure 7.13 and Figure 7.14.



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**Figure 7.13: Marked Power House Area near Left Bank Hunza River, Overburden visible along the Penstock Alignment**

**Figure 7.14: Flagged Power House Site**



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### 7.5.2 Proposal for Detail Design Regarding Project Layout

A modification in Feasibility stage Alternative-I A layout is proposed by MC based on described review findings and site visit observations. The layout modified by MC is “Modified Alternate-I A” and is presented in figure 7.15. The modifications are to be checked for technical and economic viability during Detail design stage by EPC Contractor. Following are components of this proposal and recommendations for Detail Design are also given.

- **Weir Body**

The naturally formed Attabad Lake dam body due to the landslide has been surviving since 2010. The prevailing scenario of overflow indicates that existing conditions are naturally stabilized. Attempts to excavate side slopes for enlarging the area and/or deepening to place structural foundations has the potential to destabilize the present in-situ conditions. Keeping this fact in mind, MC is proposing to utilize the naturally formed dam body in order to minimize the total cost of the project and to avoid aggravating any further potential geotechnical problems. The naturally formed embankment is proposed to be covered with “flexible gabion mattress” in order to take extra precaution to defend against any further surface erosions due to floods. The gabion mattress offers a prime advantage that the structure can be changed in height and size simply by building up or removing courses of gabions on the existing formation. After a period of operation, the shape of the structure can be adjusted according to requirements, and progressive adjustments can be made thereafter. This way of design will eliminate the necessity of any concrete structure on the Dam axis reducing the cost significantly.

Generally, gabions offer the most convenient solution than most other materials in such situations when substrata problems of permeability, erodibility, and bearing capabilities are faced. Moreover, in addition to their flexibility, which allows them to deform while remaining structurally sound, other advantages which gabions offer are relatively low cost and simplicity of construction. This is specifically significant for this site, where stone is locally available, sophisticated plant and equipment are unnecessary, Skilled craftsmen are not needed, and labour can be fully trained within a matter of days to carry out assembly and erection of the units in the required manner.

However, design of the gabion mattress should involve required hydraulic and structural stability considerations for detailing the geometry, size and fillings. Moreover, numerical and physical model should be undertaken.

The originally proposed 19 m wide under sluice is to be excavated on the left side of an overflow weir / ungated spillway, which is 60 m wide. This under sluice section is proposed primarily for drawdown of the lake level below El. 2400 masl to allow commencement of construction works on the power intake structure. Canceling the previously proposed flushing part of the Weir in the Feasibility Study would make dewatering of the construction site of the power intake and newly proposed flushing tunnel difficult. This is an important disadvantage of the newly proposed layout that should be kept in mind. Conversely, the rock face at the power intake location can also be used to advantage of this alternate proposal. A downstream rearrangement of the intakes (both power and flushing) would allow commencement of construction works on these locations behind a retained natural mound of the rock face acting as a natural plug for the upstream lake levels. The interim construction access can be managed from the downstream around and over the slided mass area to allow uninterrupted construction activities, independent of the lake water levels. The natural upstream plug can later-on be removed near completion of all works by pre-splitting and controlled blasting techniques.



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Construction stages should be considered and discussed thoroughly in the next design phase with **tentative Construction Methodology** as follows.

During low flow season i.e. December, January, February, March and April, the Contractor can work on Weir site by diverting water in two stages. In first stage, local diversion Contractor shall laydown gabion mattress on one side and then remaining portion can be laid down during second stage diversion.

- **Flushing Tunnel**

Since the Under sluices that will be utilized for sediment flushing are being avoided in the proposed alternative layout due to geotechnical issues, a tunnel at a lower level than the power intake structure is proposed to flush out the sediment that is likely to be deposited in front of the intake structure.

The flushing tunnel underneath the intake area is proposed at distance of 7m away in the plan view and flushing tunnel outlet will be after the most disturbed area. In this case the life of Powerhouse can be increased by many years. Only risk involve in this proposal will be outlet portion of the flushing tunnel which will lie in overburden area. Cut and cover conduit or even open channel can be given in this area after a transition. In worst conditions if some damage happens to outlet structure, it can easily repair any time because flushing will not be done throughout the year. One more advantage will be available to us that power house will be running continuously during repair time of this outlet structure.

It is foreseen by MC that a flushing tunnel with a diameter of 5.50 m and a length of approximately 1100 m might be constructed beneath the power intake structure. This flushing tunnel will be capable of flushing about 250 $m^3/s$ discharge with a velocity of approximately 10 m/s which will be enough to convey the sediment downstream without any deposition. The velocity during the operation should not be less than 4 m/s in order not to have sedimentation inside the flushing tunnel. It is recommended to control the flushing tunnel with a gate located at the entrance, as the approach of the access tunnel to the valve chamber remains within the landslide and poses difficulties. Hydromechanical equipment, gate and gate slots must be designed with the corrosive effects of sedimentary water in mind.

The proposed flushing tunnel inlet base elevation is recommended to be 2380 m leaving a distance of approximately 2 x D between the headrace tunnel and flushing tunnel which is thought to be enough for this type of rock formation. The rock formation at the inlet area is classified as Granodiorite and is suitable for tunnel construction. The slope of the flushing tunnel might be selected approximately as 0.5%. The exit elevation of the flushing tunnel will be approximately at 2375 m.

The water velocity is limited (nearly 10 m/s) in the proposed flushing tunnel. Therefore, there is no need for an extraordinary energy dissipater structure at first glance. But riprap or gabion mattress should be placed at the outlet of the flushing tunnel for surface protection. It is also recommended to study a suitable energy dissipater structure in the next design stage. But the detail designer has to consider the possible deposit of sediment at the outlet of the flushing tunnel (inside the proposed energy dissipater structure).

The downstream part of the tunnel will pass through the landslide (about 250 m long from the outlet), and it is difficult to do tunnel excavation in this region. Therefore, the excavation in this region can alternately be open-cut and the system in this region might be an open channel system. However, if there is a probability of a landslide forming in the open cut slopes of this channel, then a closed conduit might be constructed to avoid the probability of blocking the tunnel outlet and the channel by landslide.



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Regarding the **tentative Construction Methodology,** Contractor will approach the intake area of power and flushing tunnels trough an adit from the existing road leaving 3 to 5m plug area of existing rock. Once construction of power intake and flushing tunnel is completed then contractor can remove this rock plug.

Since the sedimentation and flushing of the reservoir depend on lots of variables, the flushing tunnel diameter, discharge capacity, effectiveness of the system and intake level must be determined with a hydraulic numerical model study / physical model study by EPC contractor. The EPC Contractor should carry out the detail design of the tunnel in such a manner that any damage (abrasion, cavitation, etc.) to the concrete cover or rock mass in the flushing tunnel can be prevented during flushing operation.

Following are the recommendations regarding hydrological and sedimentation aspects for proposed flushing tunnel.

- Flushing tunnel should run periodically to remove silts deposited in front of power intake or nearby power intake vicinity.
- Flushing tunnel is purposed to be adopted for removal of certain estimated capacity of sediments, not for flushing maximum sediment volume.
- Flushing tunnel should be operational by considering reservoir storage capacity in balance position.
- Water availability, Reservoir operation for power generation and Flushing tunnel action to be linked in such a manner to keep project parameters and objectives functional.
- Flows study indicated that after utilization of 60 cumecs design discharge, water releases / spill periods are (May to October) with maximum releases in July (679 cumecs) and August (649 cumecs), respectively. Lean period from (Nov to April), where shortages are reduces by utilization of reservoir live storage water.
- Selection period for flushing is to be in July and August. The water release volume would be used for flushing purpose, which keep the reservoir storage capacity in balance. Sediment study also reflected, maximum sediment deposition in July and August. So, July and August are ideal periods for flushing tunnel operational, which would enhance project life and meet the objectives in a successful manner.

- **Power Tunnel Design Aspects**

Power Tunnel alignment seems appropriate. However, surface overburden is present along the Power Tunnel alignment as presented in the surface geological maps from Feasibility study which might be an indication of less rock cover. This aspect is to be studied during Detail Design studies by EPC Contractor. Moreover, the surge shaft / end portal of the Power Tunnel appears to end in sheared and jointed rock in terrain susceptible to external slope stability failure. This has to be given due consideration in Detail Design studies, particularly in view of the fact that the area is prone to earthquakes of large magnitudes.

- **Powerhouse**

Surface Powerhouse as proposed in Feasibility study is located adjacent to main river on an alluvium terrace. To minimize cost of protection works from maximum flood and for its increased safety, the Powerhouse may be moved to a slightly higher ground. It would reduce the Penstock length, at the cost of some extra excavation being proposed on an elevated surface profile for Powerhouse. The excavation may also additionally safeguard against structural stability issues. However, the primary measures of foundation design might remain similar to the pervious conceptual location, due to similarity in the strata. At the proposed site, surface powerhouse can be constructed. Surface powerhouse, tailrace channel and bifurcated penstock can be placed at required elevation by excavating the alluvium.



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Another possibility, which can be explored, is underground powerhouse. In case of underground length of steel liner will become minimum length while length of tailrace channel will become longest. In this case head losses will become minimum. The project area is located in zone-4 regarding seismic activities. It is evident from past experiences that underground power houses behave much better as compared to surface Powerhouses during any seismic hazard activity. If economics allow, technically this option will be more stable safe with minimum O & M requirements.

### 7.5.3 Future Prospects of Modified Layout

A schematic drawing showing the proposed modifications in Feasibility study Alternative-I A layout is presented in Figure 7.15 as “Modified Alternate-1A layout”.

If in case all slide material is washed away at Weir site then a temporary coffer dam can be added in front of intake area in a shorter duration which will restore power house and then a new / fresh Weir/ Dam in this area can be constructed.

If intake structure is moved to Weir location and in case all slide material washes away then in this scenario considerable time will be required for restoration of Weir/Dam for generation of power.

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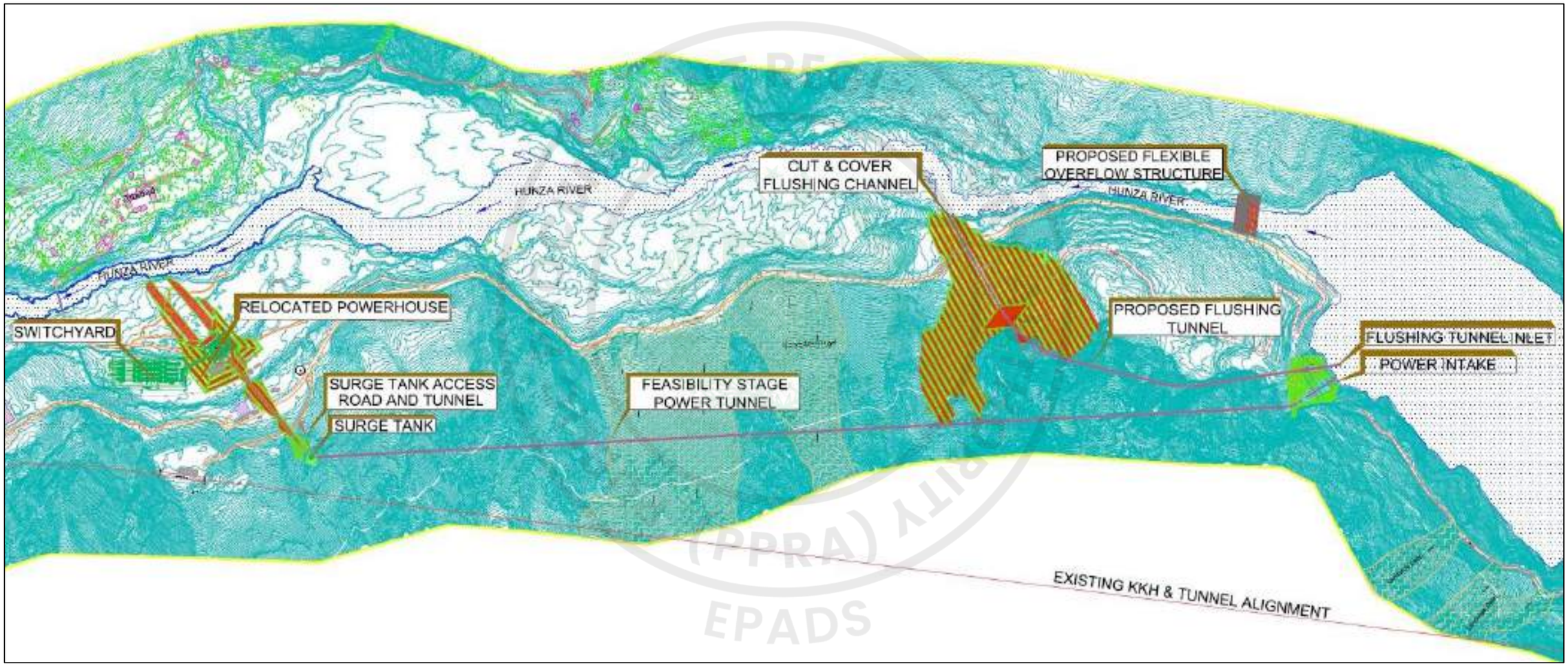


**Figure 7.15: Proposed Modified Alternate-1A layout**



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# 8 REVIEW OF POWER POTENTIAL STUDIES

## 8.1 GENERAL

The demand for electricity varies seasonally. In lower areas of the country demand reaches to its maximum in summer season and remains lower in winter. But in northern area of the country especially in Gilgit-Baltistan (GB) demand for power and energy is maximum in winter season and remains within lower ranges in summer. Electricity demands also vary during the same day, people use more power in the morning and in the evening. Therefore, many powerhouses are managed to tackle such peak times. For this purpose, temporary storage is done in the lake/pond/forebay and releases during peak hours. Such projects have small storage as compared to large dam's storage.

As the lake had already been developed so reservoir capacity has not been enhanced than present to avoid inundation of upstream areas due to increase of water levels, however, flushing will be carried out to retain the present capacity of the lake. Area Capacity Curve from Feasibility study is shown in Figure 8.1.

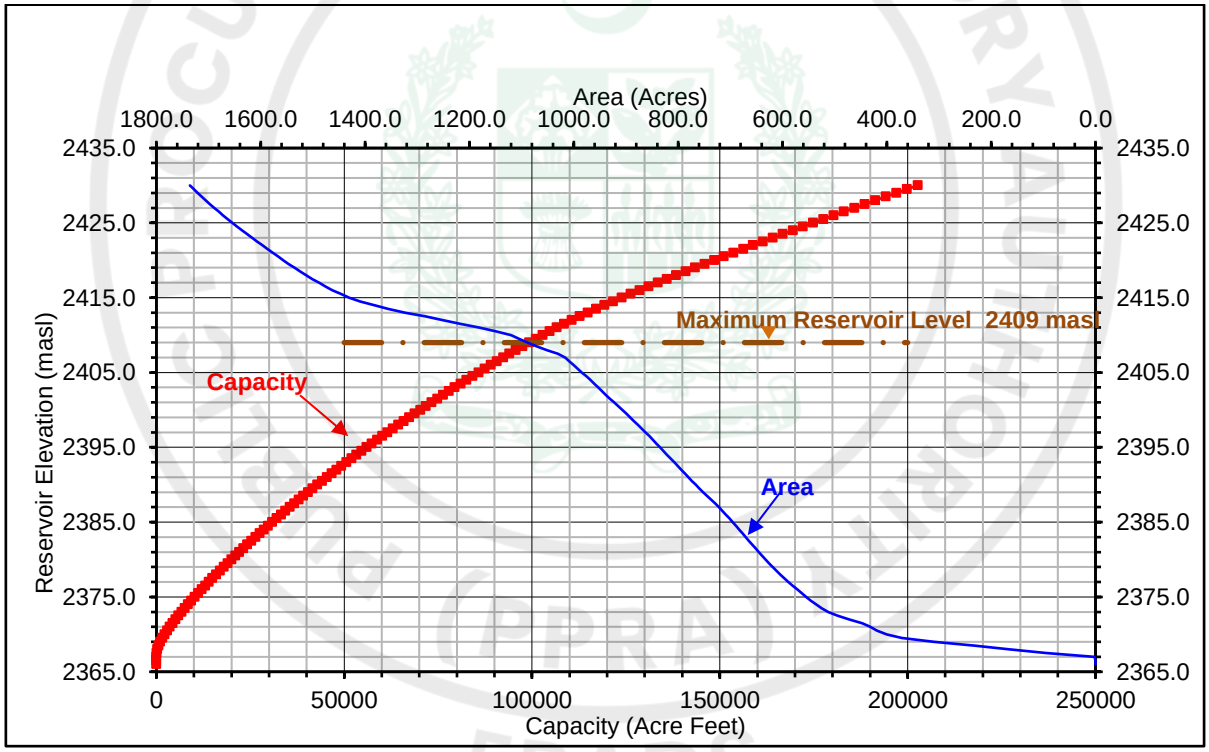


**Figure 8.1: Area Capacity Curve**

## 8.2 WATER AVAILABILITY AT RESERVOIR

Mean annual flows are calculated for the period 1966-2015. Average value for mean annual flow has been calculated as 208.36 $m^3/s$. Flows are generally maximum in July and August almost touching 700 $m^3/s$. Whereas, flows are low from December to April each year when snow falls in the catchment. The graph shows that design discharge of 60 $m^3/s$ is available for about half year (almost 6 months). Graph also shows that flows are exceeding the design discharge from June to mid-December which shows the potential of hydropower generation. Graphical presentation of Mean Annual Flows is shown in Figure 8.2 and graphical presentation of Mean Monthly Flows is shown in Figure 8.3.




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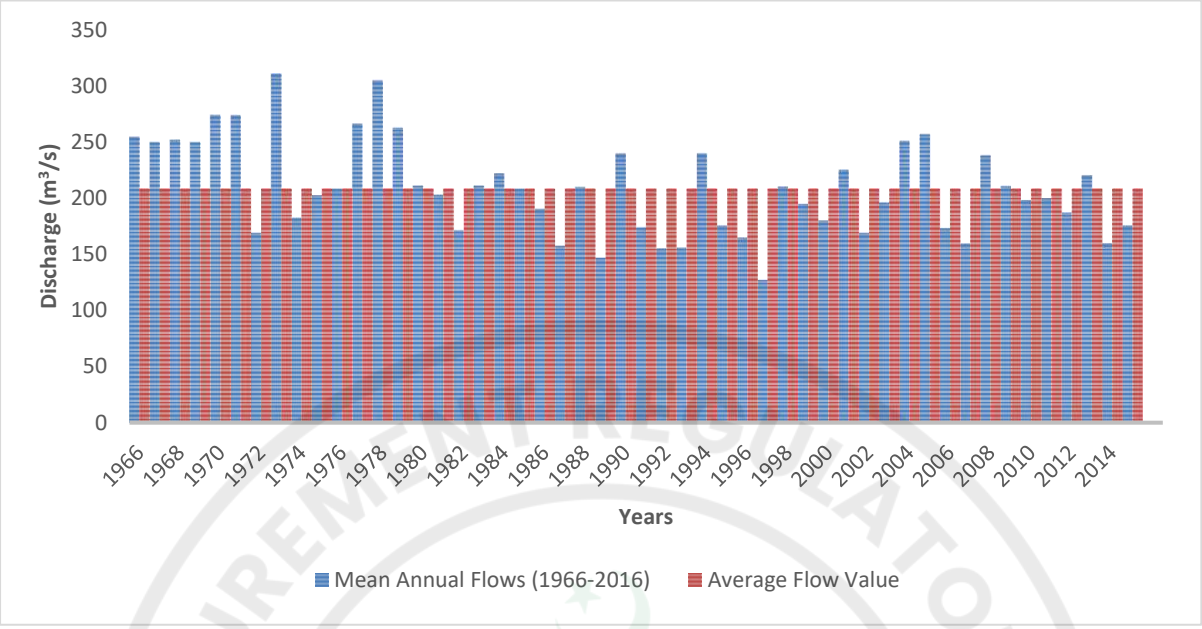


**Figure 8.2: Mean Annual Flows**

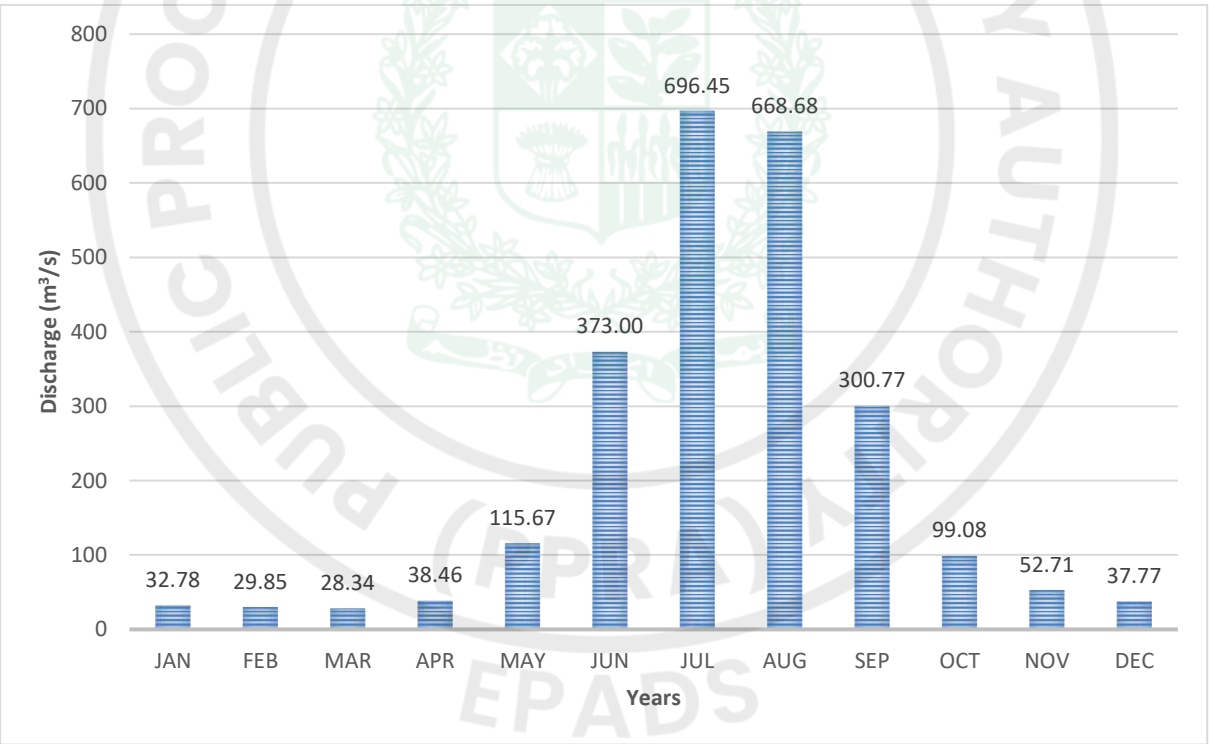


**Figure 8.3: Mean Monthly Flows**

Maximum, Mean and Minimum daily flows for the period 1966-2015 are also plotted in the Figure 8.4 to depict the flow pattern at Attabad Lake site.




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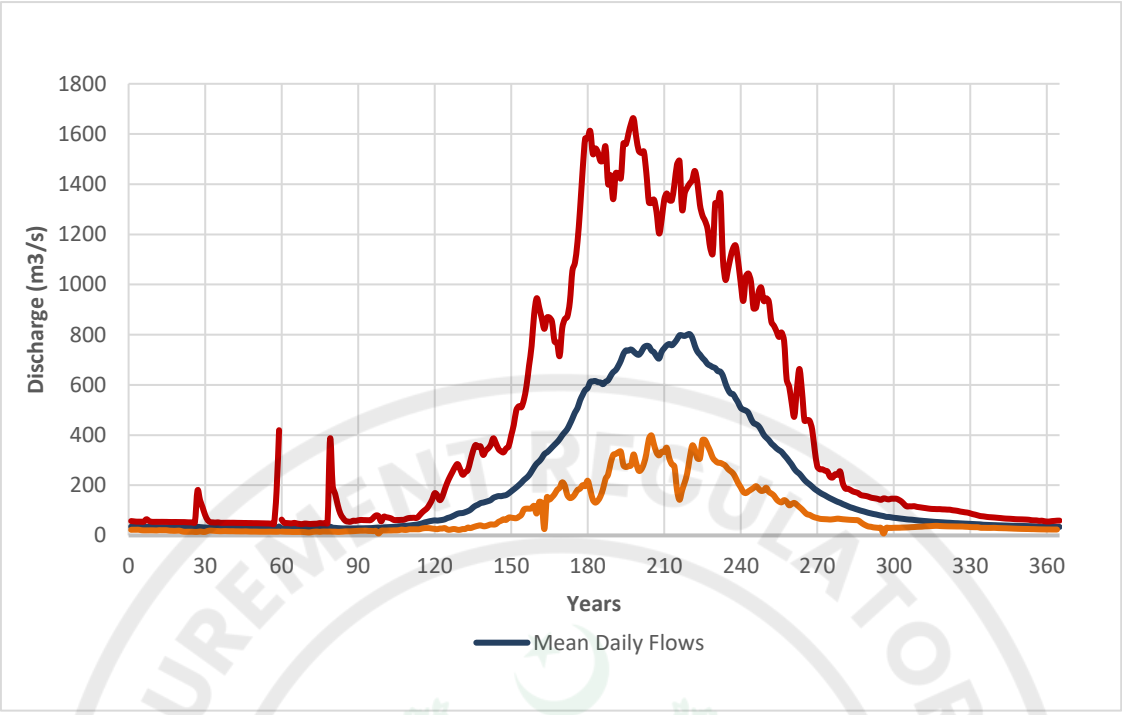


**Figure 8.4: Mean, Maximum & Minimum Daily Flows**

### 8.2.1 Flow Duration Curve (FDC)

Flow Duration Curve (FDC) for Attabad Lake HPP as plotted on the basis of almost 51 years (1966-2016) is shown here in Figure 8.5. Flow duration curve results are shown in Table 8.1. From FDC it is evident that design discharge of 60 $m^3/s$ is available for almost 50% of the time. Therefore, design discharge of 60 $m^3/s$ is justified for the generation of 54 MW power.

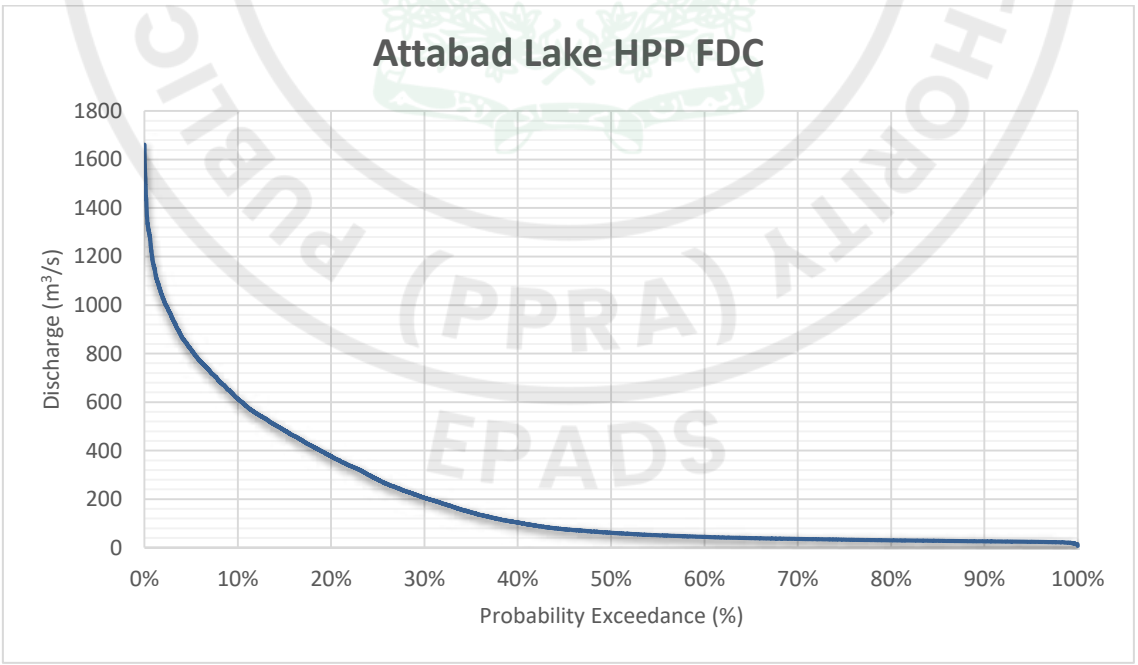


**Figure 8.5 Attabad Lake Flow Duration Curve (FDC)**



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**Table 8.1: Flow Duration Curve Results**

| Probability Exceedance (%) | Flow ($m^3/s$) | Probability Exceedance (%) | Flow ($m^3/s$) |
|---|---|---|---|
| 10 | 613.4 | 60 | 44.3 |
| 20 | 376.6 | 70 | 36 |
| 30 | 205 | 80 | 30.3 |
| 40 | 103.3 | 90 | 26.2 |
| 50 | 61.3 | 99 | 20.5 |

### 8.2.2 Tail Water Rating Curve

In the Feasibility Study, tail-water rating curve for the downstream of Powerhouse was presented. However, the details of the calculations were not stated in the report such as manning coefficient assumed, which cross-section the calculations have been made on etc. The tailwater rating curve has been calculated during Review studies using HecRAS with cross sections from Feasibility study drawings and 2-3 m of difference has been obtained for all discharges. This might be due to the reason that the cross sectional information and other inputs are not know. Therefore, the difference in the results seems acceptable.

## 8.3 POWER AND ENERGY STUDIES

### 8.3.1 Net Head

Net design head in the Feasibility Report has been reported to vary between 105 m to 107 m. Review study revealed that the net head varies from 104.5 m to 106.5 m, therefore the results are significantly close to each other and acceptable at the feasibility stage.

The river discharge given in the 2nd period of July 1998 in Table 8-7 of the Feasibility Report is 832.02 $m^3/s$. 60 $m^3/s$ part of this discharge is used for energy production in the power plant and the remaining 772.02 $m^3/s$ is discharged through spillway. In this case, the water level elevation in the reservoir becomes approximately 2417.28 m according to our calculations. The water level for the same period in Figure 8-7 is 2416.80 m, which is close enough for the feasibility phase.

Tailwater water levels at various discharges given in Feasibility report Figure 8-8 coincide with the information given in Table 8.3. It has been determined that the information given in Section 8.5.2 (Table 8.3) of Feasibility report is sufficiently accurate and acceptable.

The tailwater channel width appears to be 45 m in the Powerhouse drawings. When the water height is calculated for 60 $m^3/sec$ discharge in accordance with this width, the water depth above the crest is 0.85 m and the water level is 2298.85 m. In this case, it is understood that the water level of the stream bed (Feasibility Report Figure 8-8) dictates the tail water elevation and the net head calculations should be made accordingly.

### 8.3.2 Power and Energy Potential

Power and energy potential at the site have been estimated on average 10-daily basis using time series data from 1966 to 2015. Available head across the hydropower facility has been computed keeping in view the minimum and maximum operation water levels i.e. 2,012 to 2,014 m.a.s.l. Tailwater rating curve has been used for estimating the tailwater levels on the downstream side for determining the head available for power generation.

The power estimates have been computed by using the following formula and efficiency coefficients are given in Table 8.2.



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$$P = \frac{\gamma \times n \times g \times H \times Q}{1000}$$

where,

| | | |
|---|---|---|
| P | = | Power output, 54 MW |
| ρ | = | Density of water, 1,000 kg /$m^3$ |
| g | = | Gravity acceleration, 9.81 m/$s^2$ |
| η | = | Overall efficiency of the hydroelectric plant 88.32% |
| Q | = | Design discharge, 60m3/s |
| H | = | Net Head varies between 105 m to 107.5 m depending head Water levels |

**Table 8.2: Efficiency Coefficients of Various Power Plant Components**

| Component | Efficiency |
|---|---|
| Turbine & Speed Increaser | 91.5% |
| Generator | 97.5% |
| Transformer | 99% |
| **Overall** | 88.32% |

The average daily energy has been calculated as follows:

$$E = \frac{P \times h \times d}{1000}$$

where,

| | | |
|---|---|---|
| E | = | Energy output (GWh) |
| P | = | Power output (MW) |
| h | = | Hours in a day |
| d | = | Number of days in each time step |

### 8.3.3 Optimization of Power and Energy

In previous studies (year 2017), 32.5 MW capacity plant had been proposed for this project, however, keeping in view the potential of the lake and availability of head, the power and energy optimization have been carried out to size the plant. Upstream water levels and tail water rating along with the average flow data for the period 1966 to 2015 have been used for calculating the power, energy and plant factor.

Comparison of power and energy potential of this study with the previous study has been tabulated in Table 8.3.



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**Table 8.3: Summary of Power & Energy Potential**

| Power and Energy Parameters | As in Previous Studies Conducted through Consultants | As in Feasibility Study, 2021, Conducted by WAPDA |
|---|---|---|
| Design Discharge ($m^3/s$) | 40 | 60 |
| Gross Head (m) | 106 | 112 |
| Power Capacity (MW) | 32.5 | 54 |
| Mean Annual Energy (GWh) | 256.66 | 373.69 |
| Plant Factor (%) | 92.70 | 79 |

## 8.4 REVIEW STAGE CONFIRMATORY ENERGY CALCULATIONS

Review stage confirmatory energy calculations by MC have been done for three options for validation purpose.

a. With (02) No. Generating Units.
b. With (03) No. Generating Units.
c. With (04) No. Generating Units.

The detail calculations are presented in following sections.



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### 8.4.1 Power and Energy Calculations based on Flow Duration Curve (FDC) method with Two (02) No. of Generating Units.



**ATTABAD LAKE HYDROPOWER PROJECT**

**TABLE 8.1**

**POWER AND ENERGY CALCULATIONS**

(FLOW DURATION CURVE METHOD)

| | | | | |
|---|---|---|---|---|
| Design Discharge | $Q_D$ | = | **60.0** | $m^3$/sec |
| Environmental Flows | $Q_E$ | = | **0.00** | $m^3$/sec |
| No. of Units | | = | **2** | *FRANCIS* |
| Design Discharge (single unit) | $Q_{unit}$ | = | **30.000** | $m^3$/sec |
| Gross Head | $H_g$ | = | 112.00 | m |
| Head Loss | $H_L$ | = | 6.00 | m |
| Net Head | $H_n$ | = | **106.00** | m |
| Turbine Efficiency at Design Discharge | $h_T$ | = | 91.5% | |
| Generator Efficiency | $h_G$ | = | 96.6% | |
| Transformer Efficiency | $h_{Tr}$ | = | 98.0% | |
| Flushing Period | $T_{FL}$ | = | 10 | days |

| | | |
|---|---|---|
| **GROSS POWER** | **54.04** | **MW** |
| **ANNUAL ENERG** | **372.779** | **GWh** |
| **PLANT FACTOR** | **78.740** | **%** |

| TIME INCR. | | PERIOD | FLOW DURATION | NET HEAD | TURBINE - 1 | | | | TURBINE - 2 | | | | Total Powe | ANNUAL ENERGY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | $Q_1$ | $h_{T1}$ | Power$_1$ | Energy$_1$ | $Q_2$ | $h_{T2}$ | Power$_2$ | Energy$_2$ | P=P1+P2 +P3+P4 | Total |
| (Days) | (%) | (Days) | ($m^3$/s) | (m) | ($m^3$/s) | (%) | (MW) | (GWh) | ($m^3$/s) | (%) | (MW) | (GWh) | (MW) | (GWh) |
| 1 | 0.3% | 4 | 1567.123 | 106.0 | 30.000 | 93.3% | 27.554 | 2.645 | 30.000 | 93.3% | 27.554 | 2.645 | 55.108 | 5.290 |
| 5 | 1.4% | 5 | 1436.616 | 106.0 | 30.000 | 93.3% | 27.554 | 3.306 | 30.000 | 93.3% | 27.554 | 3.306 | 55.108 | 6.613 |
| 10 | 2.7% | 5 | 1271.233 | 106.0 | 30.000 | 93.3% | 27.554 | 3.306 | 30.000 | 93.3% | 27.554 | 3.306 | 55.108 | 6.613 |
| 15 | 4.1% | 5 | 1106.849 | 106.0 | 30.000 | 93.3% | 27.554 | 3.306 | 30.000 | 93.3% | 27.554 | 3.306 | 55.108 | 6.613 |



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| TIME INCR. | | PERIOD | FLOW DURATION | NET HEAD | TURBINE - 1 | | | | TURBINE - 2 | | | | Total Power P=P1+P2 +P3+P4 | ANNUAL ENERGY Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | $Q_1$ | $\eta_{T1}$ | $Power_1$ | $Energy_1$ | $Q_2$ | $\eta_{T2}$ | $Power_2$ | $Energy_2$ | | |
| (Days) | (%) | (Days) | ($m^3/s$) | (m) | ($m^3/s$) | (%) | (MW) | (GWh) | ($m^3/s$) | (%) | (MW) | (GWh) | (MW) | (GWh) |
| 20 | 5.5% | 5 | 962.929 | 106.0 | 30.000 | 93.3% | 27.554 | 3.306 | 30.000 | 93.3% | 27.554 | 3.306 | 55.108 | 6.613 |
| 25 | 6.8% | 5 | 857.011 | 106.0 | 30.000 | 93.3% | 27.554 | 3.306 | 30.000 | 93.3% | 27.554 | 3.306 | 55.108 | 6.613 |
| 30 | 8.2% | 5 | 751.093 | 106.0 | 30.000 | 93.3% | 27.554 | 3.306 | 30.000 | 93.3% | 27.554 | 3.306 | 55.108 | 6.613 |
| 35 | 9.6% | 5 | 645.175 | 106.0 | 30.000 | 93.3% | 27.554 | 3.306 | 30.000 | 93.3% | 27.554 | 3.306 | 55.108 | 6.613 |
| 40 | 11.0% | 5 | 590.693 | 106.0 | 30.000 | 93.3% | 27.554 | 3.306 | 30.000 | 93.3% | 27.554 | 3.306 | 55.108 | 6.613 |
| 45 | 12.3% | 5 | 558.255 | 106.0 | 30.000 | 93.3% | 27.554 | 3.306 | 30.000 | 93.3% | 27.554 | 3.306 | 55.108 | 6.613 |
| 50 | 13.7% | 5 | 525.816 | 106.0 | 30.000 | 93.3% | 27.554 | 3.306 | 30.000 | 93.3% | 27.554 | 3.306 | 55.108 | 6.613 |
| 55 | 15.1% | 5 | 493.378 | 106.0 | 30.000 | 93.3% | 27.554 | 3.306 | 30.000 | 93.3% | 27.554 | 3.306 | 55.108 | 6.613 |
| 60 | 16.4% | 5 | 460.940 | 106.0 | 30.000 | 93.3% | 27.554 | 3.306 | 30.000 | 93.3% | 27.554 | 3.306 | 55.108 | 6.613 |
| 65 | 17.8% | 5 | 428.501 | 106.0 | 30.000 | 93.3% | 27.554 | 3.306 | 30.000 | 93.3% | 27.554 | 3.306 | 55.108 | 6.613 |
| 70 | 19.2% | 5 | 396.063 | 106.0 | 30.000 | 93.3% | 27.554 | 3.306 | 30.000 | 93.3% | 27.554 | 3.306 | 55.108 | 6.613 |
| 75 | 20.5% | 5 | 367.197 | 106.0 | 30.000 | 93.3% | 27.554 | 3.306 | 30.000 | 93.3% | 27.554 | 3.306 | 55.108 | 6.613 |
| 80 | 21.9% | 5 | 343.690 | 106.0 | 30.000 | 93.3% | 27.554 | 3.306 | 30.000 | 93.3% | 27.554 | 3.306 | 55.108 | 6.613 |
| 85 | 23.3% | 5 | 320.184 | 106.0 | 30.000 | 93.3% | 27.554 | 3.306 | 30.000 | 93.3% | 27.554 | 3.306 | 55.108 | 6.613 |
| 90 | 24.7% | 5 | 296.677 | 106.0 | 30.000 | 93.3% | 27.554 | 3.306 | 30.000 | 93.3% | 27.554 | 3.306 | 55.108 | 6.613 |
| 95 | 26.0% | 5 | 273.170 | 106.0 | 30.000 | 93.3% | 27.554 | 3.306 | 30.000 | 93.3% | 27.554 | 3.306 | 55.108 | 6.613 |
| 100 | 27.4% | 5 | 249.663 | 106.0 | 30.000 | 93.3% | 27.554 | 3.306 | 30.000 | 93.3% | 27.554 | 3.306 | 55.108 | 6.613 |
| 105 | 28.8% | 5 | 226.156 | 106.0 | 30.000 | 93.3% | 27.554 | 3.306 | 30.000 | 93.3% | 27.554 | 3.306 | 55.108 | 6.613 |
| 110 | 30.1% | 5 | 203.807 | 106.0 | 30.000 | 93.3% | 27.554 | 3.306 | 30.000 | 93.3% | 27.554 | 3.306 | 55.108 | 6.613 |
| 115 | 31.5% | 5 | 189.675 | 106.0 | 30.000 | 93.3% | 27.554 | 3.306 | 30.000 | 93.3% | 27.554 | 3.306 | 55.108 | 6.613 |
| 120 | 32.9% | 5 | 175.744 | 106.0 | 30.000 | 93.3% | 27.554 | 3.306 | 30.000 | 93.3% | 27.554 | 3.306 | 55.108 | 6.613 |



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| TIME INCR. | | PERIOD | FLOW DURATION | NET HEAD | TURBINE - 1 | | | | TURBINE - 2 | | | | Total Power | ANNUAL ENERGY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | $Q_1$ | $\eta_{T1}$ | $Power_1$ | $Energy_1$ | $Q_2$ | $\eta_{T2}$ | $Power_2$ | $Energy_2$ | P=P1+P2 +P3+P4 | Total |
| (Days) | (%) | (Days) | ($m^3/s$) | (m) | ($m^3/s$) | (%) | (MW) | (GWh) | ($m^3/s$) | (%) | (MW) | (GWh) | (MW) | (GWh) |
| 125 | 34.2% | 5 | 161.812 | 106.0 | 30.000 | 93.3% | 27.554 | 3.306 | 30.000 | 93.3% | 27.554 | 3.306 | 55.108 | 6.613 |
| 130 | 35.6% | 5 | 147.881 | 106.0 | 30.000 | 93.3% | 27.554 | 3.306 | 30.000 | 93.3% | 27.554 | 3.306 | 55.108 | 6.613 |
| 135 | 37.0% | 5 | 133.949 | 106.0 | 30.000 | 93.3% | 27.554 | 3.306 | 30.000 | 93.3% | 27.554 | 3.306 | 55.108 | 6.613 |
| 140 | 38.4% | 5 | 120.018 | 106.0 | 30.000 | 93.3% | 27.554 | 3.306 | 30.000 | 93.3% | 27.554 | 3.306 | 55.108 | 6.613 |
| 145 | 39.7% | 5 | 106.086 | 106.0 | 30.000 | 93.3% | 27.554 | 3.306 | 30.000 | 93.3% | 27.554 | 3.306 | 55.108 | 6.613 |
| 150 | 41.1% | 5 | 98.697 | 106.0 | 30.000 | 93.3% | 27.554 | 3.306 | 30.000 | 93.3% | 27.554 | 3.306 | 55.108 | 6.613 |
| 155 | 42.5% | 5 | 92.944 | 106.0 | 30.000 | 93.3% | 27.554 | 3.306 | 30.000 | 93.3% | 27.554 | 3.306 | 55.108 | 6.613 |
| 160 | 43.8% | 5 | 87.190 | 106.0 | 30.000 | 93.3% | 27.554 | 3.306 | 30.000 | 93.3% | 27.554 | 3.306 | 55.108 | 6.613 |
| 165 | 45.2% | 5 | 81.437 | 106.0 | 30.000 | 93.3% | 27.554 | 3.306 | 30.000 | 93.3% | 27.554 | 3.306 | 55.108 | 6.613 |
| 170 | 46.6% | 5 | 75.684 | 106.0 | 30.000 | 93.3% | 27.554 | 3.306 | 30.000 | 93.3% | 27.554 | 3.306 | 55.108 | 6.613 |
| 175 | 47.9% | 5 | 69.930 | 106.0 | 30.000 | 93.3% | 27.554 | 3.306 | 30.000 | 93.3% | 27.554 | 3.306 | 55.108 | 6.613 |
| 180 | 49.3% | 5 | 64.177 | 106.0 | 30.000 | 93.3% | 27.554 | 3.306 | 30.000 | 93.3% | 27.554 | 3.306 | 55.108 | 6.613 |
| 185 | 50.7% | 5 | 60.136 | 106.0 | 30.000 | 93.3% | 27.554 | 3.306 | 30.000 | 93.3% | 27.554 | 3.306 | 55.108 | 6.613 |
| 190 | 52.1% | 5 | 57.907 | 106.0 | 28.903 | 93.5% | 26.592 | 3.191 | 28.903 | 93.5% | 26.592 | 3.191 | 53.185 | 6.382 |
| 195 | 53.4% | 5 | 55.678 | 106.0 | 27.739 | 93.6% | 25.568 | 3.068 | 27.739 | 93.6% | 25.568 | 3.068 | 51.135 | 6.136 |
| 200 | 54.8% | 5 | 53.149 | 106.0 | 26.575 | 93.5% | 24.463 | 2.936 | 26.575 | 93.5% | 24.463 | 2.936 | 48.926 | 5.871 |
| 205 | 56.2% | 5 | 50.821 | 106.0 | 25.410 | 93.2% | 23.312 | 2.797 | 25.410 | 93.2% | 23.312 | 2.797 | 46.623 | 5.595 |
| 210 | 57.5% | 5 | 48.492 | 106.0 | 24.246 | 92.9% | 22.168 | 2.660 | 24.246 | 92.9% | 22.168 | 2.660 | 44.335 | 5.320 |
| 215 | 58.9% | 5 | 46.163 | 106.0 | 23.082 | 92.6% | 21.031 | 2.524 | 23.082 | 92.6% | 21.031 | 2.524 | 42.062 | 5.047 |
| 220 | 60.3% | 5 | 44.073 | 106.0 | 22.036 | 91.8% | 19.911 | 2.389 | 22.036 | 91.8% | 19.911 | 2.389 | 39.823 | 4.779 |
| 225 | 61.6% | 5 | 42.936 | 106.0 | 21.468 | 91.0% | 19.239 | 2.309 | 21.468 | 91.0% | 19.239 | 2.309 | 38.478 | 4.617 |



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| TIME INCR. | | PERIOD | FLOW DURATION | NET HEAD | TURBINE - 1 | | | | TURBINE - 2 | | | | Total Power | ANNUAL ENERGY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | $Q_1$ | $\eta_{T1}$ | $Power_1$ | $Energy_1$ | $Q_2$ | $\eta_{T2}$ | $Power_2$ | $Energy_2$ | P=P1+P2 +P3+P4 | Total |
| (days) | (%) | (days) | ($m^3/s$) | (m) | ($m^3/s$) | (%) | (MW) | (GWh) | ($m^3/s$) | (%) | (MW) | (GWh) | (MW) | (GWh) |
| 230 | 63.0% | 5 | 41.799 | 106.0 | 20.899 | 90.3% | 18.575 | 2.229 | 20.899 | 90.3% | 18.575 | 2.229 | 37.151 | 4.458 |
| 235 | 64.4% | 5 | 40.662 | 106.0 | 20.331 | 89.5% | 17.920 | 2.150 | 20.331 | 89.5% | 17.920 | 2.150 | 35.840 | 4.301 |
| 240 | 65.8% | 5 | 39.525 | 106.0 | 19.762 | 88.8% | 17.273 | 2.073 | 19.762 | 88.8% | 17.273 | 2.073 | 34.546 | 4.145 |
| 245 | 67.1% | 5 | 38.388 | 106.0 | 19.194 | 88.0% | 16.634 | 1.996 | 19.194 | 88.0% | 16.634 | 1.996 | 33.268 | 3.992 |
| 250 | 68.5% | 5 | 37.251 | 106.0 | 18.625 | 87.3% | 16.004 | 1.920 | 18.625 | 87.3% | 16.004 | 1.920 | 32.008 | 3.841 |
| 255 | 69.9% | 5 | 36.114 | 106.0 | 18.057 | 86.5% | 15.382 | 1.846 | 18.057 | 86.5% | 15.382 | 1.846 | 30.764 | 3.692 |
| 260 | 71.2% | 5 | 35.297 | 106.0 | 17.649 | 86.0% | 14.941 | 1.793 | 17.649 | 86.0% | 14.941 | 1.793 | 29.881 | 3.586 |
| 265 | 72.6% | 5 | 34.516 | 106.0 | 17.258 | 85.5% | 14.523 | 1.743 | 17.258 | 85.5% | 14.523 | 1.743 | 29.045 | 3.485 |
| 270 | 74.0% | 5 | 33.736 | 106.0 | 16.868 | 85.0% | 14.108 | 1.693 | 16.868 | 85.0% | 14.108 | 1.693 | 28.217 | 3.386 |
| 275 | 75.3% | 5 | 32.955 | 106.0 | 16.477 | 84.5% | 13.698 | 1.644 | 16.477 | 84.5% | 13.698 | 1.644 | 27.397 | 3.288 |
| 280 | 76.7% | 5 | 32.174 | 106.0 | 16.087 | 83.9% | 13.292 | 1.595 | 16.087 | 83.9% | 13.292 | 1.595 | 26.584 | 3.190 |
| 285 | 78.1% | 5 | 31.393 | 106.0 | 15.697 | 83.4% | 12.890 | 1.547 | 15.697 | 83.4% | 12.890 | 1.547 | 25.780 | 3.094 |
| 290 | 79.5% | 5 | 30.612 | 106.0 | 15.306 | 82.9% | 12.492 | 1.499 | 15.306 | 82.9% | 12.492 | 1.499 | 24.983 | 2.998 |
| 295 | 80.8% | 5 | 29.953 | 106.0 | 29.953 | 93.3% | 27.521 | 3.303 | 0.000 | 0.0% | 0.000 | 0.000 | 27.521 | 3.303 |
| 300 | 82.2% | 5 | 29.401 | 106.0 | 29.401 | 93.4% | 27.029 | 3.244 | 0.000 | 0.0% | 0.000 | 0.000 | 27.029 | 3.244 |
| 305 | 83.6% | 5 | 28.840 | 106.0 | 28.840 | 93.5% | 26.536 | 3.184 | 0.000 | 0.0% | 0.000 | 0.000 | 26.536 | 3.184 |
| 310 | 84.9% | 5 | 28.278 | 106.0 | 28.278 | 93.6% | 26.042 | 3.125 | 0.000 | 0.0% | 0.000 | 0.000 | 26.042 | 3.125 |
| 315 | 86.3% | 5 | 27.716 | 106.0 | 27.716 | 93.8% | 25.548 | 3.066 | 0.000 | 0.0% | 0.000 | 0.000 | 25.548 | 3.066 |
| 320 | 87.7% | 5 | 27.155 | 106.0 | 27.155 | 93.7% | 25.039 | 3.005 | 0.000 | 0.0% | 0.000 | 0.000 | 25.039 | 3.005 |
| 325 | 89.0% | 5 | 26.593 | 106.0 | 26.593 | 93.5% | 24.481 | 2.938 | 0.000 | 0.0% | 0.000 | 0.000 | 24.481 | 2.938 |
| 330 | 90.4% | 5 | 25.966 | 106.0 | 25.966 | 93.3% | 23.860 | 2.863 | 0.000 | 0.0% | 0.000 | 0.000 | 23.860 | 2.863 |



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| TIME INCR. | | PERIOD | FLOW DURATION | NET HEAD | TURBINE - 1 | | | | TURBINE - 2 | | | | Total Power | ANNUAL ENERGY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | $Q_1$ | $\eta_{T1}$ | $Power_1$ | $Energy_1$ | $Q_2$ | $\eta_{T2}$ | $Power_2$ | $Energy_2$ | P=P1+P2 +P3+P4 | Total |
| (days) | (%) | (days) | ($m^3/s$) | (m) | ($m^3/s$) | (%) | (MW) | (GWh) | ($m^3/s$) | (%) | (MW) | (GWh) | (MW) | (GWh) |
| 335 | 91.8% | 5 | 25.185 | 106.0 | 25.185 | 93.1% | 23.090 | 2.771 | 0.000 | 0.0% | 0.000 | 0.000 | 23.090 | 2.771 |
| 340 | 93.2% | 5 | 24.404 | 106.0 | 24.404 | 92.9% | 22.323 | 2.679 | 0.000 | 0.0% | 0.000 | 0.000 | 22.323 | 2.679 |
| 345 | 94.5% | 5 | 23.623 | 106.0 | 23.623 | 92.7% | 21.559 | 2.587 | 0.000 | 0.0% | 0.000 | 0.000 | 21.559 | 2.587 |
| 350 | 95.9% | 5 | 22.842 | 106.0 | 22.842 | 92.5% | 20.798 | 2.496 | 0.000 | 0.0% | 0.000 | 0.000 | 20.798 | 2.496 |
| 355 | 97.3% | 5 | 22.062 | 106.0 | 22.062 | 91.8% | 19.942 | 2.393 | 0.000 | 0.0% | 0.000 | 0.000 | 19.942 | 2.393 |
| 360 | 98.6% | 5 | 21.281 | 106.0 | 21.281 | 90.8% | 19.020 | 2.282 | 0.000 | 0.0% | 0.000 | 0.000 | 19.020 | 2.282 |
| 365 | 100.0% | 5 | 20.500 | 106.0 | 20.500 | 89.8% | 18.114 | 2.174 | 0.000 | 0.0% | 0.000 | 0.000 | 18.114 | 2.174 |
| **MEAN ANNUAL ENERGY (GWh)** | | | | | | | = | | | | | | | **383.28** |

Annual Downtime Losses 10 days closure) = 2.74%

**Actual Mean Annual Energy (GWh)** = **372.8**

$$\text{Plant Factor} = \frac{372.8 \times 10^6}{54.04 \times 8760000} = \frac{\text{Actual Energy}}{\text{Theoretical Energy}}$$

Plant Factor = **78.74%**



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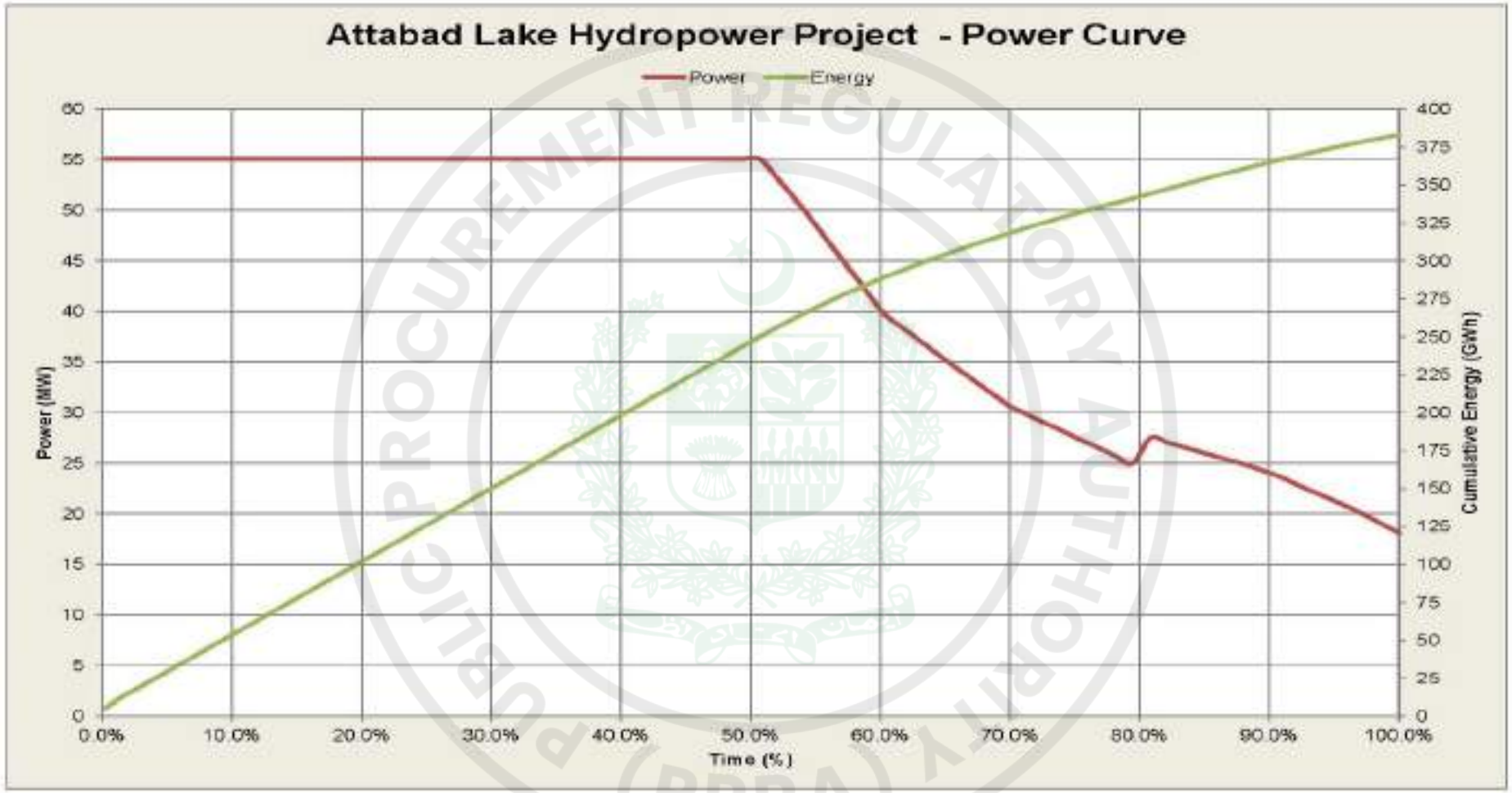




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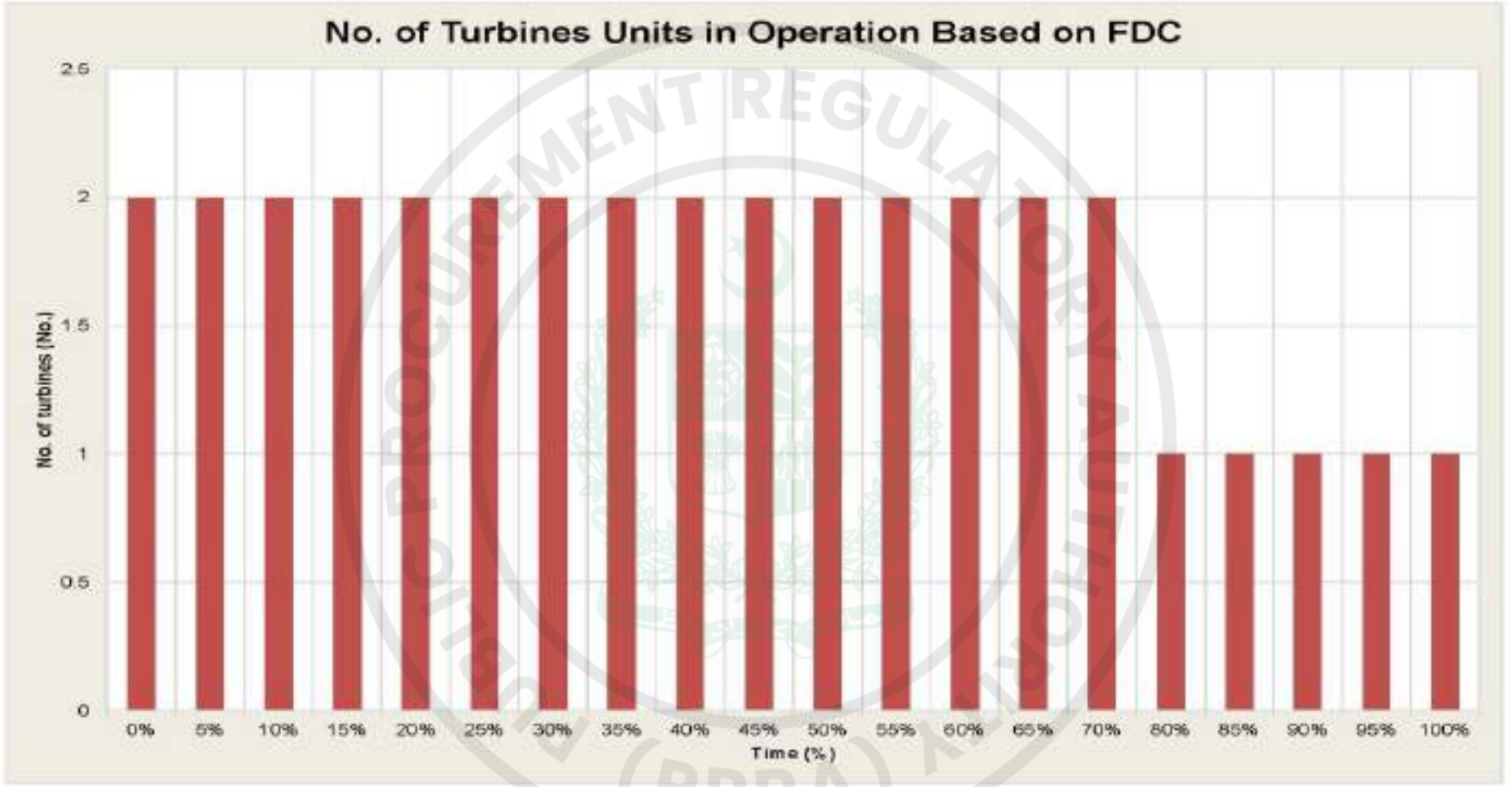


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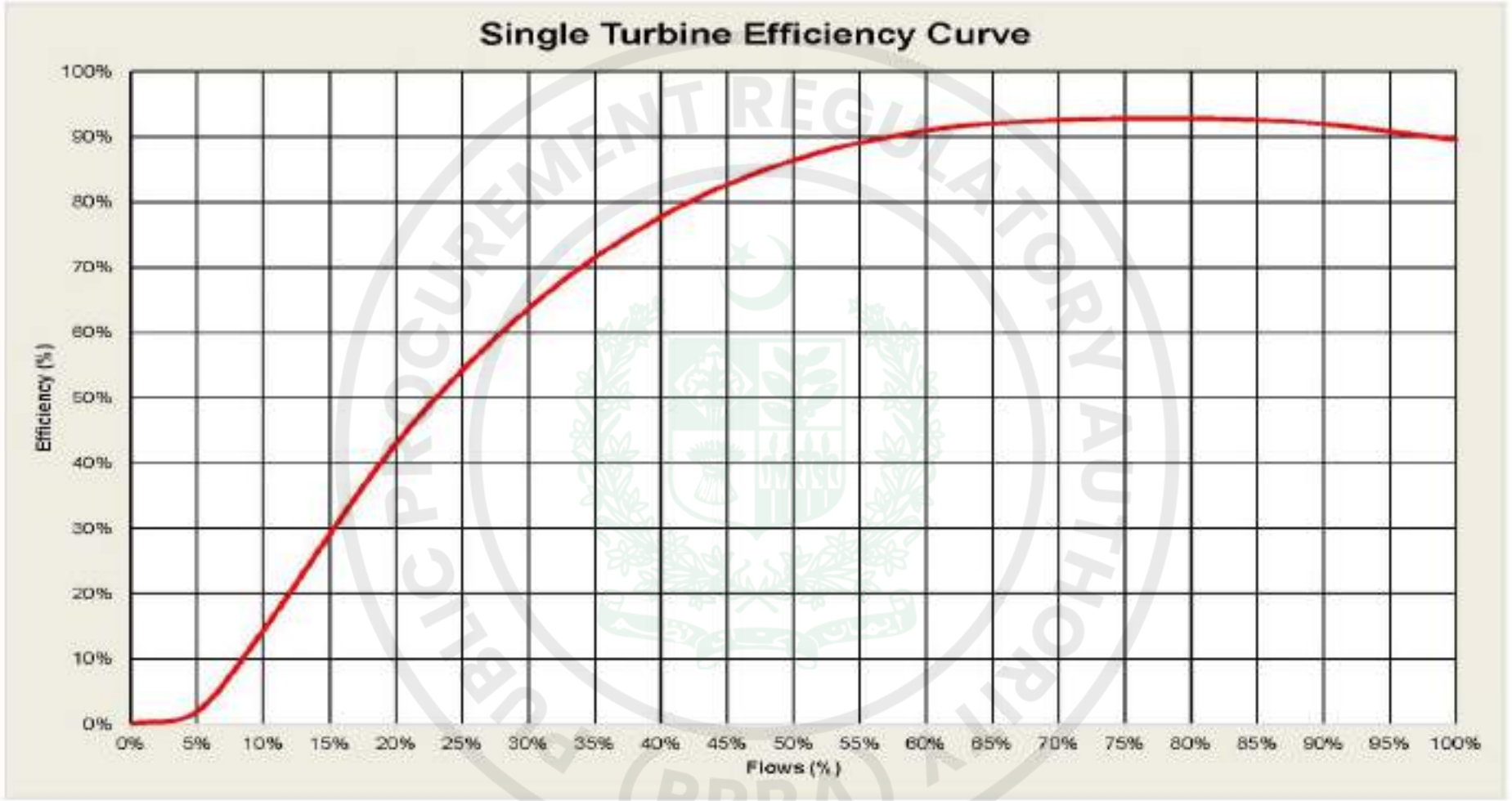




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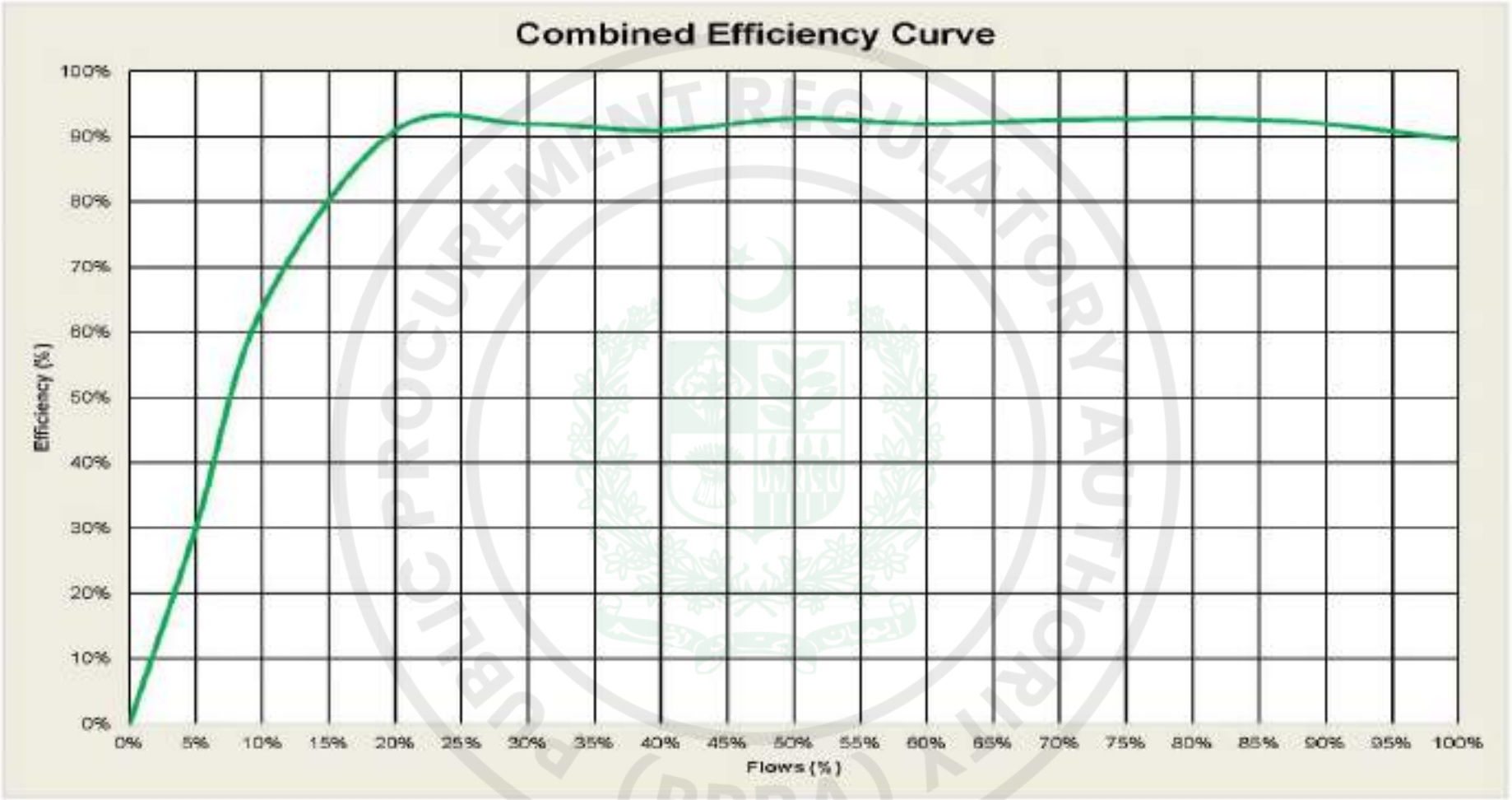




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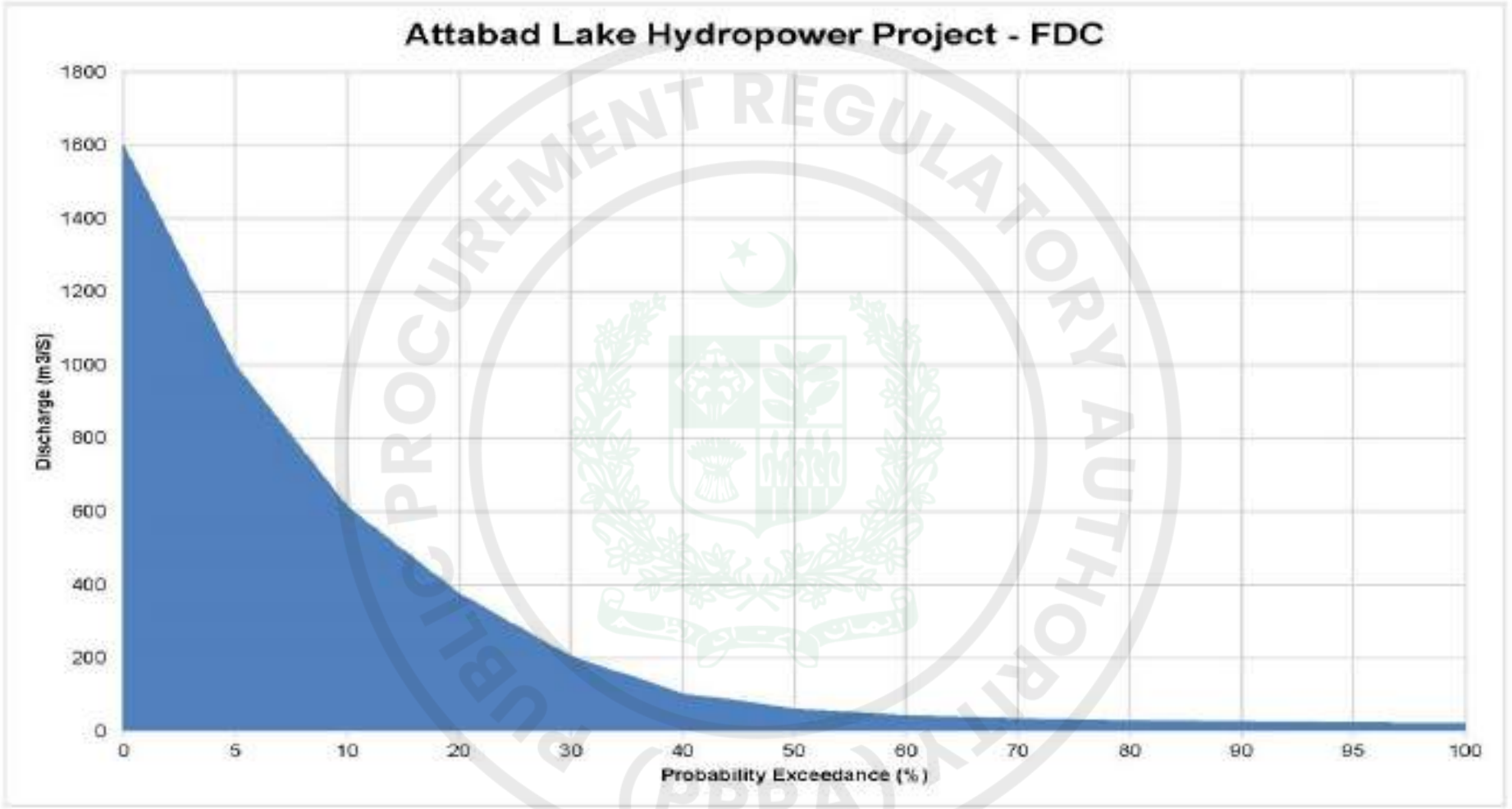




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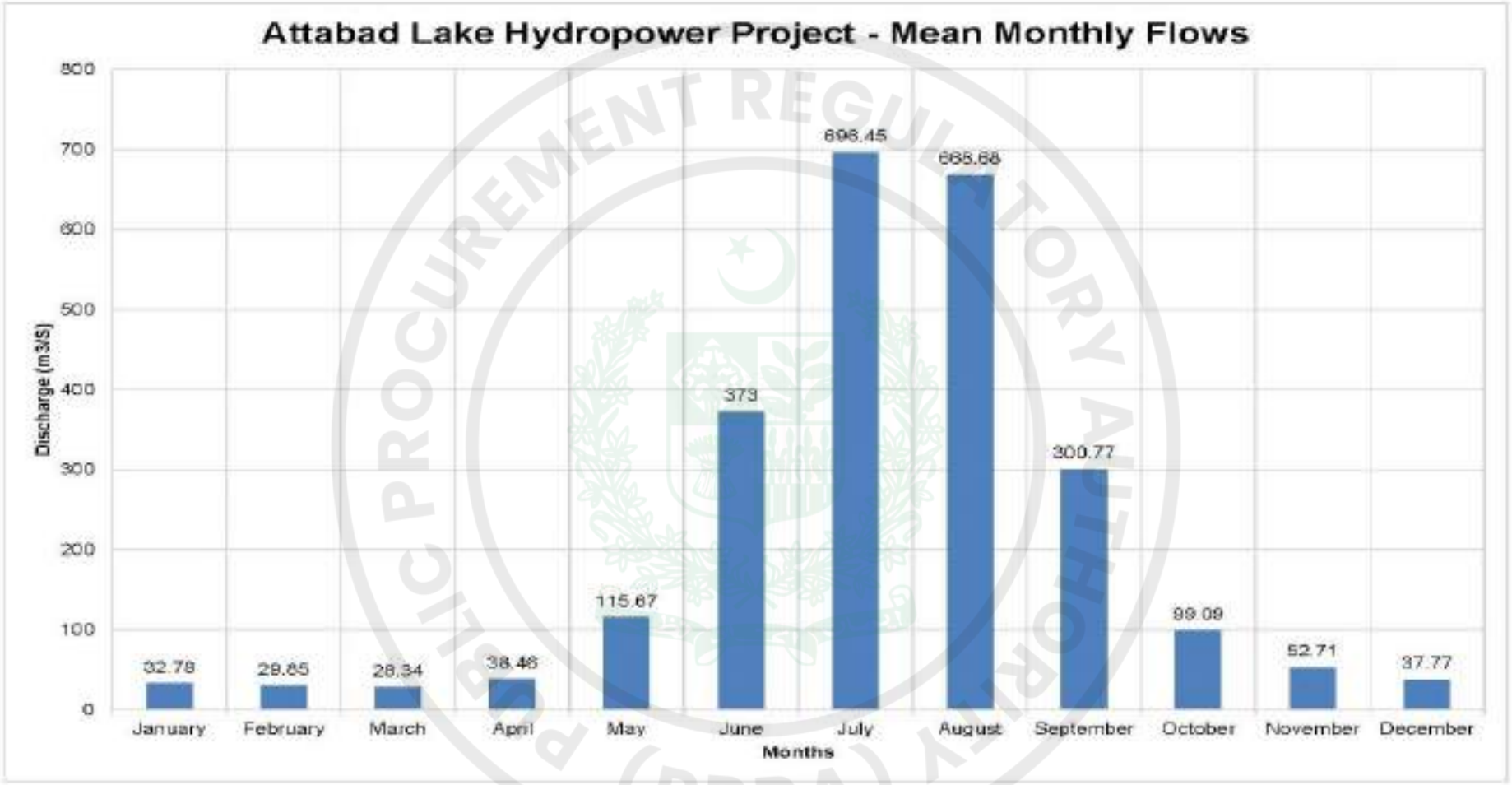


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## 8.4.2 Power and Energy Calculations based on Flow Duration Curve (FDC) method with Three (03) No. of Generating Units



ATTABAD LAKE HYDROPOWER PROJECT

TABLE 8.2

POWER AND ENERGY CALCULATIONS

(FLOW DURATION CURVE METHOD)

| | | | | |
|---|---|---|---|---|
| Design Discharge | $Q_D$ | = | 60.0 | $m^3/sec$ |
| Environmental Flows | $Q_E$ | = | 0.00 | $m^3/sec$ |
| No. of Units | | = | 3 | FRANCIS |
| Design Discharge (single unit) | $Q_{unit}$ | = | 20.000 | $m^3/sec$ |
| Gross Head | $H_g$ | = | 112.00 | m |
| Head Loss | $H_L$ | = | 6.00 | m |
| Net Head | $H_n$ | = | 106.00 | m |
| Turbine Efficiency at Design Discharge | $h_T$ | = | 91.5% | |
| Generator Efficiency | $h_G$ | = | 96.6% | |
| Transformer Efficiency | $h_{TR}$ | = | 98.0% | |
| Flushing Period | $T_{FL}$ | = | 10 | days |

| | | |
|---|---|---|
| GROSS POWER | 54.04 | MW |
| ANNUAL ENERGY | 374.06 | GWh |
| PLANT FACTOR | 79.011 | % |

| TIME EXCD. | | PERIOD | FLOW DURATION | NET HEAD | TURBINE - 1 | | | | TURBINE - 2 | | | | TURBINE - 3 | | | | Total Power | ANNUAL ENERGY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | $Q_1$ | $h_T$ | Power | Energy | $Q_2$ | $h_T$ | Power | Energy | $Q_3$ | $h_T$ | Power | Energy | P=P1+P2+P3+P4 | Total |
| days | (%) | days | $m^3/sec$ | m | $m^3/sec$ | (%) | (MW) | (MW) | $m^3/sec$ | (%) | (MW) | (MW) | $m^3/sec$ | (%) | (MW) | (MW) | (MW) | (MW) |
| 1 | 0.3% | 4 | 1567.123 | 106.0 | 20.000 | 93.3% | 18.369 | 1.763 | 20.000 | 93.3% | 18.369 | 1.763 | 20.000 | 93.3% | 18.369 | 1.763 | 55.108 | 5.290 |
| 5 | 1.4% | 5 | 1436.616 | 106.0 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 55.108 | 6.613 |
| 10 | 2.7% | 5 | 1271.233 | 106.0 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 55.108 | 6.613 |
| 15 | 4.1% | 5 | 1106.849 | 106.0 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 55.108 | 6.613 |
| 20 | 5.5% | 5 | 982.929 | 106.0 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 55.108 | 6.613 |
| 25 | 6.8% | 5 | 857.011 | 106.0 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 55.108 | 6.613 |
| 30 | 8.2% | 5 | 751.068 | 106.0 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 55.108 | 6.613 |
| 35 | 9.6% | 5 | 645.175 | 106.0 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 55.108 | 6.613 |
| 40 | 11.0% | 5 | 590.693 | 106.0 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 55.108 | 6.613 |
| 45 | 12.3% | 5 | 559.255 | 106.0 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 55.108 | 6.613 |



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| TIME INCR. | | PERIOD | FLOW DURATION | NET HEAD | TURBINE - 1 | | | | TURBINE - 2 | | | | TURBINE - 3 | | | | Total Power | ANNUAL ENERGY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | $Q_1$ | $\eta_1$ | $Power_1$ | $Energy_1$ | $Q_2$ | $\eta_2$ | $Power_2$ | $Energy_2$ | $Q_3$ | $\eta_3$ | $Power_3$ | $Energy_3$ | $P=P_1+P_2+P_3$ | Total |
| (days) | (%) | (days) | ($m^3$/s) | (m) | ($m^3$/s) | (%) | (MW) | (GWh) | ($m^3$/s) | (%) | (MW) | (GWh) | ($m^3$/s) | (%) | (MW) | (GWh) | (MW) | (GWh) |
| 50 | 13.7% | 5 | 525.818 | 106.0 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 55.108 | 6.613 |
| 55 | 15.1% | 5 | 493.378 | 106.0 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 55.108 | 6.613 |
| 60 | 16.4% | 5 | 460.840 | 106.0 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 55.108 | 6.613 |
| 65 | 17.8% | 5 | 428.501 | 106.0 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 55.108 | 6.613 |
| 70 | 19.2% | 5 | 396.060 | 106.0 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 55.108 | 6.613 |
| 75 | 20.5% | 5 | 367.197 | 106.0 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 55.108 | 6.613 |
| 80 | 21.8% | 5 | 343.690 | 106.0 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 55.108 | 6.613 |
| 85 | 23.3% | 5 | 320.184 | 106.0 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 55.108 | 6.613 |
| 90 | 24.7% | 5 | 296.677 | 106.0 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 55.108 | 6.613 |
| 95 | 26.0% | 5 | 273.170 | 106.0 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 55.108 | 6.613 |
| 100 | 27.4% | 5 | 249.663 | 106.0 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 55.108 | 6.613 |
| 105 | 28.8% | 5 | 226.156 | 106.0 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 55.108 | 6.613 |
| 110 | 30.1% | 5 | 203.607 | 106.0 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 55.108 | 6.613 |
| 115 | 31.5% | 5 | 189.675 | 106.0 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 55.108 | 6.613 |
| 120 | 32.8% | 5 | 175.744 | 106.0 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 55.108 | 6.613 |
| 125 | 34.2% | 5 | 161.812 | 106.0 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 55.108 | 6.613 |
| 130 | 35.6% | 5 | 147.881 | 106.0 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 55.108 | 6.613 |
| 135 | 37.0% | 5 | 133.949 | 106.0 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 55.108 | 6.613 |
| 140 | 38.4% | 5 | 120.018 | 106.0 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 55.108 | 6.613 |
| 145 | 39.7% | 5 | 106.086 | 106.0 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 55.108 | 6.613 |
| 150 | 41.1% | 5 | 98.697 | 106.0 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 55.108 | 6.613 |
| 155 | 42.5% | 5 | 92.944 | 106.0 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 55.108 | 6.613 |
| 160 | 43.8% | 5 | 87.190 | 106.0 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 55.108 | 6.613 |
| 165 | 45.2% | 5 | 81.437 | 106.0 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 55.108 | 6.613 |
| 170 | 46.6% | 5 | 75.684 | 106.0 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 55.108 | 6.613 |
| 175 | 47.9% | 5 | 69.930 | 106.0 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 55.108 | 6.613 |
| 180 | 49.3% | 5 | 64.177 | 106.0 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 55.108 | 6.613 |



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| TIME INCR. | | PERIOD | FLOW DURATION | NET HEAD | TURBINE - 1 | | | | TURBINE - 2 | | | | TURBINE - 3 | | | | Total Power | ANNUAL ENERGY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | $Q_1$ | $\eta_1$ | $Power_1$ | $Energy_1$ | $Q_2$ | $\eta_2$ | $Power_2$ | $Energy_2$ | $Q_3$ | $\eta_3$ | $Power_3$ | $Energy_3$ | $P=P1+P2+P3+Pa$ | Total |
| Hours | (%) | Hours | $(m^3/s)$ | (m) | $(m^3/s)$ | (%) | (MW) | (GWh) | $(m^3/s)$ | (%) | (MW) | (GWh) | $(m^3/s)$ | (%) | (MW) | (GWh) | (MW) | (GWh) |
| 185 | 50.7% | 5 | 60.136 | 106.0 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 20.000 | 93.3% | 18.369 | 2.204 | 55.108 | 6.613 |
| 190 | 52.1% | 5 | 57.807 | 106.0 | 19.269 | 93.5% | 17.728 | 2.127 | 19.269 | 93.5% | 17.728 | 2.127 | 19.269 | 93.5% | 17.728 | 2.127 | 53.186 | 6.382 |
| 195 | 53.4% | 5 | 55.478 | 106.0 | 18.493 | 93.6% | 17.045 | 2.045 | 18.493 | 93.6% | 17.045 | 2.045 | 18.493 | 93.6% | 17.045 | 2.045 | 51.135 | 6.136 |
| 200 | 54.8% | 5 | 53.148 | 106.0 | 17.716 | 93.5% | 16.309 | 1.957 | 17.716 | 93.5% | 16.309 | 1.957 | 17.716 | 93.5% | 16.309 | 1.957 | 48.926 | 5.871 |
| 205 | 56.2% | 5 | 50.821 | 106.0 | 16.940 | 93.2% | 15.541 | 1.865 | 16.940 | 93.2% | 15.541 | 1.865 | 16.940 | 93.2% | 15.541 | 1.865 | 46.623 | 5.595 |
| 210 | 57.5% | 5 | 48.492 | 106.0 | 16.164 | 92.9% | 14.778 | 1.773 | 16.164 | 92.9% | 14.778 | 1.773 | 16.164 | 92.9% | 14.778 | 1.773 | 44.336 | 5.320 |
| 215 | 58.9% | 5 | 46.163 | 106.0 | 15.388 | 92.6% | 14.021 | 1.682 | 15.388 | 92.6% | 14.021 | 1.682 | 15.388 | 92.6% | 14.021 | 1.682 | 42.062 | 5.047 |
| 220 | 60.3% | 5 | 44.073 | 106.0 | 14.691 | 91.8% | 13.274 | 1.593 | 14.691 | 91.8% | 13.274 | 1.593 | 14.691 | 91.8% | 13.274 | 1.593 | 39.823 | 4.779 |
| 225 | 61.6% | 5 | 42.936 | 106.0 | 14.312 | 91.0% | 12.826 | 1.539 | 14.312 | 91.0% | 12.826 | 1.539 | 14.312 | 91.0% | 12.826 | 1.539 | 38.478 | 4.617 |
| 230 | 63.0% | 5 | 41.799 | 106.0 | 13.933 | 90.3% | 12.384 | 1.486 | 13.933 | 90.3% | 12.384 | 1.486 | 13.933 | 90.3% | 12.384 | 1.486 | 37.151 | 4.458 |
| 235 | 64.4% | 5 | 40.662 | 106.0 | 13.554 | 89.5% | 11.947 | 1.434 | 13.554 | 89.5% | 11.947 | 1.434 | 13.554 | 89.5% | 11.947 | 1.434 | 35.840 | 4.301 |
| 240 | 65.8% | 5 | 39.525 | 106.0 | 19.762 | 93.4% | 18.181 | 2.179 | 19.762 | 93.4% | 18.181 | 2.179 | 0.000 | 0.0% | 0.000 | 0.000 | 36.322 | 4.359 |
| 245 | 67.1% | 5 | 38.388 | 106.0 | 19.194 | 93.5% | 17.682 | 2.119 | 19.194 | 93.5% | 17.682 | 2.119 | 0.000 | 0.0% | 0.000 | 0.000 | 35.324 | 4.239 |
| 250 | 68.5% | 5 | 37.251 | 106.0 | 18.625 | 93.6% | 17.162 | 2.059 | 18.625 | 93.6% | 17.162 | 2.059 | 0.000 | 0.0% | 0.000 | 0.000 | 34.324 | 4.119 |
| 255 | 69.9% | 5 | 36.114 | 106.0 | 18.057 | 93.6% | 16.647 | 1.998 | 18.057 | 93.6% | 16.647 | 1.998 | 0.000 | 0.0% | 0.000 | 0.000 | 33.293 | 3.995 |
| 260 | 71.2% | 5 | 35.297 | 106.0 | 17.649 | 93.5% | 16.241 | 1.949 | 17.649 | 93.5% | 16.241 | 1.949 | 0.000 | 0.0% | 0.000 | 0.000 | 32.483 | 3.898 |
| 265 | 72.6% | 5 | 34.519 | 106.0 | 17.258 | 93.3% | 15.855 | 1.903 | 17.258 | 93.3% | 15.855 | 1.903 | 0.000 | 0.0% | 0.000 | 0.000 | 31.710 | 3.805 |
| 270 | 74.0% | 5 | 33.736 | 106.0 | 16.868 | 93.2% | 15.470 | 1.856 | 16.868 | 93.2% | 15.470 | 1.856 | 0.000 | 0.0% | 0.000 | 0.000 | 30.938 | 3.713 |
| 275 | 75.3% | 5 | 32.955 | 106.0 | 16.477 | 93.0% | 15.086 | 1.810 | 16.477 | 93.0% | 15.086 | 1.810 | 0.000 | 0.0% | 0.000 | 0.000 | 30.172 | 3.621 |
| 280 | 76.7% | 5 | 32.174 | 106.0 | 16.087 | 92.8% | 14.703 | 1.764 | 16.087 | 92.8% | 14.703 | 1.764 | 0.000 | 0.0% | 0.000 | 0.000 | 29.406 | 3.529 |
| 285 | 78.1% | 5 | 31.393 | 106.0 | 15.697 | 92.7% | 14.322 | 1.719 | 15.697 | 92.7% | 14.322 | 1.719 | 0.000 | 0.0% | 0.000 | 0.000 | 28.643 | 3.437 |
| 290 | 79.5% | 5 | 30.612 | 106.0 | 15.306 | 92.5% | 13.941 | 1.673 | 15.306 | 92.5% | 13.941 | 1.673 | 0.000 | 0.0% | 0.000 | 0.000 | 27.883 | 3.346 |
| 295 | 80.8% | 5 | 29.963 | 106.0 | 14.982 | 92.4% | 13.622 | 1.635 | 14.982 | 92.4% | 13.622 | 1.635 | 0.000 | 0.0% | 0.000 | 0.000 | 27.244 | 3.269 |
| 300 | 82.2% | 5 | 29.401 | 106.0 | 14.701 | 91.8% | 13.286 | 1.594 | 14.701 | 91.8% | 13.286 | 1.594 | 0.000 | 0.0% | 0.000 | 0.000 | 26.572 | 3.189 |
| 305 | 83.6% | 5 | 28.840 | 106.0 | 14.420 | 91.3% | 12.953 | 1.554 | 14.420 | 91.3% | 12.953 | 1.554 | 0.000 | 0.0% | 0.000 | 0.000 | 25.906 | 3.109 |
| 310 | 84.9% | 5 | 28.278 | 106.0 | 14.139 | 90.7% | 12.624 | 1.515 | 14.139 | 90.7% | 12.624 | 1.515 | 0.000 | 0.0% | 0.000 | 0.000 | 25.247 | 3.030 |
| 315 | 86.3% | 5 | 27.716 | 106.0 | 13.858 | 90.1% | 12.297 | 1.476 | 13.858 | 90.1% | 12.297 | 1.476 | 0.000 | 0.0% | 0.000 | 0.000 | 24.594 | 2.951 |



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| TIME INCR. | | PERIOD | FLOW DURATION | NET HEAD | TURBINE - 1 | | | | TURBINE - 2 | | | | TURBINE - 3 | | | | Total Power | ANNUAL ENERGY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | $Q_1$ | $\eta_1$ | Power$_1$ | Energy$_1$ | $Q_2$ | $\eta_2$ | Power$_2$ | Energy$_2$ | $Q_3$ | $\eta_3$ | Power$_3$ | Energy$_3$ | P=P1+P2+P3+P4 | Total |
| (days) | (%) | (days) | ($m^3$/s) | (m) | ($m^3$/s) | (%) | (MW) | (GWh) | ($m^3$/s) | (%) | (MW) | (GWh) | ($m^3$/s) | (%) | (MW) | (GWh) | (MW) | (GWh) |
| 320 | 87.7% | 5 | 27.155 | 106.0 | 13.577 | 89.6% | 11.974 | 1.437 | 13.577 | 89.6% | 11.974 | 1.437 | 0.000 | 0.0% | 0.000 | 0.000 | 23.947 | 2.874 |
| 325 | 89.0% | 5 | 26.593 | 106.0 | 13.297 | 89.0% | 11.653 | 1.398 | 13.297 | 89.0% | 11.653 | 1.398 | 0.000 | 0.0% | 0.000 | 0.000 | 23.306 | 2.797 |
| 330 | 90.4% | 5 | 25.966 | 106.0 | 12.983 | 89.4% | 11.299 | 1.356 | 12.983 | 89.4% | 11.299 | 1.356 | 0.000 | 0.0% | 0.000 | 0.000 | 22.598 | 2.712 |
| 335 | 91.8% | 5 | 25.185 | 106.0 | 12.592 | 87.6% | 10.863 | 1.304 | 12.592 | 87.6% | 10.863 | 1.304 | 0.000 | 0.0% | 0.000 | 0.000 | 21.726 | 2.607 |
| 340 | 93.2% | 5 | 24.404 | 106.0 | 12.202 | 86.9% | 10.434 | 1.252 | 12.202 | 86.9% | 10.434 | 1.252 | 0.000 | 0.0% | 0.000 | 0.000 | 20.867 | 2.504 |
| 345 | 94.5% | 5 | 23.623 | 106.0 | 11.812 | 86.1% | 10.010 | 1.201 | 11.812 | 86.1% | 10.010 | 1.201 | 0.000 | 0.0% | 0.000 | 0.000 | 20.020 | 2.402 |
| 350 | 95.9% | 5 | 22.842 | 106.0 | 11.421 | 85.3% | 9.592 | 1.151 | 11.421 | 85.3% | 9.592 | 1.151 | 0.000 | 0.0% | 0.000 | 0.000 | 19.184 | 2.302 |
| 355 | 97.3% | 5 | 22.062 | 106.0 | 11.031 | 84.5% | 9.180 | 1.102 | 11.031 | 84.5% | 9.180 | 1.102 | 0.000 | 0.0% | 0.000 | 0.000 | 18.360 | 2.203 |
| 360 | 98.6% | 5 | 21.281 | 106.0 | 10.640 | 83.8% | 8.774 | 1.053 | 10.640 | 83.8% | 8.774 | 1.053 | 0.000 | 0.0% | 0.000 | 0.000 | 17.549 | 2.106 |
| 365 | 100.0% | 5 | 20.500 | 106.0 | 10.250 | 83.0% | 8.374 | 1.005 | 10.250 | 83.0% | 8.374 | 1.005 | 0.000 | 0.0% | 0.000 | 0.000 | 16.748 | 2.010 |
| MEAN ANNUAL ENERGY (GWh) | | | | | | | | - | | | | | | | | | | 384.60 |
| Annual Downtime Losses 10 days closure) | | | | | | | | - | | | | | | | | | | 2.74% |
| **Actual Mean Annual Energy (GWh)** | | | | | | | | - | | | | | | | | | | **374.1** |

$$\text{Plant Factor} = \frac{374.1 \times 10^6}{54.04 \times 8760000} = \frac{\text{Actual Energy}}{\text{Theoretical Energy}}$$

Plant Factor = **79.01%**



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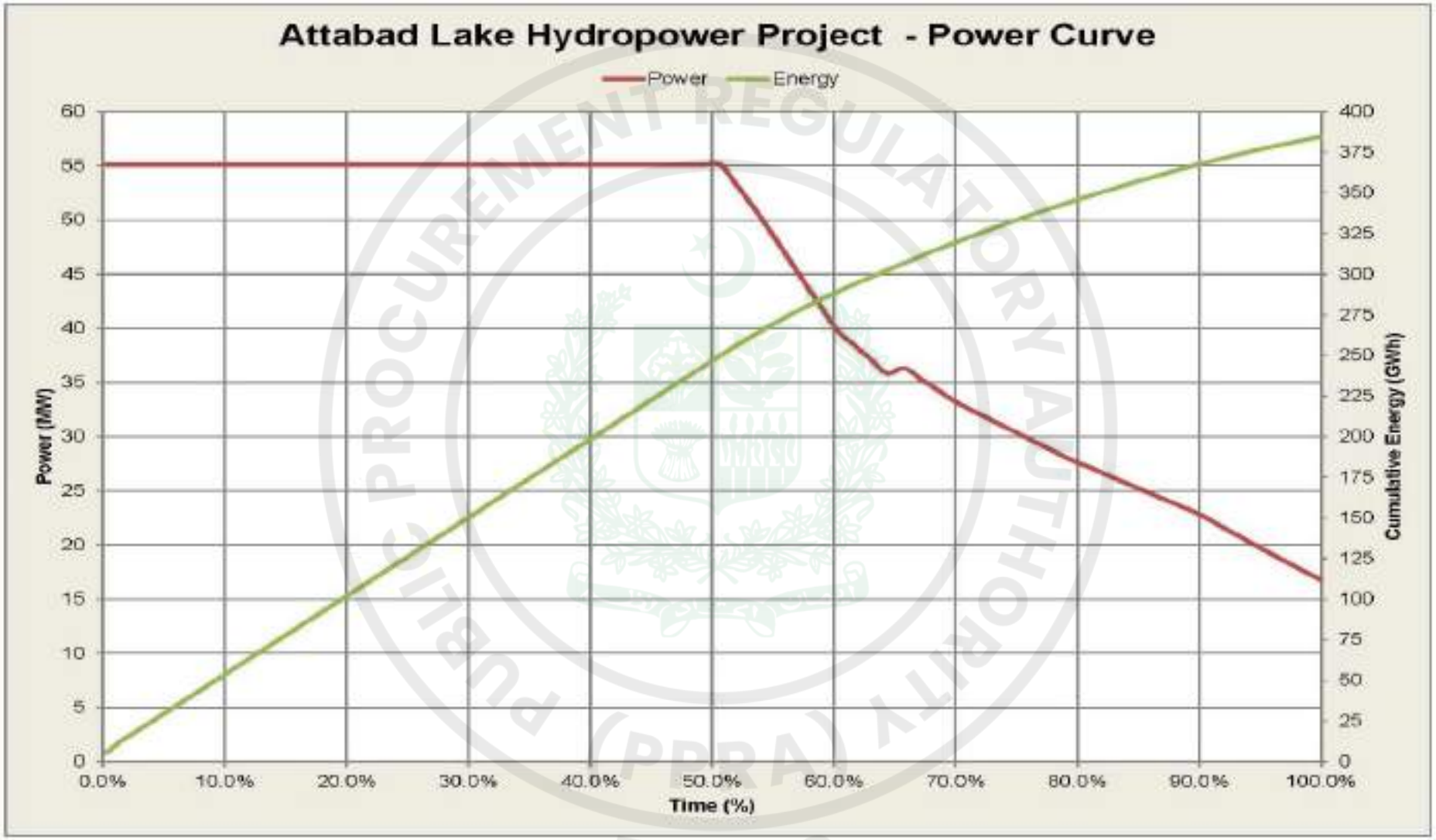




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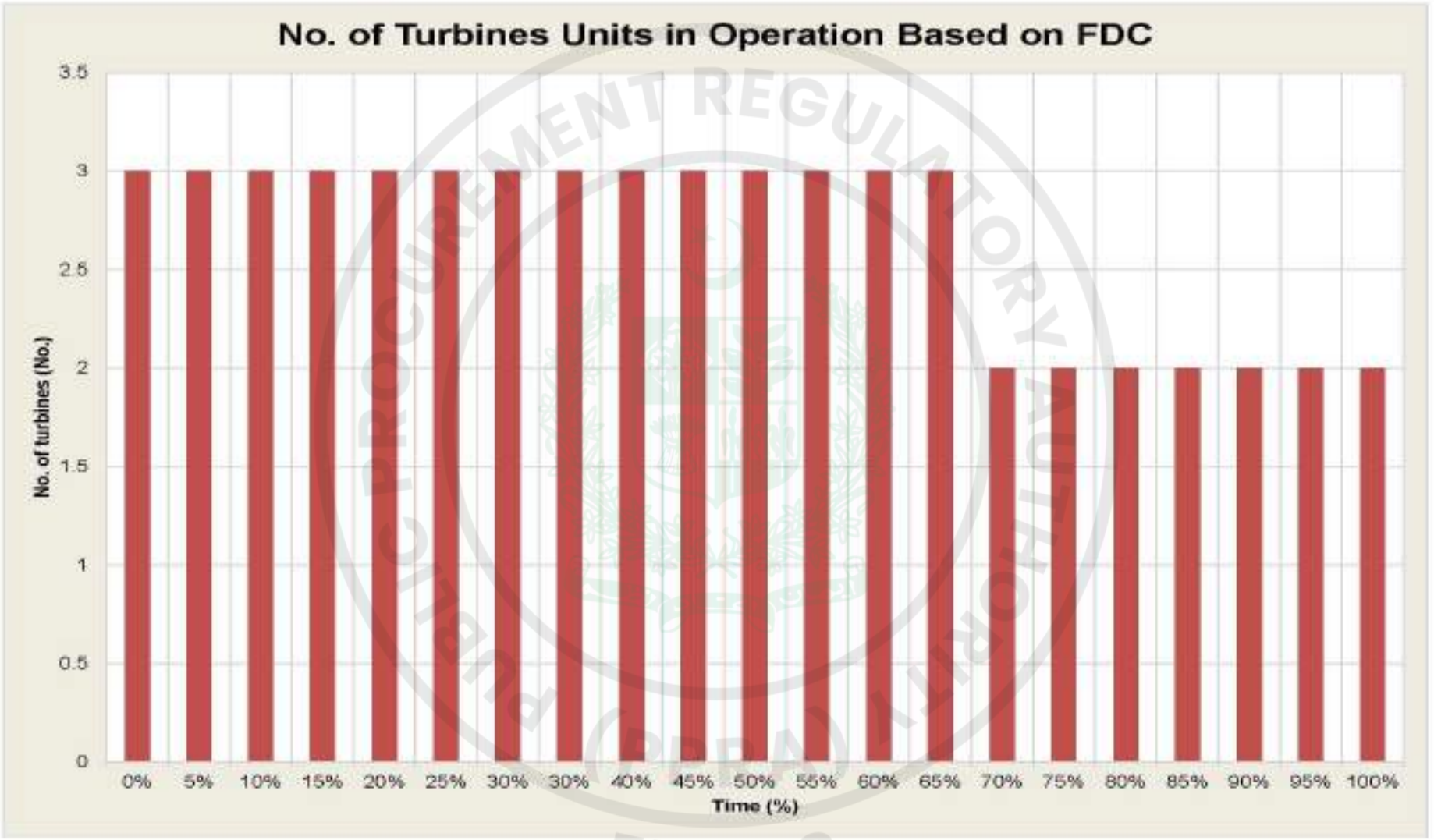




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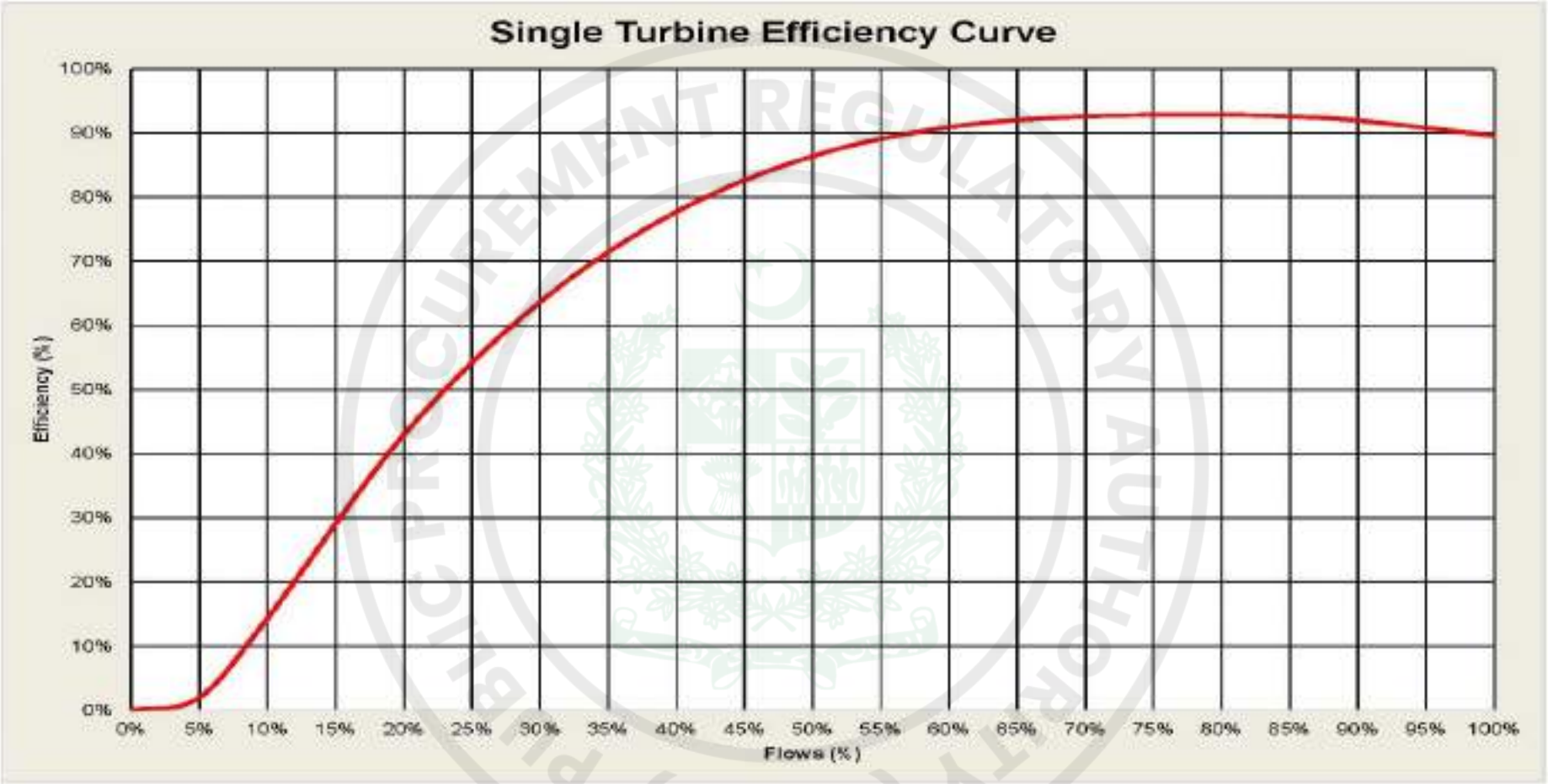




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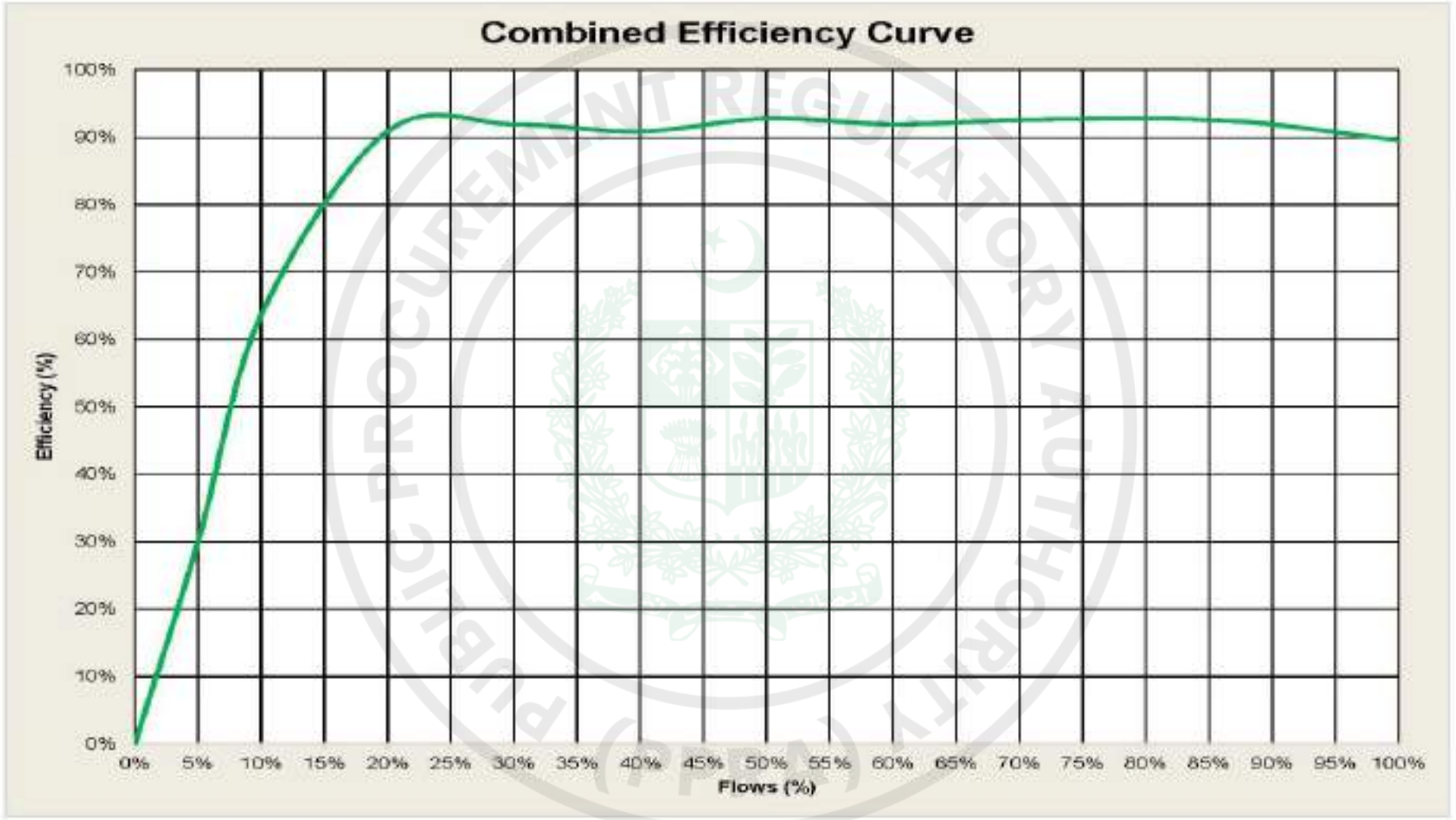




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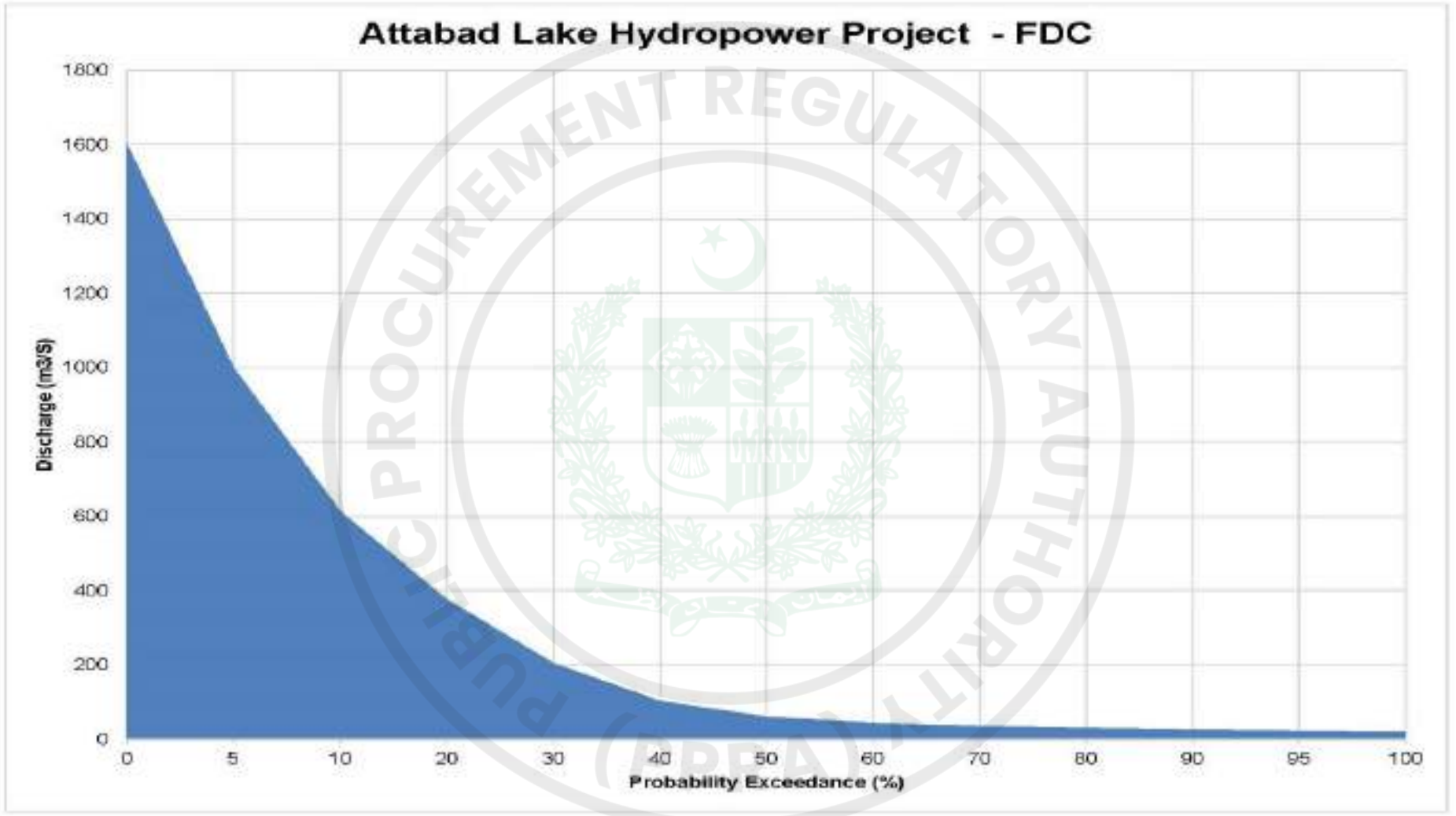




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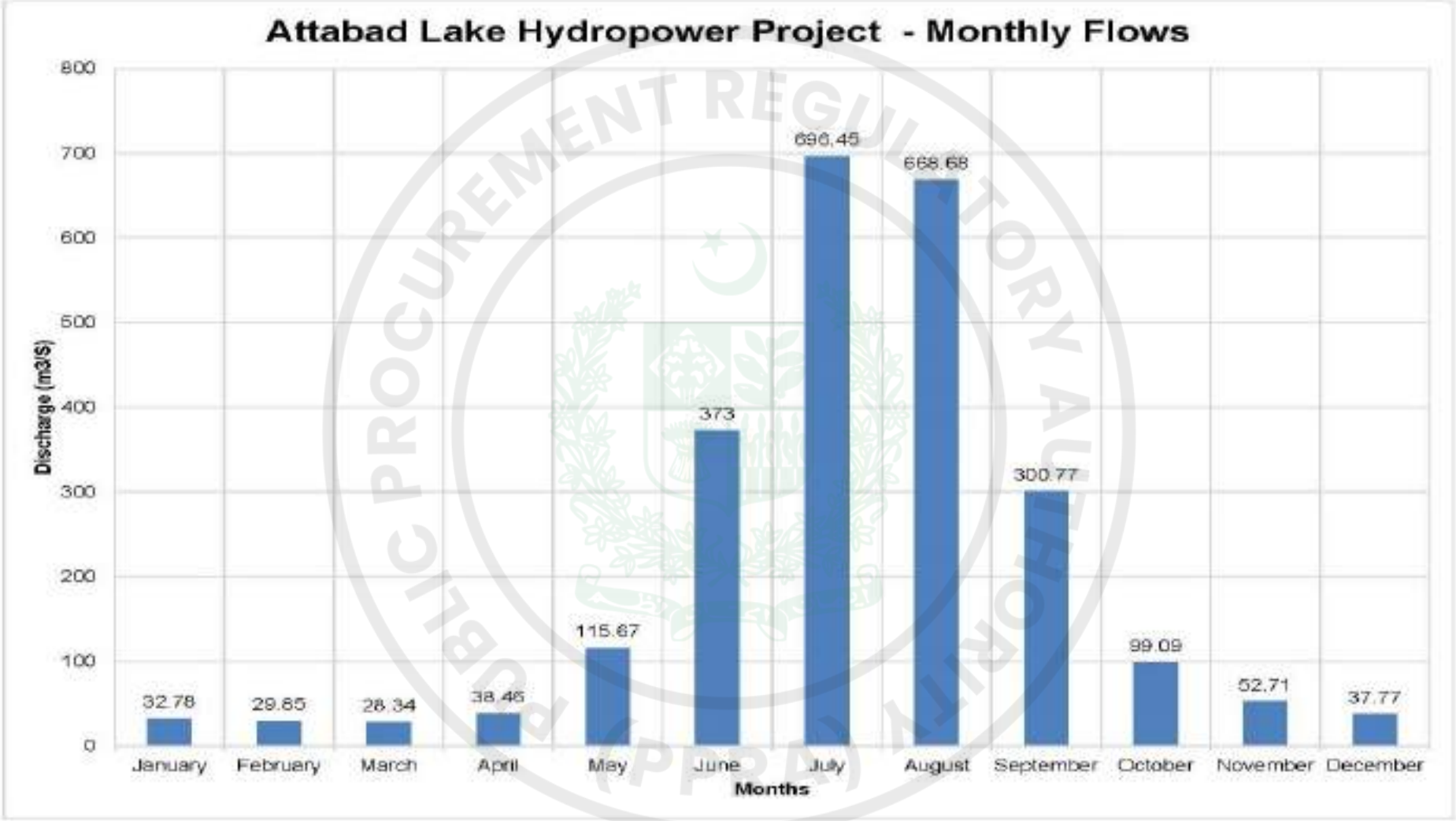


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## 8.4.3 Power and Energy Calculations based on Flow Duration Curve (FDC) method with Four (04) No. of Generating Units



**ATTABAD LAKE HYDROPOWER PROJECT**

**TABLE 8.3**

**POWER AND ENERGY CALCULATIONS**

(FLOW DURATION CURVE METHOD)

| | | | | |
|---|---|---|---|---|
| Design Discharge | $Q_D$ | = | 60.0 | $m^3/sec$ |
| Environmental Flows | $Q_E$ | = | 0.00 | $m^3/sec$ |
| No. of Units | | = | 4 | FRANCIS |
| Design Discharge (single unit) | $Q_{D/S}$ | = | 15.000 | $m^3/sec$ |
| Gross Head | $H_g$ | = | 112.00 | m |
| Head Loss | $H_L$ | = | 6.00 | m |
| Net Head | $H_n$ | = | 106.00 | m |
| Turbine Efficiency at Design Discharge | $\eta_T$ | = | 91.5% | |
| Generator Efficiency | $\eta_G$ | = | 96.8% | |
| Transformer Efficiency | $\eta_T$ | = | 98.0% | |
| Flushing Period | $T_D$ | = | 10 | days |

| | | |
|---|---|---|
| GROSS POWER | 64.94 | MW |
| ANNUAL ENERGY | 570.14 | GWh |
| PLANT FACTOR | 79.451 | % |

| TIME (DAYS) | | PERIOD | FLOW DURATION | NET HEAD | TURBINE - 1 | | | | TURBINE - 2 | | | | TURBINE - 3 | | | | TURBINE - 4 | | | | TOTAL POWER | ANNUAL ENERGY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | $Q_T$ | $\eta_T$ | Power | Energy | $Q_T$ | $\eta_T$ | Power | Energy | $Q_T$ | $\eta_T$ | Power | Energy | $Q_T$ | $\eta_T$ | Power | Energy | | |
| days | % | days | $m^3/s$ | m | $m^3/s$ | % | MW | GWh | $m^3/s$ | % | MW | GWh | $m^3/s$ | % | MW | GWh | $m^3/s$ | % | MW | GWh | MW | GWh |
| 1 | 0.3% | 4 | 1567.123 | 106.0 | 15.000 | 92.3% | 13.777 | 1.223 | 15.000 | 92.3% | 13.777 | 1.223 | 15.000 | 92.3% | 13.777 | 1.223 | 15.000 | 92.3% | 13.777 | 1.223 | 55.106 | 5.296 |
| 5 | 1.4% | 6 | 1426.816 | 106.0 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 55.106 | 5.513 |
| 10 | 2.7% | 6 | 1271.230 | 106.0 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 55.106 | 5.513 |
| 15 | 4.1% | 6 | 1108.548 | 106.0 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 55.106 | 5.513 |
| 20 | 5.5% | 6 | 982.929 | 106.0 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 55.106 | 5.513 |
| 25 | 6.8% | 6 | 887.011 | 106.0 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 55.106 | 5.513 |
| 30 | 8.2% | 6 | 751.093 | 106.0 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 55.106 | 5.513 |
| 35 | 9.6% | 6 | 645.175 | 106.0 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 55.106 | 5.513 |
| 40 | 11.0% | 6 | 590.083 | 106.0 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 55.106 | 5.513 |
| 45 | 12.3% | 6 | 555.258 | 106.0 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 55.106 | 5.513 |
| 50 | 13.7% | 6 | 520.919 | 106.0 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 55.106 | 5.513 |
| 55 | 15.1% | 6 | 493.378 | 106.0 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 55.106 | 5.513 |
| 60 | 16.4% | 6 | 480.048 | 106.0 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 55.106 | 5.513 |
| 65 | 17.8% | 6 | 426.561 | 106.0 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 55.106 | 5.513 |
| 70 | 19.2% | 6 | 396.063 | 106.0 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 55.106 | 5.513 |
| 75 | 20.5% | 6 | 367.197 | 106.0 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 55.106 | 5.513 |
| 80 | 21.8% | 6 | 343.089 | 106.0 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 15.000 | 92.3% | 13.777 | 1.653 | 55.106 | 5.513 |



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| TIME INCR. | | PERIOD | FLOW DURATION | NET HEAD | TURBINE - 1 | | | | TURBINE - 2 | | | | TURBINE - 3 | | | | TURBINE - 4 | | | | Total Power (P1+P2+P3+P4) | ANNUAL ENERGY Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | $Q_1$ | $\eta_1$ | $Power_1$ | $Energy_1$ | $Q_2$ | $\eta_2$ | $Power_2$ | $Energy_2$ | $Q_3$ | $\eta_3$ | $Power_3$ | $Energy_3$ | $Q_4$ | $\eta_4$ | $Power_4$ | $Energy_4$ | | |
| days | % | days | $m^3/s$ | m | $m^3/s$ | % | MW | GWh | $m^3/s$ | % | MW | GWh | $m^3/s$ | % | MW | GWh | $m^3/s$ | % | MW | GWh | MW | GWh |
| 85 | 23.3% | 5 | 320.184 | 106.0 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 55.106 | 6.613 |
| 90 | 24.7% | 5 | 296.627 | 106.0 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 55.106 | 6.613 |
| 95 | 26.0% | 6 | 273.170 | 106.0 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 55.106 | 6.613 |
| 100 | 27.4% | 5 | 249.663 | 106.0 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 55.106 | 6.613 |
| 105 | 28.8% | 5 | 226.156 | 106.0 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 55.106 | 6.613 |
| 110 | 30.1% | 5 | 203.667 | 106.0 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 55.106 | 6.613 |
| 115 | 31.5% | 6 | 168.676 | 106.0 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 55.106 | 6.613 |
| 120 | 32.9% | 5 | 175.744 | 106.0 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 55.106 | 6.613 |
| 125 | 34.2% | 6 | 161.612 | 106.0 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 55.106 | 6.613 |
| 130 | 35.6% | 5 | 147.661 | 106.0 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 55.106 | 6.613 |
| 135 | 37.0% | 5 | 133.949 | 106.0 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 55.106 | 6.613 |
| 140 | 38.4% | 5 | 120.018 | 106.0 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 55.106 | 6.613 |
| 145 | 39.7% | 5 | 106.086 | 106.0 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 55.106 | 6.613 |
| 150 | 41.1% | 5 | 93.897 | 106.0 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 55.106 | 6.613 |
| 155 | 42.5% | 5 | 82.844 | 106.0 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 55.106 | 6.613 |
| 160 | 43.9% | 5 | 67.193 | 106.0 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 55.106 | 6.613 |
| 165 | 45.2% | 5 | 61.437 | 106.0 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 55.106 | 6.613 |
| 170 | 46.6% | 5 | 75.884 | 106.0 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 55.106 | 6.613 |
| 175 | 47.9% | 5 | 69.930 | 106.0 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 55.106 | 6.613 |
| 180 | 49.3% | 5 | 64.177 | 106.0 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 55.106 | 6.613 |
| 185 | 50.7% | 5 | 60.139 | 106.0 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 15.000 | 93.3% | 13.777 | 1.653 | 55.106 | 6.613 |
| 190 | 52.1% | 6 | 57.897 | 106.0 | 14.462 | 93.5% | 13.296 | 1.595 | 14.462 | 93.5% | 13.296 | 1.595 | 14.462 | 93.5% | 13.296 | 1.595 | 14.462 | 93.5% | 13.296 | 1.595 | 53.185 | 6.382 |
| 195 | 53.4% | 5 | 55.479 | 106.0 | 13.870 | 93.6% | 12.764 | 1.531 | 13.870 | 93.6% | 12.764 | 1.531 | 13.870 | 93.6% | 12.764 | 1.531 | 13.870 | 93.6% | 12.764 | 1.531 | 51.056 | 6.127 |
| 200 | 54.8% | 5 | 53.149 | 106.0 | 13.287 | 93.6% | 12.231 | 1.468 | 13.287 | 93.6% | 12.231 | 1.468 | 13.287 | 93.6% | 12.231 | 1.468 | 13.287 | 93.6% | 12.231 | 1.468 | 48.926 | 5.871 |
| 205 | 56.2% | 5 | 50.821 | 106.0 | 12.705 | 93.2% | 11.656 | 1.399 | 12.705 | 93.2% | 11.656 | 1.399 | 12.705 | 93.2% | 11.656 | 1.399 | 12.705 | 93.2% | 11.656 | 1.399 | 46.823 | 5.595 |
| 210 | 57.5% | 6 | 48.492 | 106.0 | 12.123 | 92.9% | 11.064 | 1.330 | 12.123 | 92.9% | 11.064 | 1.330 | 12.123 | 92.9% | 11.064 | 1.330 | 12.123 | 92.9% | 11.064 | 1.330 | 44.256 | 5.320 |
| 215 | 58.9% | 5 | 46.163 | 106.0 | 11.541 | 92.6% | 10.515 | 1.262 | 11.541 | 92.6% | 10.515 | 1.262 | 11.541 | 92.6% | 10.515 | 1.262 | 11.541 | 92.6% | 10.515 | 1.262 | 42.062 | 5.047 |
| 220 | 60.3% | 5 | 44.073 | 106.0 | 14.691 | 93.4% | 13.509 | 1.621 | 14.691 | 93.4% | 13.509 | 1.621 | 14.691 | 93.4% | 13.509 | 1.621 | 0.000 | 0.0% | 0.000 | 0.000 | 40.519 | 4.862 |
| 225 | 61.6% | 5 | 42.038 | 106.0 | 14.012 | 93.5% | 13.173 | 1.581 | 14.012 | 93.5% | 13.173 | 1.581 | 14.012 | 93.5% | 13.173 | 1.581 | 0.000 | 0.0% | 0.000 | 0.000 | 39.520 | 4.742 |
| 230 | 63.0% | 5 | 41.799 | 106.0 | 13.933 | 93.6% | 13.048 | 1.641 | 13.933 | 93.6% | 13.048 | 1.641 | 13.933 | 93.6% | 13.048 | 1.641 | 0.000 | 0.0% | 0.000 | 0.000 | 39.519 | 4.922 |
| 235 | 64.4% | 5 | 40.882 | 106.0 | 13.664 | 93.7% | 12.496 | 1.600 | 13.664 | 93.7% | 12.496 | 1.600 | 13.664 | 93.7% | 12.496 | 1.600 | 0.000 | 0.0% | 0.000 | 0.000 | 37.456 | 4.499 |
| 240 | 65.8% | 5 | 39.828 | 106.0 | 13.178 | 93.4% | 12.120 | 1.454 | 13.178 | 93.4% | 12.120 | 1.454 | 13.178 | 93.4% | 12.120 | 1.454 | 0.000 | 0.0% | 0.000 | 0.000 | 36.360 | 4.363 |
| 245 | 67.1% | 6 | 38.388 | 106.0 | 12.796 | 93.2% | 11.748 | 1.409 | 12.796 | 93.2% | 11.748 | 1.409 | 12.796 | 93.2% | 11.748 | 1.409 | 0.000 | 0.0% | 0.000 | 0.000 | 35.236 | 4.228 |
| 250 | 68.5% | 5 | 37.251 | 106.0 | 12.417 | 93.0% | 11.372 | 1.365 | 12.417 | 93.0% | 11.372 | 1.365 | 12.417 | 93.0% | 11.372 | 1.365 | 0.000 | 0.0% | 0.000 | 0.000 | 34.116 | 4.094 |



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| TIME IN DEC. | | PERIOD | FLOW DURATION | NET HEAD | TURBINE - 1 | | | | TURBINE - 2 | | | | TURBINE - 3 | | | | TURBINE - 4 | | | | Total Power | ANNUAL ENERGY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | $Q_1$ | $\eta_1$ | Power$_1$ | Energy$_1$ | $Q_2$ | $\eta_2$ | Power$_2$ | Energy$_2$ | $Q_3$ | $\eta_3$ | Power$_3$ | Energy$_3$ | $Q_4$ | $\eta_4$ | Power$_4$ | Energy$_4$ | P=P1+P2 +P3+P4 | Total |
| (Hour) | (%) | (Hour) | ($m^3$/s) | (m) | ($m^3$/s) | (%) | (MW) | (GWh) | ($m^3$/s) | (%) | (MW) | (GWh) | ($m^3$/s) | (%) | (MW) | (GWh) | ($m^3$/s) | (%) | (MW) | (GWh) | (MW) | (GWh) |
| 255 | 69.9% | 6 | 36.114 | 106.0 | 12.039 | 92.6% | 11.001 | 1.320 | 12.039 | 92.6% | 11.001 | 1.320 | 12.039 | 92.6% | 11.001 | 1.320 | 0.000 | 0.0% | 0.000 | 0.000 | 33.002 | 3.960 |
| 260 | 71.2% | 6 | 36.297 | 106.0 | 11.766 | 92.7% | 10.735 | 1.288 | 11.766 | 92.7% | 10.735 | 1.288 | 11.766 | 92.7% | 10.735 | 1.288 | 0.000 | 0.0% | 0.000 | 0.000 | 32.204 | 3.864 |
| 265 | 72.6% | 6 | 34.510 | 106.0 | 11.505 | 92.5% | 10.491 | 1.259 | 11.505 | 92.5% | 10.491 | 1.259 | 11.505 | 92.5% | 10.491 | 1.259 | 0.000 | 0.0% | 0.000 | 0.000 | 31.483 | 3.778 |
| 270 | 74.0% | 6 | 33.726 | 106.0 | 11.245 | 92.4% | 10.227 | 1.227 | 11.245 | 92.4% | 10.227 | 1.227 | 11.245 | 92.4% | 10.227 | 1.227 | 0.000 | 0.0% | 0.000 | 0.000 | 30.682 | 3.682 |
| 275 | 75.3% | 6 | 32.965 | 106.0 | 10.995 | 91.7% | 9.916 | 1.190 | 10.995 | 91.7% | 9.916 | 1.190 | 10.995 | 91.7% | 9.916 | 1.190 | 0.000 | 0.0% | 0.000 | 0.000 | 29.749 | 3.570 |
| 280 | 76.7% | 6 | 32.174 | 106.0 | 10.725 | 91.0% | 9.669 | 1.160 | 10.725 | 91.0% | 9.669 | 1.160 | 10.725 | 91.0% | 9.669 | 1.160 | 0.000 | 0.0% | 0.000 | 0.000 | 29.008 | 3.481 |
| 285 | 78.1% | 6 | 31.393 | 106.0 | 10.464 | 90.3% | 9.395 | 1.127 | 10.464 | 90.3% | 9.395 | 1.127 | 10.464 | 90.3% | 9.395 | 1.127 | 0.000 | 0.0% | 0.000 | 0.000 | 27.914 | 3.350 |
| 290 | 79.5% | 6 | 30.612 | 106.0 | 10.204 | 89.6% | 9.084 | 1.090 | 10.204 | 89.6% | 9.084 | 1.090 | 10.204 | 89.6% | 9.084 | 1.090 | 0.000 | 0.0% | 0.000 | 0.000 | 27.013 | 3.242 |
| 295 | 80.8% | 6 | 29.963 | 106.0 | 14.982 | 93.3% | 13.761 | 1.651 | 14.982 | 93.3% | 13.761 | 1.651 | 0.000 | 0.0% | 0.000 | 0.000 | 0.000 | 0.0% | 0.000 | 0.000 | 27.521 | 3.303 |
| 300 | 82.2% | 6 | 29.491 | 106.0 | 14.701 | 93.4% | 13.515 | 1.622 | 14.701 | 93.4% | 13.515 | 1.622 | 0.000 | 0.0% | 0.000 | 0.000 | 0.000 | 0.0% | 0.000 | 0.000 | 27.029 | 3.244 |
| 305 | 83.6% | 6 | 28.840 | 106.0 | 14.420 | 93.5% | 13.258 | 1.592 | 14.420 | 93.5% | 13.258 | 1.592 | 0.000 | 0.0% | 0.000 | 0.000 | 0.000 | 0.0% | 0.000 | 0.000 | 26.516 | 3.184 |
| 310 | 84.9% | 6 | 28.278 | 106.0 | 14.139 | 93.6% | 13.021 | 1.563 | 14.139 | 93.6% | 13.021 | 1.563 | 0.000 | 0.0% | 0.000 | 0.000 | 0.000 | 0.0% | 0.000 | 0.000 | 26.042 | 3.125 |
| 315 | 86.3% | 6 | 27.716 | 106.0 | 13.858 | 93.6% | 12.774 | 1.533 | 13.858 | 93.6% | 12.774 | 1.533 | 0.000 | 0.0% | 0.000 | 0.000 | 0.000 | 0.0% | 0.000 | 0.000 | 25.548 | 3.066 |
| 320 | 87.7% | 6 | 27.155 | 106.0 | 13.577 | 93.7% | 12.529 | 1.503 | 13.577 | 93.7% | 12.529 | 1.503 | 0.000 | 0.0% | 0.000 | 0.000 | 0.000 | 0.0% | 0.000 | 0.000 | 25.059 | 3.005 |
| 325 | 89.0% | 6 | 26.593 | 106.0 | 13.297 | 93.5% | 12.241 | 1.469 | 13.297 | 93.5% | 12.241 | 1.469 | 0.000 | 0.0% | 0.000 | 0.000 | 0.000 | 0.0% | 0.000 | 0.000 | 24.481 | 2.938 |
| 330 | 90.4% | 6 | 25.969 | 106.0 | 12.993 | 93.3% | 11.939 | 1.433 | 12.993 | 93.3% | 11.939 | 1.433 | 0.000 | 0.0% | 0.000 | 0.000 | 0.000 | 0.0% | 0.000 | 0.000 | 23.993 | 2.879 |
| 335 | 91.8% | 6 | 25.186 | 106.0 | 12.592 | 93.1% | 11.546 | 1.385 | 12.592 | 93.1% | 11.546 | 1.385 | 0.000 | 0.0% | 0.000 | 0.000 | 0.000 | 0.0% | 0.000 | 0.000 | 23.093 | 2.771 |
| 340 | 93.2% | 6 | 24.404 | 106.0 | 12.202 | 92.9% | 11.161 | 1.339 | 12.202 | 92.9% | 11.161 | 1.339 | 0.000 | 0.0% | 0.000 | 0.000 | 0.000 | 0.0% | 0.000 | 0.000 | 22.323 | 2.679 |
| 345 | 94.5% | 6 | 23.623 | 106.0 | 11.812 | 92.7% | 10.779 | 1.294 | 11.812 | 92.7% | 10.779 | 1.294 | 0.000 | 0.0% | 0.000 | 0.000 | 0.000 | 0.0% | 0.000 | 0.000 | 21.559 | 2.587 |
| 350 | 95.9% | 6 | 22.842 | 106.0 | 11.421 | 92.5% | 10.399 | 1.248 | 11.421 | 92.5% | 10.399 | 1.248 | 0.000 | 0.0% | 0.000 | 0.000 | 0.000 | 0.0% | 0.000 | 0.000 | 20.798 | 2.496 |
| 355 | 97.3% | 6 | 22.062 | 106.0 | 11.031 | 91.6% | 9.971 | 1.196 | 11.031 | 91.6% | 9.971 | 1.196 | 0.000 | 0.0% | 0.000 | 0.000 | 0.000 | 0.0% | 0.000 | 0.000 | 19.942 | 2.393 |
| 360 | 98.6% | 6 | 21.281 | 106.0 | 10.640 | 90.6% | 9.510 | 1.141 | 10.640 | 90.6% | 9.510 | 1.141 | 0.000 | 0.0% | 0.000 | 0.000 | 0.000 | 0.0% | 0.000 | 0.000 | 19.020 | 2.282 |
| 365 | 100.0% | 6 | 20.500 | 106.0 | 10.250 | 89.9% | 9.057 | 1.087 | 10.250 | 89.9% | 9.057 | 1.087 | 0.000 | 0.0% | 0.000 | 0.000 | 0.000 | 0.0% | 0.000 | 0.000 | 18.114 | 2.174 |
| MEAN ANNUAL ENERGY (GWh) | | | | | | | | = | | | | | | | | | | | | | | 386.74 |

Annual Downtime Losse 10 days closure) = 2.74%

**Actual Mean Annual Energy (GWh)** = 376.1

Plant Factor = $\frac{336.1 \times 10^6}{54.04 \times 8760.00}$ = $\frac{\text{Actual Energy}}{\text{Theortical Energy}}$

Plant Factor = **79.46%**



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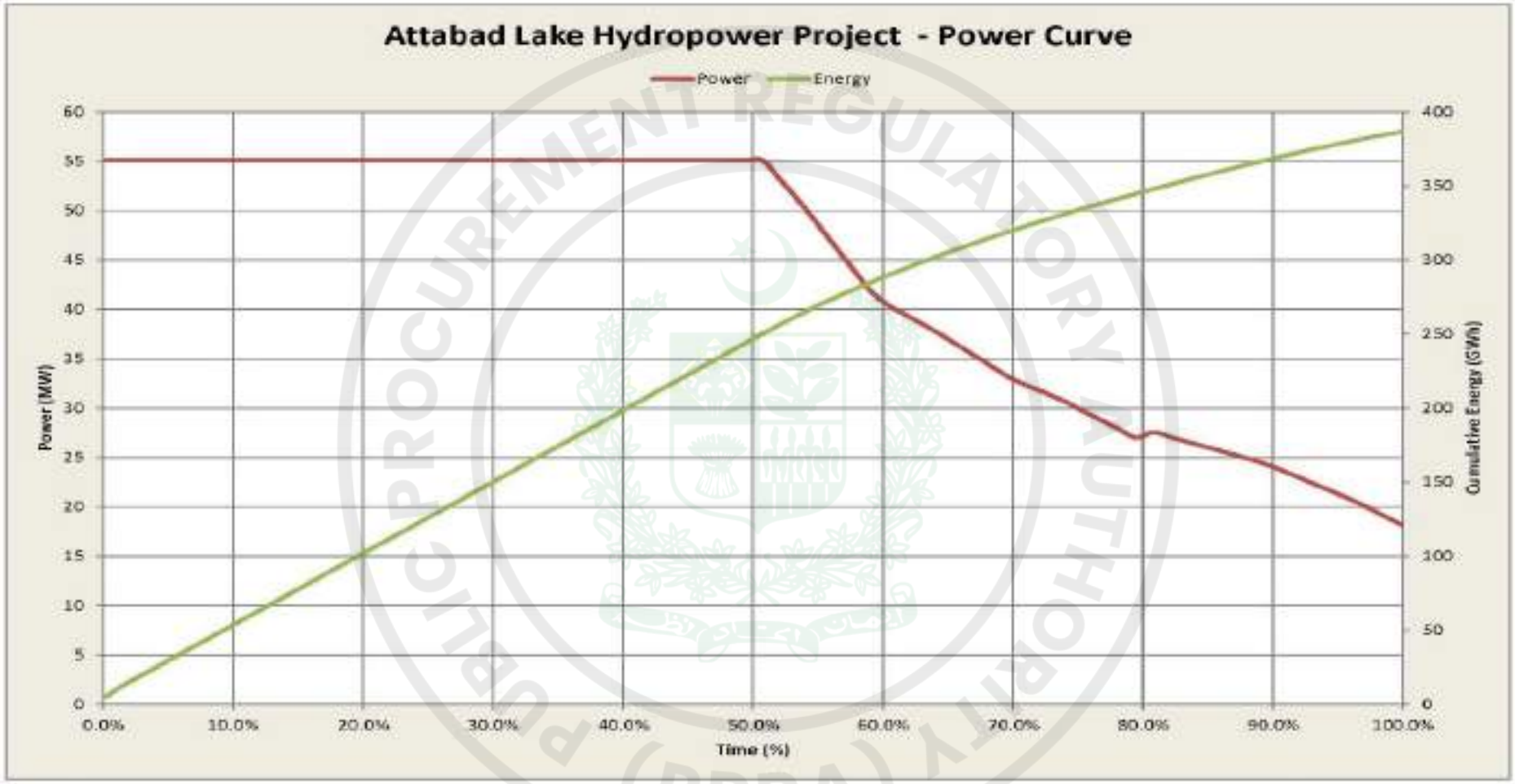




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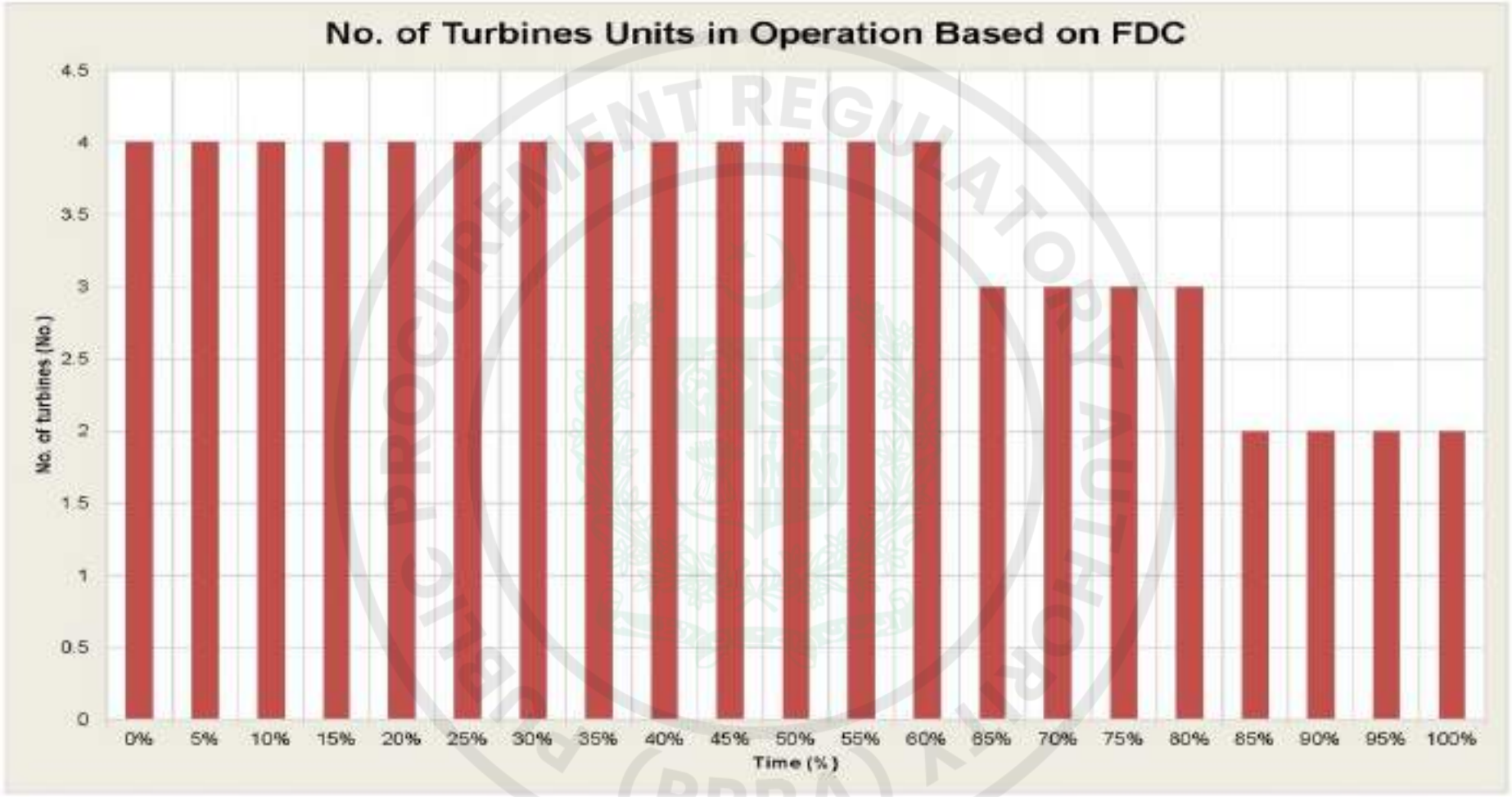




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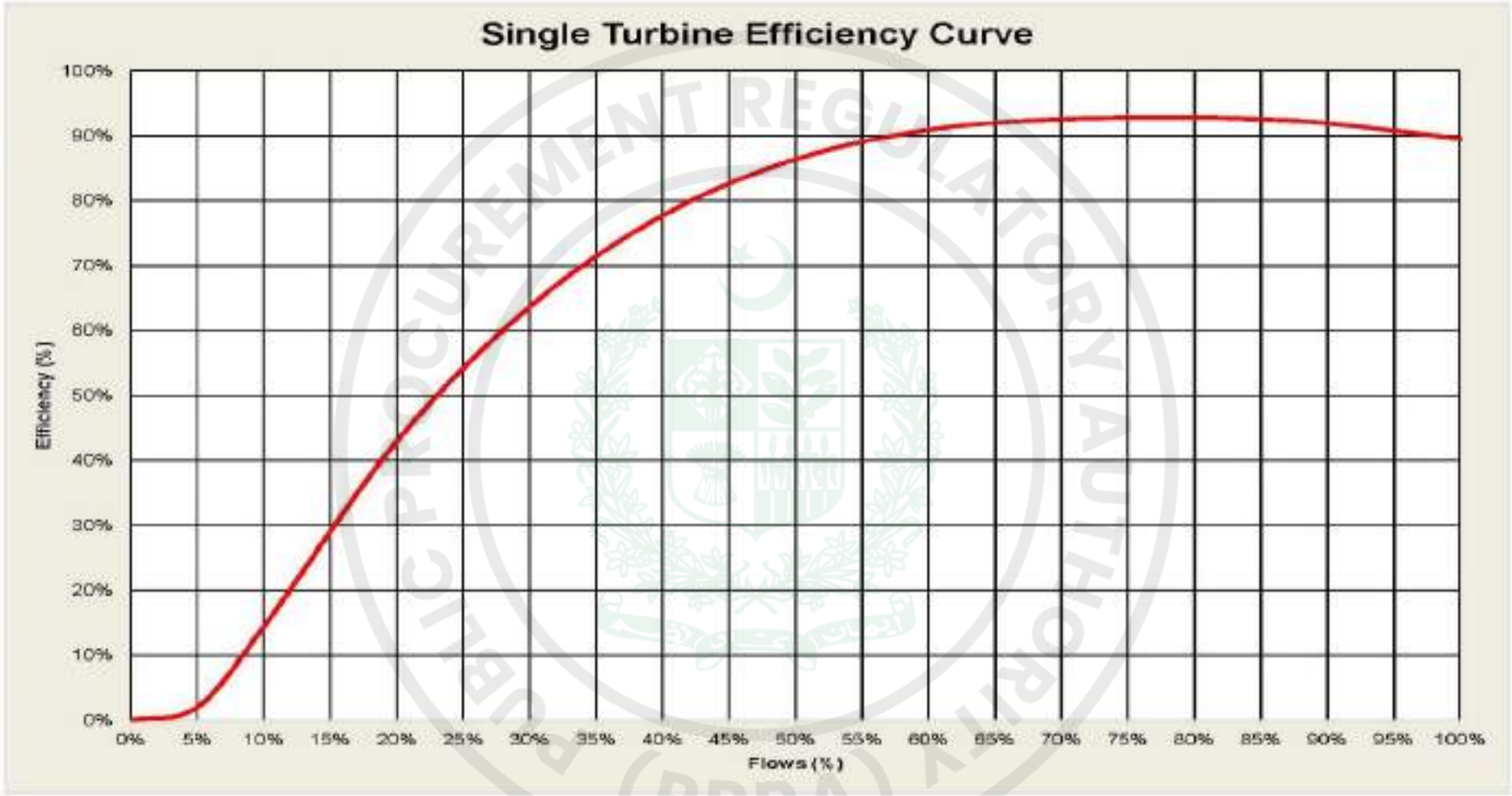




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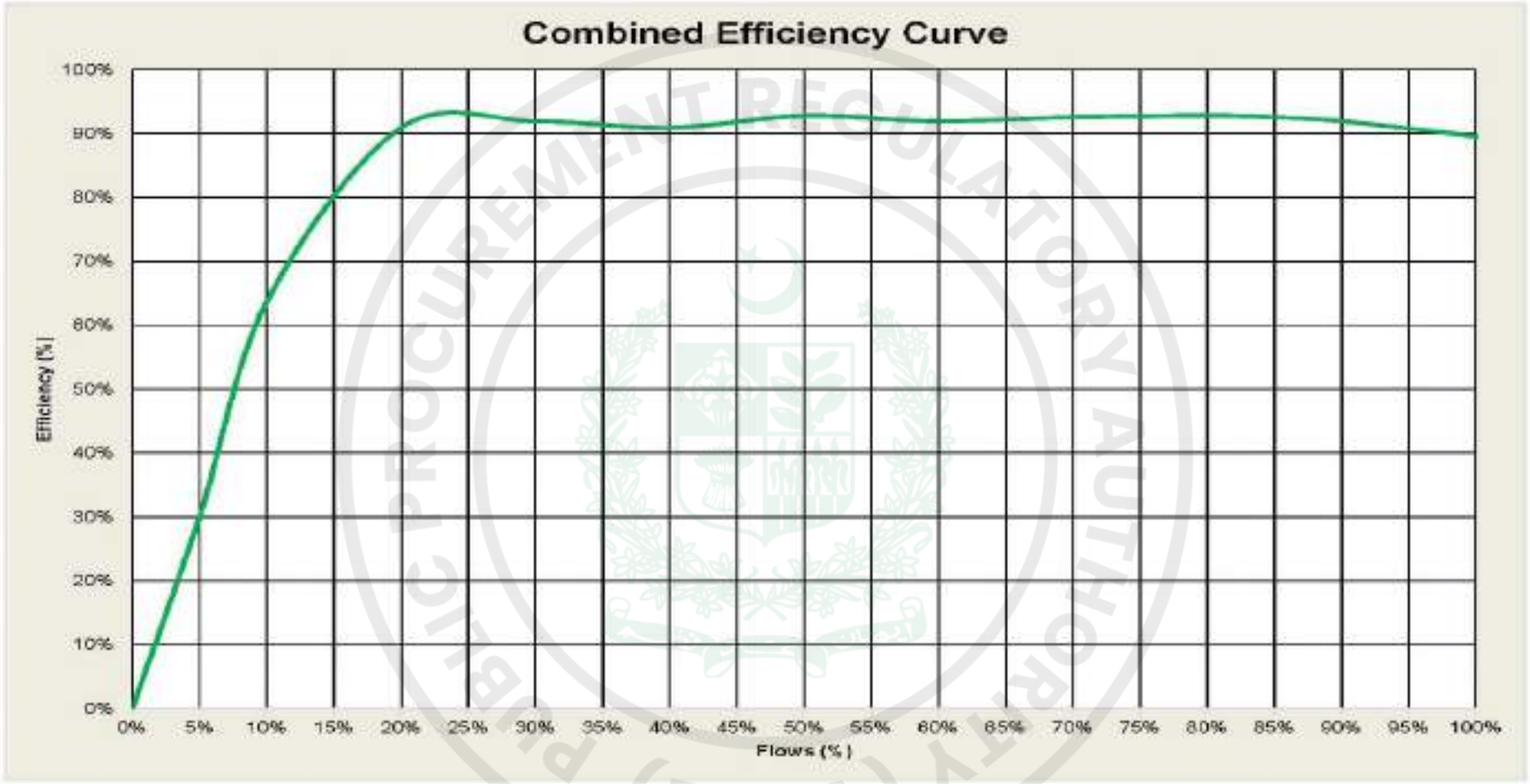


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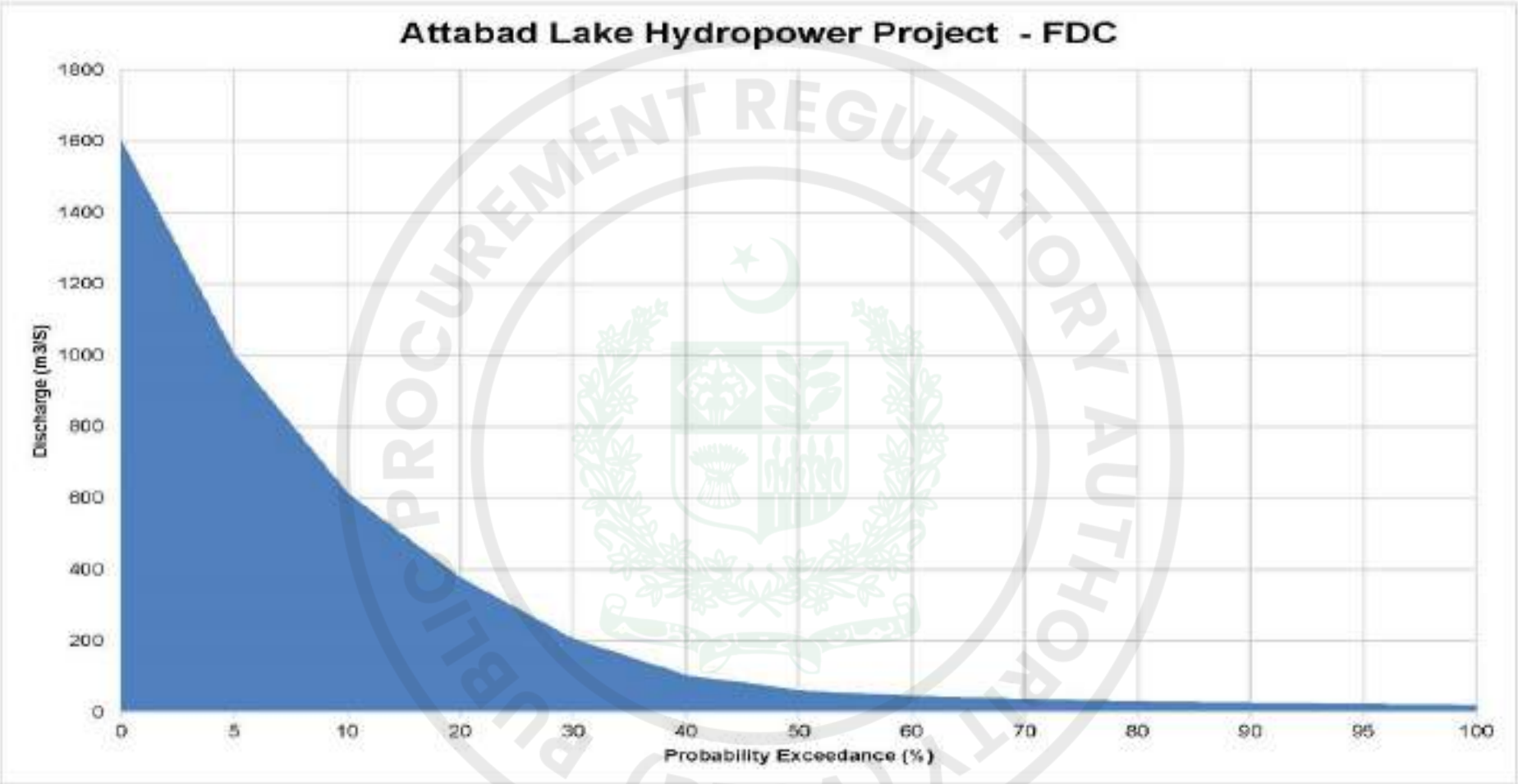


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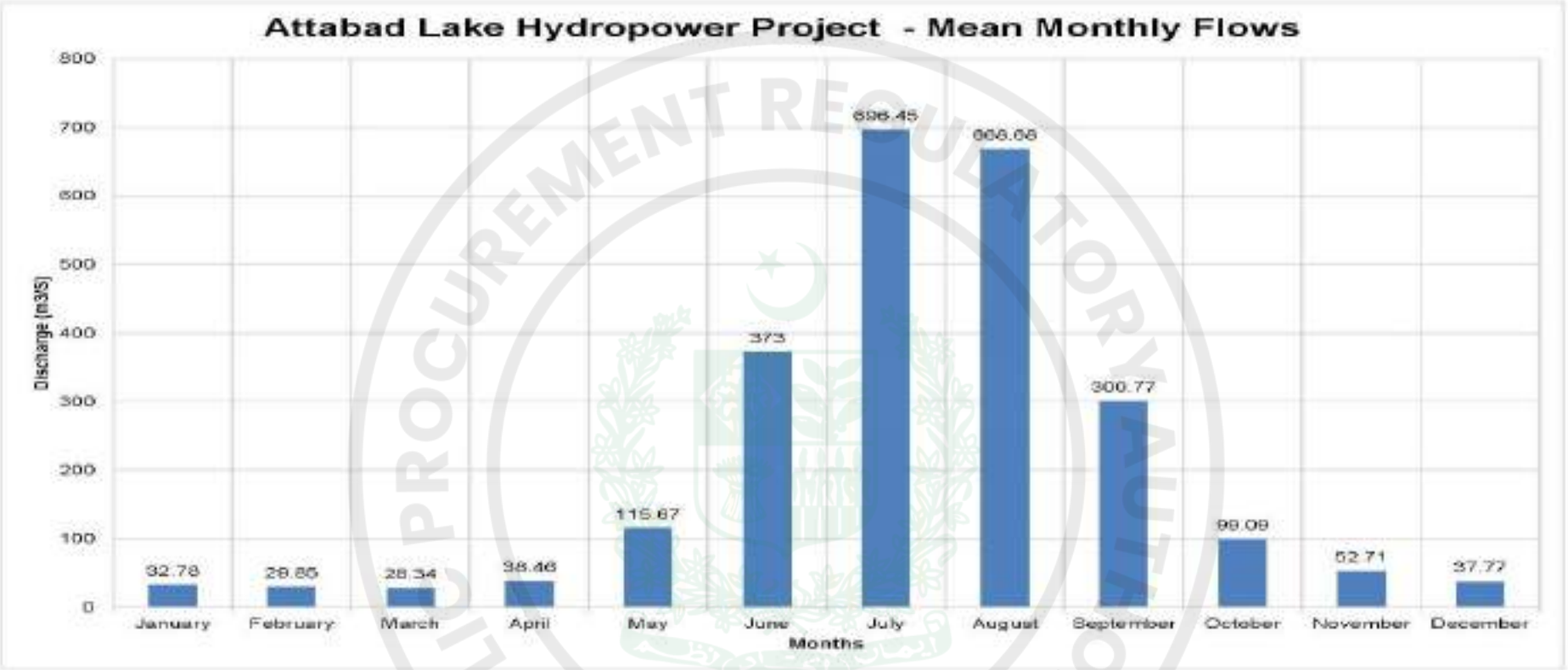


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## 8.5 REVIEW FINDINGS

Based on verifying study and calculations MC are of the opinion that solution finalized in the Feasibility study with installed capacity of 54MW with 79% plant factor is most optimized solution.

However, as per recommendations from Mechanical expert, efficiency of turbine can be taken as 93%. MC endorse the selection of turbine with 93% efficiency which may result in little higher installed capacity of about 57 MW.

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# 9 REVIEW OF STRUCTURE DESIGN STUDIES

## 9.1 GENERAL

In general, there are differences between values in the Feasibility Report and respective drawings. There are also differences for the same variable in the Feasibility Report in different sections. This issue should be corrected in the next design stages.

The inflow after the January 2010 land slide filled upstream valley created a 22 km long reservoir till the end of May 2010. The estimated lake initial storage was about 310 million $m^3$.

The deposited mass as a result of land slide is mainly composed of non-cohesive rock flour (fine dust, silt, silt gravels and cobbles) at the toe of the failed slope. Large boulders of granodioritic rocks with intrusions of granite, pegmatite and apatite were deposited close to the left bank of Hunza River. The deposit on the downstream side is composed of black clay with high plasticity and organic content. The upstream shoulder of the natural dam has mild slope and downstream slope is quite steep. With 2 km long dam, there is rare chance of piping failure. A view from Weir Site is shown in photograph given in Figure 9.1.

**Figure 9.1: View from Attabad Lake HPP Reservoir**

## 9.2 HYDRAULIC MODELLING OF RESERVOIR

The Hydrologic Engineering Center's River Analysis System (HEC-RAS 5.0.7) program has been used in the Feasibility Study of Attabad Lake HPP in order to analyze and assess the impact of design flood (3250 $m^3/s$) on the proposed system. A 1D-Unsteady numerical modeling has been used in the analysis. As a result of this analysis, it is found that there would be no major impact on the upstream settlements due to the overflow weir at 2414 m.a.s.l. and flood would remain within the river system. Weir site upstream and downstream views are given in photographs in Figure 9.2 and Figure 9.3.



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In the feasibility dated 2021 prepared by WAPDA, hydrological data between 1966 to 2015 have been used. The latest information should be accessed and hydrology should be updated. It will be good for the health of the projects to observe the increases in the flood discharge due to global climate change in Pakistan in recent years and, if possible, to apply them to the projects.

The hydraulic model that has been prepared during the Feasibility Study is a suitable approach.

**Figure 9.2: Weir Site Location Downstream View**

**Figure 9.3: Weir Site Location upstream view**



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## 9.3 NATURAL DAMMING ON HUNZA RIVER

It is possible that the lower elevations of the reservoir will be filled with sediment due to the construction of the body on the slide mass. The bottom spillway system in a classical dam is not within the scope of the project.

## 9.4 HYDRAULIC DESIGN

### 9.4.1 Hydraulic Design of Weir/Spillway and Stilling Basin

- **Weir/Spillway Discharge Capacity Overflow Ungated Structure**

In the feasibility report, it is mentioned that “The spillway discharge capacity at elevation 2421.4 masl is 3250 m³/s. along with overflow spillway, two low level flushing outlets would be in operation to discharge 600 m³/2. The total discharge through overflow weir/ungated spillway is 3250 m³/s, which is 10000 year return period. The spillway can therefore safely pass the PMF discharge with sufficient free board.”

According to the drawings, the maximum flood water elevation is calculated as 2421.00 m and therefore the water head at the uncontrolled ogee shaped spillway is 7 m. However, the spillway discharge elevation is given as 2421.4 m in the section of the feasibility report 9.4.1.1, this incompatibility should be eliminated in the next design phase. It is not possible to pass $Q_{10000}$, that is, 3250 m³/sec, from the uncontrolled spillway with 60 m spillway width and 7 m water head.

Quick calculations show that the uncontrolled ogee shaped spillway has a discharge capacity of approximately 2400 m³/sec. The discharge capacity of the undersluice section, with a dimension of 5x5 m, having a hydraulic head of 16.5 m from the center of the opening is approximately 270 m³/sec. The total discharge capacity for 3 gates is approximately 810 m³/sec. The total discharge capaity of the uncontrolled and gated undersluice parts is 3210 m³/sec and it is very close to the design flood discharge. Therefore, the calculations can be considered accurate. Since the gated undersluice section of the spillway will work together with the uncontrolled ogee shaped spillway to evacuate the flood to the downstream, it is of great importance that the gates are always working. Therefore, reliable energy must be guaranteed for the weir location.

Weir sluice gate operation is vital for sediment flushing and full utilization of energy potential in accordance with the considerations expressed in the reservoir operating system given in Chapter 8.2 of Feasibility Report.

- **Design of Spillway Stilling Basin**

In this section of Feasibility Report, stilling basin design of the uncontrolled ogee shaped spillway has been done with the following dimensions:

| | |
|---|---|
| Invert of stilling basin | 2397.0 masl |
| Width of stilling basin | 60.0 m |
| Elevation of river bed d/s | 2400.00 masl |
| Length of stilling basin | 55.0 m |

There are inconsistencies between the elevations used in drawings and calculations. According to the control calculations, the calculations are generally confirmed, but the stilling basin wall top elevation in the drawings is insufficient compared to the calculations. In this framework, calculations and design compatibility should be ensured in the next stage.



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### 9.4.2 Flushing Outlets

Three low level sediment flushing cum diversion outlets have been provided on the left bank upstream of the embankment dam to enable flushing of sediment in front of the power intakes in the Feasibility Study. Design of under sluice from Feasibility study is given below.

| | | |
|---|---|---|
| Maximum upstream Water Level | 2421.4 | m.a.s.l. |
| Maximum downstream Water Level | 2405.0 | m.a.s.l. |
| Upstream Bed Level | 2400.0 | m.a.s.l. |
| Downstream Bed Level | 2400.0 | m.a.s.l. |
| Design Discharge | 720 | $m^3/s$ |
| Width of Undersluice | 5.0 | m |
| Height of Undersluice | 5.0 | m |
| Gravitational Acceleration | 9.81 | $m/s^2$ |
| Cross sectional Area | 25 | |
| Wetted Perimeter | 20 | |
| Hydraulic Radius | 1.25 | |
| (U/S water level) - (D/S water level) = h | 16.40 | m |
| **CAPACITY OF UNDER SLUICE** | | |
| $X = (1/1+f_i+f_o+f_c+f_{fr})^{\wedge}1/2$ | | |
| where | | |
| Coefficient for intake losses ($f_i$) | 0.06 | |
| Coefficient for outlet losses ($f_o$) | 1 | |
| Coefficient for change in cross sec. ($f_c$) | 0.04 | |
| Coefficient for friction losses ($f_{fr}$) | | |
| Stickler's coefficient (k) | 70 | |
| $f_{fr} =$ | 0.13 | |
| $X =$ | 0.67 | |
| $V = \frac{X}{(2gh)^{\wedge}0.5}$ | 12.00 | m/s |
| Q = One Under Sluice | **300.0** | $m^3/s$ |
| Discharge through three Undersluices | **900.1** | $m^3/s$ |

According to the control calculations, the capacity of each of the undersluice gates is approximately 270 $m^3/s$. The discharge capacity calculation, which depends on many assumptions, is correct. It is recommended to conduct a model test to verify the effect of the gates on each other and the flushing ability of the undersluice system.

Since the gated under sluice section of the spillway will work together with the uncontrolled ogee shaped spillway to evacuate the flood to the downstream, it is of great importance that



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the gates are always working. Therefore, reliable energy must be guaranteed for the weir location.

Weir sluice gate operation is vital for sediment flushing and full utilization of energy potential.

Even if geotechnical ground improvements are to be made, it is necessary to pay attention to the division of the structure into blocks in such a way that the possible minimal different settlements and the possible jamming of the gates will be prevented, that is, the caps will remain in a single block.

### 9.4.3 Freeboard Calculations

- **Wind Speed**

Since there is no wind data available specific to the Attabad Lake HPP region, it is assumed as 100 km/hr with all speed correction factors applied in the Feasibility Study. The calculations and assumptions made are in accordance with the general tendency.

- **Design Wave Height and Duration**

The wind height has been calculated using Molitor - Stevenson Formula as Hs = 1.21 m in the Feasibility report. The adopted crest elevation of the cofferdam is fixed at 2420.0 m.a.s.l. The channel will discharge in free flow condition.

If detailed wind and fetch information is obtained during the application design project phase, more detailed study is recommended.

## 9.5 DESIGN OF RIVER DIVERSION WORKS

It is suggested to do the construction with stage construction utilizing diversion channels. This method is suitable for such a construction, however, after obtaining detail inputs for mapping, floods and design of weir, river diversion works need to be checked to see if it is appropriate. It can be applied in principle, but should be re-examined with current hydrological data during the application phase.

### 9.5.1 Discharge Capacity of River Diversion Works

The design flood return period for Attabad Lake HPP has been selected as 20 years in the Feasibility Study. The design of the diversion system in dam-type structures is made using Q25 (with freeboard) and Q50 (without freeboard) flow rates. Q5 (with freeboard) and Q10 (without freeboard) flow rates are used in weir type structures. Attabad Hydropower Facility is in between these two facilities. Therefore, it is reasonable for the designer to use the Q20 flow rate with a freeboard. However, in the next stages, it should also be checked which frequency flow passes without freeboard.

Moreover, it is stated that the cofferdam will be strengthened in case of any possible overtopping. Diversion channel discharge rating has been calculated as given in Table 9.1.



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**Table 9.1 Diversion channel discharge rating calculations**

| Geometrical Input Data | | | Calculation of Downstream Rating Curve | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Length of Canal : | 475.00 | m | Wat. Dep | Area | Wett.Par | Hydr.Rad. | Discharge | Velocity | Froude No. |
| Slope Water Side : 1: | 1.00 | - | m | $m^2$ | m | m | $m^3/s$ | m/s | - |
| Hydraulic Bed Width : | 25.00 | m | 0.00 | 0.00 | 25.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Strickler Value (M) | 45.00 | - | 0.40 | 10.16 | 26.13 | 0.39 | 27.37 | 2.69 | 1.36 |
| Slope of Energy Line (S) | 6 /475 | - | 0.80 | 20.64 | 27.26 | 0.76 | 86.71 | 4.20 | 1.50 |
| | | | 1.20 | 31.44 | 28.39 | 1.11 | 170.19 | 5.41 | 1.58 |
| Water Depth : (Input) | 5.00 | m | 1.60 | 42.56 | 29.53 | 1.44 | 274.67 | 6.45 | 1.63 |
| Depth : (From rating curve) | 5.00 | m | 2.00 | 54.00 | 30.66 | 1.76 | 398.33 | 7.38 | 1.67 |
| $Q = MxR^{0.667}xS^{0.5}xA$ | | | 2.40 | 65.76 | 31.79 | 2.07 | 539.97 | 8.21 | 1.69 |
| Discharge | 1857.79 | $m^3/s$ | 2.80 | 77.84 | 32.92 | 2.36 | 698.73 | 8.98 | 1.71 |
| | | | 3.20 | 90.24 | 34.05 | 2.65 | 874.02 | 9.69 | 1.73 |
| WL Canal Start : | 2403.00 | m.a.s.l. | 3.60 | 102.96 | 35.18 | 2.93 | 1065.38 | 10.35 | 1.74 |
| WL Canal End : | 2397.00 | m.a.s.l. | 4.00 | 116.00 | 36.31 | 3.19 | 1272.50 | 10.97 | 1.75 |
| | | | 4.40 | 129.36 | 37.45 | 3.45 | 1495.13 | 11.56 | 1.76 |
| BL Canal Start : | 2398.00 | m.a.s.l. | 4.80 | 143.04 | 38.58 | 3.71 | 1733.09 | 12.12 | 1.77 |
| BL Canal End : | 2392.00 | m.a.s.l. | 5.00 | 150.00 | 39.14 | 3.83 | 1857.79 | 12.39 | 1.77 |

Crest level of the cofferdam has been selected as 2421.0 masl allowing 2.0 m freeboard.

Since there is no detailed information in the drawings, the calculations could not be checked. During the detailed design phase, after the final maps are obtained, necessary design studies will be carried out, and controls will be made after the cross sections are obtained.

## 9.6 POWER INTAKE STRUCTURE

In the Feasibility Study twin intakes have been provided for intake of water into the power waterway system with 30.0 m³/s capacity of each. The invert of the intake is placed at elevation 2412.0 m.a.s.l. based on sediment control and submergence considerations. Deck and other operating levels have been set at 2422.0 m.a.s.l.so that the intake can perform over a range of operating water levels in the reservoir including maximum flood water levels.

The drawing contains slightly different information than report. The water intake drawing and the information about the geometry expressed in the report are inconsistent. The drawing should be harmonized with the design and calculations to be made in the next stage.

### 9.6.1 Hydraulic Design of Intake

- **Criteria for Design**

Intake structure dimensions and type is suitable in terms of hydraulics.

- **Intake Submergence**

There are also some inconsistencies between drawings and Feasibility Report. Power intake submergence has been calculated with Gordon's relationship for asymmetrical flow in the Feasibility Study and determined as $S_{min}$ = 3.75 m.

The submergence has been calculated as 1.75m. The value calculated in the Feasibility Report is higher than this value. Therefore, after finalizing the intake dimensions during next stages of design, submergence calculation should be renewed.



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After the drawing of the water intake is finalized as stated in section 9.7 according to the calculations to be made, it should be ensured that the critical submergence is controlled according to the calculations to be made and the current system.

Critical submergence depth should also be verified by hydraulic model test.

- **Power Intake Settings**

| | |
|---|---|
| Maximum Operation Level | 2414.0 m.a.s.l. |
| Minimum Operation Level | 2412.0 m.a.s.l. |
| Required submergence | 2.0 m |
| Intake waterway height | 4.5 m |
| Required Invert level | 2404.0 m.a.s.l. |

The intake invert has been set at 2404.0 m.a.s.l.

Since vortex formation is dependent on many factors including orientation of the intake to flow and not only on submergence, hydraulic model studies are recommended at detailed design stage to confirm that vortices do not form at the intake. Power intake site photograph is given in Figure 9.4.

**Figure 9.4: Water Intake Location**

- **Trashrack Cross-sectional Area**

The velocity of the water was limited to 1 m/s and a gross trashrack area of 60 square meters was selected. The trashrack grid spacing design, gross and net velocities should be reviewed with the EM equipment supplier.



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## 9.7 LOW PRESSURE TUNNEL

Loss types, formulas, and velocity inside reinforced concrete tunnel limitation are mentioned. 5.5 m tunnel diameter was found as a result of optimization. However, the tunnel diameter given in the drawings is 5.2 m, which is inconsistent with the 5.5 m stated in the report. The tunnel diameter is suitable as the velocity criteria given in concrete lined tunnels are met. In the report, the longitudinal slope of the tunnel is given as 0.4%. In the next design stages, the friction loss calculation together with the local losses should be renewed to ensure that the piezometry does not intersect the tunnel profile and that a safe positive pressure is formed inside the tunnel.

Low pressure tunnel from intake to surge tank would be excavated in the left bank rock formation parallel and at lower elevation to existing highway tunnel. The length of headrace tunnel is estimated about 2320 m. The closest part of the headrace scheme to the KKH Tunnel is at surge tank. At this point, the surge tank bottom elevation is 2385m, whereas the KKH tunnel invert elevation is 2376m. The perpendicular distance between the outer walls of the structures is 65m. Since the geological formation is defined as moderately weathered gneiss in the as-built drawings of the KKH tunnel, the interaction between the structures is regarded as safe.

The biggest portion of the underground works is the excavation of the headrace tunnel, which is approximately 2.3 km long. The headrace tunnel covers about 95% of the total underground works excavation volume.

Headrace tunnel was optimized by considering different diameters for design discharge of 60 $m^3/s$.

The optimized diameter of low pressure headrace tunnel is 5.5m and its length 2320m. The upstream level of tunnel is El. 2,402.5 masl whereas downstream level is El. 2,385 masl.

The proposed alignment for tunnel is generally fine with overburden surface cover along some locations which can be further investigated for sub surface rock cover during detail design investigations by EPC contractor.

In the Feasibility Report, the geological profile of the low pressure tunnel and proposed construction methodology and support systems are missing, hence, the quantities used in the cost estimates could not be verified. Typical support systems and their application changes shall be evaluated further to reach a more sound cost estimate.

The measures to be taken at the fault zone which the low pressure tunnel is passing through shall be clarified and incorporated in the tender design.

The data for existing KKH road tunnels alignment, elevation and geological profile is important for the design of new tunnel to arrive at a practical and safe design for its construction.

In addition to low pressure tunnel itself, the two (02) adits (access tunnels) reaching the power intake section and surge tank section that are about 450 and 202 meters long respectively shall be elaborated further. The cross sections, supports systems and geological profiles of adits need to be incorporated to the tender design of EPC documents.

In case of any other alternative layout scheme of the hydropower project that requires a tunnel arrangement, the geological longitudinal profile, cross section and provisional support systems need to be added to the tender design of EPC documents.



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## 9.8 SURGE TANK

Throttled cylindrical surge tank has been selected during the Feasibility Study. The cross sectional area of the cylindrical surge tank is selected with a factor of safety of 2.5 times larger than the Thoma-Criterion to ensure adequate stability of plant operation.

Choosing the throttled surge tank is appropriate in terms of minimizing the energy tunnel losses during energy production. Photograph of Surge Tank location and Penstock alignments is shown in Figure 9.5.

**Figure 9.5: Penstock and Surge Tank Location**

### 9.8.1 Hydraulic Design of Surge Tank

Main features of Surge Tank hydraulic design are summarized in Table 9.2.



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**Table 9.2 Minimum Cross Section for Surge Tank at Headrace Tunnel**

| | | | |
|---|---|---|---|
| Total headrace discharge | Q | 60 | $m^3/s$ |
| Length of headrace tunnel | L | 2320 | m |
| Diameter of Tunnel | D | 5.50 | m |
| Cross section area | A | 24.62 | $m^2$ |
| Head loss | h | 2.6 | m |
| Velocity in tunnel | v | 2.46 | m/s |
| Velocity head | $v^2/2g$ | 0.31 | m |
| Minimum reservoir level | $W_L$ | 2412.0 | m.a.s.l |
| Minimum tailwater level | $W_L$ | 2302.0 | m.a.s.l |
| Head difference | $H_o$ | 110.0 | m |
| Net head | $H_n$ | 105.2 | m |
| | $A_S$ | 63.16 | $m^2$ |
| | 1.5 $A_S$ | 90.08 | |
| | $D_{Ssquared}$ | 10.7 | m |
| | $D_{Sselected}$ | 10.0 | m |

Following scenarios have been assumed for the design of the surge tank:

LC-UP 1) Load acceptance from partial load, not exceeding 50 % total load increase; subsequent full load rejection;

LC-UP 2) Load acceptance of two units after synchronization; subsequent full load rejection;

LC-DN 1) Full load acceptance of two turbines followed by another turbine after a certain time interval

LC-DN 2) Load reduction by 50 per cent and subsequent complete load acceptance.

Calculations for turbine load acceptance, turbine load rejection durations and valve opening-closing durations will be repeated with the exact durations after the E/M manufacturer is determined.

Some investors/clients also want to study successive opening-closing, reopening-reclosing scenarios, therefore additional scenarios can be added to the surge tank design within the scope of this project.

### 9.8.2 Load Case Maximum Upsurge

This load case represents the most unfavorable moment for upsurge which is full load rejection when the headrace tunnel is at its maximum. Following assumptions and scenarios are made in the Feasibility Study for maximum upsurge:

| | | |
|---|---|---|
| Turbine load acceptance after synchronization | | 5.0 seconds (10 to100%) |
| Wicket gate closure at turbine load rejection : | | 5.0 seconds (100 to 0 %) |
| Maximum Reservoir Level | : | 2414.0 m.a.s.l. |
| Minimum tunnel roughness | : | 0.3 mm |



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| | |
|---|---|
| LC-UP 1) | Load acceptance from partial load, not exceeding 50 % total load increase; subsequent full load rejection; |
| LC-UP 2) | Load acceptance of two units after synchronization; subsequent full load rejection; |
| LC-DN 1) | Full load acceptance of two turbines followed by another turbine after a certain time interval |
| LC-DN 2) | Load reduction by 50 per cent and subsequent complete load acceptance. |

A conservative approach is taken in the present feasibility design, full load acceptance of two units connected to the headrace tunnel will be assumed as extraordinary load case for which the surge tank design shall guarantee the specified minimum freeboard margins. Following assumptions are made in the Feasibility Study for minimum down surge:

| | |
|---|---|
| Turbine load acceptance after synchronization | 50 sec (10-100%) |
| Wicket gate closure at turbine load rejection | 5.0 sec (100-0%) |
| Minimum reservoir water level | 2412.0 m.a.s.l. |
| Maximum turbine discharge | 20 $m^3/s$ |
| Maximum tunnel roughness | 0.3 mm |

Water level variation and Discharge variation is presented in Figure 9.6 and Figure 9.7 respectively.

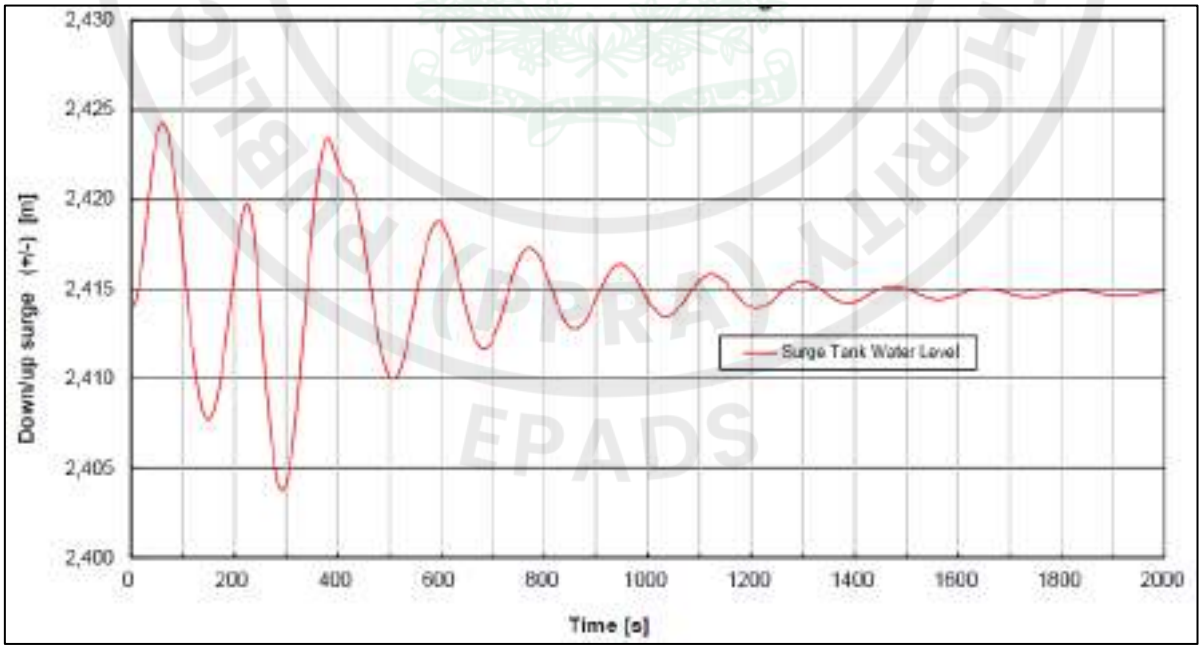


**Figure 9.6: Water Level Variation in Surge Tank**




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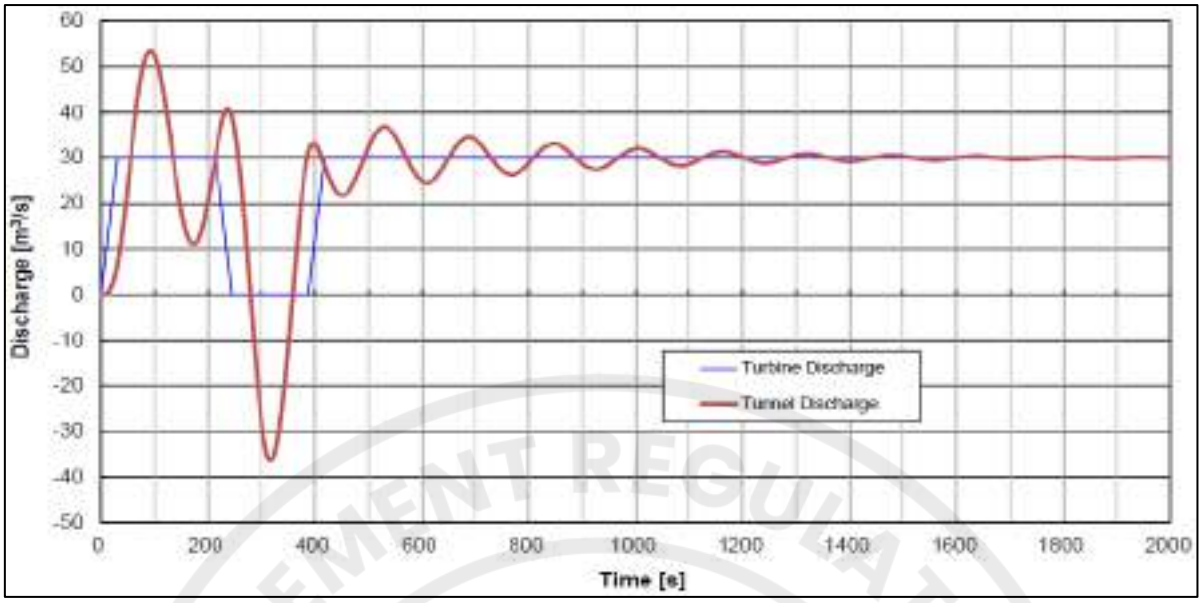


**Figure 9.7: Discharge Variation in Surge Tank**

During the examination of upsurge and downsurge conditions, an initial elevation should be used for T=0 sec, taking into account the losses in the conveyance system and the maximum and minimum water elevations of the reservoir. For downsurge, minimum water level and maximum system discharge (for 3 turbines) and on-off scenarios should be used while the system is stopped. For Upsurge, calculations should be made in case of sudden load rejection of 3 turbines operating at maximum flow rate at the maximum elevation of the reservoir. In this case, the losses should be taken into account when determining the initial level of the surge tank. In other words, it is not a correct approach to take the direct reservoir water level inside the surge tank. Upsurge and downsurge graphs should be determined by the EM equipment manufacturer for various operating and accident scenarios and given as separate graphs.

### 9.8.3 Results of Surge Tank Simulation

The results of this analysis is given in the Feasibility Study as follows:

| | |
|---|---|
| Upsurge | 2424.2 m.a.s.l |
| Down Surge | 2403.8 m.a.s.l |

In the control analyses made, it has been found that the upsurge and down surge calculations given in the report for the opening and closing of a single unit are correct. However, depending on the client's operation criteria, the opening or closing of more than one unit at the same time may occur in the system. Therefore, during the implementation project phase, the operating scenarios should be decided together with the EM supplier and the client, and the calculations should be renewed depending on the system design criteria. Cases of simultaneous opening or closing of 3 units based on past experience should also be included in the design.

## 9.9 WATER HAMMER ANALYSIS IN PENSTOCKS

For the water hammer analysis following conditions are used.



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| | |
|---|---|
| Reservoir Level | 2414.0 m.a.s.l. |
| Turbines centre line level | 2300.0 m.a.s.l. |
| Operation Mode | Full Load Rejection within 5 seconds |
| QT for single unit | 20.0 m³/s |

Due to the newly proposed location of the powerhouse, the shortening of the penstock will reduce the water hammer effect.

Since some investors do not want the water in the tunnel to flow towards the power plant and cause more damage in case of possible penstock damage, they prefer to put a butterfly valve for emergency response purposes at the first point where the penstock comes to the surface after the surge tank. In case it is decided to add such a valve, necessary precautions should be taken to prevent the penstock from buckling due to negative internal pressure. Accordingly, the drawings of a project implemented in Turkey are given in Figure 9.6 and Figure 9.7.

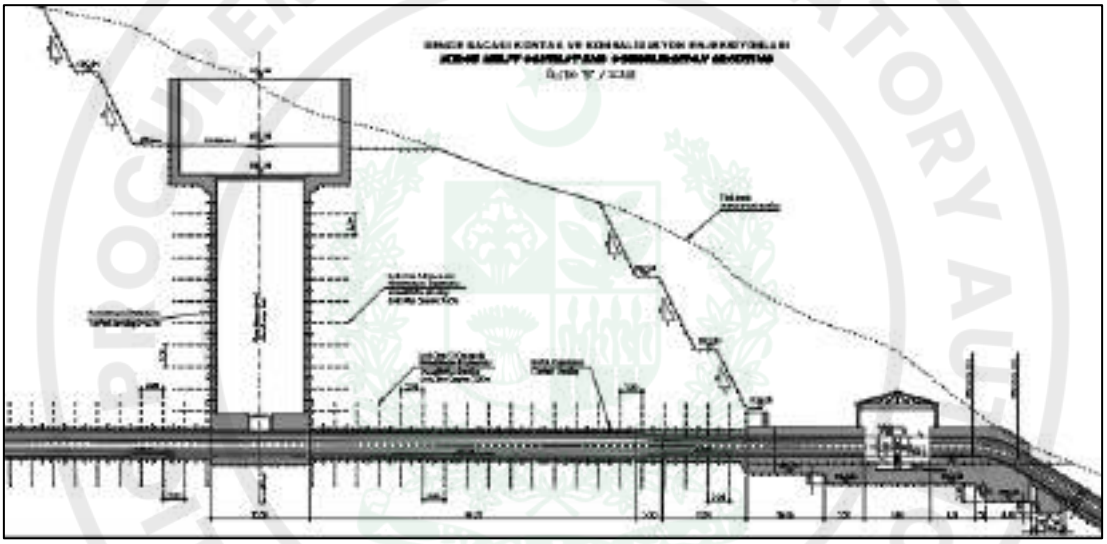

**Figure 9.8: Emergency Butterfly Valve after Surge Tank 1/2**

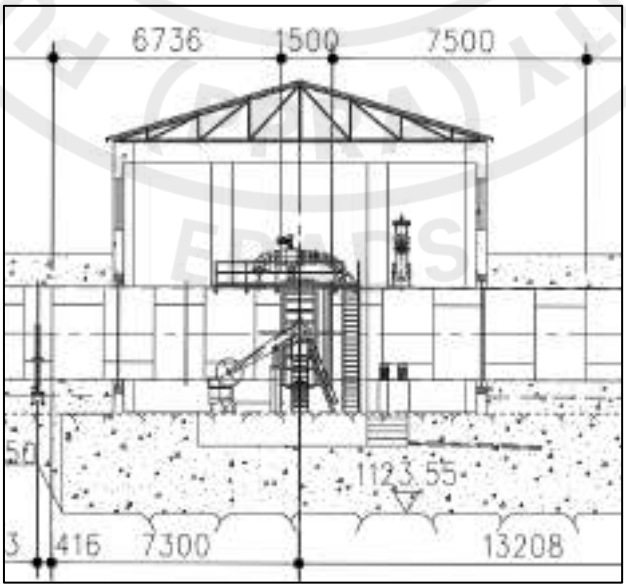


**Figure 9.9: Emergency Butterfly Valve after Surge Tank 2/2**



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### 9.9.1 Water Hammer Calculations for Single Penstock

In Attabad Hydropower Project the power house has three turbine units. Each turbine unit is connecting with one penstock. To calculate water hammer pressure in the penstocks the longest penstock is considered because it will give the maximum rise in pressure when valve of turbine closed suddenly. The longest penstock is 35m long.

| | | |
|---|---|---|
| Total discharge for 3 units | Q | = 60.0 $m^3/s$ |
| Discharge for single turbine | QT | = 20.0 $m^3/s$ |
| Diameter of penstock | D | = 2.07 m |
| Velocity in the penstock | V | = 5.89 m/s |
| Length of penstock | L | = 35 m |
| Maximum Operation Level | | = 2414.0 m.a.s.l. |
| Minimum Tail Water Level | | = 2300.0 m.a.s.l. |
| Maximum Head | | = 114 m |
| Steel liner Thickness | t | = 25 mm |
| D/t | | = 82.8 |

### 9.9.2 Pressure Wave Velocity

Following Parmakian (1955) formula is used to calculate the velocity of pressure wave in the Feasibility Study:

$$a = \sqrt{\frac{1}{\rho\left(\frac{1}{K} + \frac{DC_1}{Et}\right)}}$$

Where

E = Elastic modulus for steel = $1x10^9$ $N/m^2$

K = Volume modulus of water = $2.1x10^{11}$ $N/m^2$

$\rho$ = Mass of water = 1000 $kg/m^3$

$C_1 = 1-u^2$

u = Poisson's ratio for steel = 0.3

a = 140 m/s

### 9.9.3 Water Hammer Pressure (Allievi Chart)

Maximum pressure has been calculate as $H_0 + h_{max}$ = 107.6 m in the Feasibility study. Therefore, the pressure rise in the penstock for sudden closure of value (5 s) is 33.02 m. If the powerhouse is brought back closer to the hill, then the length of penstock will be decreased which will result in a decrease in water hammer.



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The water hammer calculations should be renewed by the mechanical engineer by using the scenarios expressed in the surge tank design according to the new location of the power plant and therefore the new penstock length.

## 9.10 POWERHOUSE

There are contradictions between the elevations specified in the powerhouse drawings and the elevations specified in the report. Other dimensions and elevations are given, but should be revised according to the detailed design data to be obtained from the turbine manufacturer. Possible changes in elevations according to the new location of the power plant should be considered in the next design.

Feasibility stage proposed Powerhouse location site photographs are given in Figure 9.8 and Figure 9.9.

**Figure 9.10: Feasibility stage Proposed Powerhouse Location 1/2**



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**Figure 9.11: Feasibility stage Proposed Powerhouse Location 2/2**

## 9.11 TAILRACE CHANNEL

From the new powerhouse location, it will be possible to connect the powerhouse to the stream bed with a tail water channel without any change in the installed power of the power plant with a channel of suitable cross-section. However, this design is also associated with the submergence required by the EM equipment



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# 10 REVIEW OF GEOTECHNICAL AND STRUCTURAL STABILITY ANALYSIS

## 10.1 REVIEW OF SLOPE STABILITY ANALYSIS

The proposed cut slopes for the project components including the Weir have been analysed using GEOSTUDIO suite SLOPE/W.

The design parameters used in the slope stability analysis during Feasibility study are given in Table 10.1.

**Table 10.1 Material parameters used for Feasibility study Slope Stability Analysis**

| Condition | Unit Weight ($Kn/m^3$) | Cohesion (KPa) | Angle of Internal Friction (Deg) |
|---|---|---|---|
| Below Water Surface | 21 | 100 | 20 |
| Above Water Surface | 18 | 120 | 25 |

Young's Modulus of Elasticity is 1.29 e +4 and poisons ratio used is 0.15.

Slope stability analysis was performed at Feasibility stage to check the stability of right and left side slopes of weir cross-section only at RD 0+50. It must be noted that all the area along the longitudinal section of Weir is slide prone. Therefore, stability of slopes along the length of Weir area should be analyzed, or at least the deepest excavation slopes (RD 0+350) for both sides must be analyzed. This should be done even if flexible gabion mattress as discussed in section on modified project layout is to be provided with some minimal cut slopes on existing natural Spillway.

Although the Feasibility study stability analyses show that the proposed slope angle is stable for the used parameters it is proposed to carry out a sensitivity/back analysis for justification of the geotechnical parameters to be considered in the slope stability calculations especially for the right bank.

The variability of slided material along with large boulders present in the slided mass also necessitate a sensitivity/back analysis for justification of the geotechnical parameters to be considered. Both on the right and left banks, there is a risk is to disturb the sliding material during excavation which will result in higher excavation volumes.

## 10.2 REVIEW OF SEEPAGE ANALYSIS

Seepage analysis is performed to analyze the Weir structure against uplift and piping using permeability values of stabilized soil blanket and slided mass. For the slided mass two different permeability values are provided at same elevation. It is reported in the Feasibility report that permeability for slided mass was used from in-situ permeability of boreholes. Boreholes 1 and 2 located at the Weir site have irregular permeability values which also do not match with the input permeability values used in seepage analysis. Also, the laboratory test results for the permeability values for stabilized soil is missing from the laboratory testing report. Therefore, the input permeability values of stabilized soil and slided material are uncertain.



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# 11 REVIEW OF HYDROMECHANICAL EQUIPMENT STUDIES

## 11.1 TURBINE

### 11.1.1 Turbine Selection Criteria

Indian standards IS 12837 - 1989 and IS 12800 (Part 3) 1991 are mentioned under clause 11.6.1.Therefore, MC recommend to replace these with: i) United States Bureau of Reclamation (USBR) Engineering Monograph no. 20, Selecting Hydraulic Reaction Turbines. ii) ASME guide for Hydropower Mechanical Design.

### 11.1.2 Type, Rated Speed & Setting

Vertical shaft Francis turbines selected in the feasibility study report (FSR) are best suited for the range of heads available for Attabad lake hydropower project. Chosen synchronous speed of 375 rpm seems appropriate, however, discrepancy found with regard to setting of the turbine. Setting of -1.5m and -2m is mentioned at different places in the report. We endorse the value of -2m below minimal tail water level.

Under clause 11.6.9, the feasibility study states that the turbines will be directly coupled to the generator rotor. Also, in clause 9.11.1 it is stated that the vertical axis Francis turbine is coupled directly to a generator. These statements confuse the reader as if there will be no turbine shaft, however, under clause 11.9 it is evident that each turbine will have its shaft. We concur with the statement of clause 11.9 and clarify that there will be two shafts one for turbine and one for generator.

### 11.1.3 Turbine Shaft

Under clause 11.9.2, Indian Standard is specified for turbine shaft. MC recommend to replace it with ASTM A668 Class D standard, also material of both turbine and generator shafts shall be the same.

### 11.1.4 Air Admission System for Aeration against Pressure Pulsation and Vortexes

Generally, the turbines should operate without aeration under all operating conditions, however, turbines may have to operate continuously for long time at part-load conditions. In order to be able to aerate the turbine, if required, aeration-taps will be foreseen for a possible later admission of air to the runner and the draft tube.

### 11.1.5 Power and Energy Potential

- **Power**

Turbine efficiency considered in the FSR of 91.5% is on lower side. However, MC recommends for EPC Contractor to use it to the order of 93% with confirmation from the manufacturer. 93% Turbine efficiency is well achievable for similar capacity vertical Francis turbines as of Attabad HPP.

Rated head of 106m selected in the FSR for power potential is reasonable, however, it is recommended that EPC contractor should reconfirm it once all the project components are designed and approved by the MC / Employer during detail design phase.

Some of the data / parameters given in the FSR has been rationalized and mentioned hereunder:

The turbine rated output: $P_t = \rho \times g \times Q \times H_n \times \eta_t$



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Where;

$P_t$ is turbine output in KW

P is water density at 15°C = 0.999 Kg/m³

g is acceleration due to gravity = 9.8 m/sec²

Q is design unit discharge = 20 m³/sec

$H_n$ is rated net head = 106 m

$\eta_t$ is turbine efficiency = 93%

$P_t$ = 9.79*20*106*0.93 = 19,300 KW

- **Annual Energy**

Headwater and tailwater ratings along with average daily flow data and head losses have been used for calculating the power, energy and plant factor. Power and annual energy have been worked out using mean of daily flow data for the years 1966 to 2015 and is presented hereunder in Table 11.1.



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## Table 11.1: Power and Energy Potential

| Day | River Flows at Weir (cumecs) | Head Water Level (m) | Flows less Ecological Flows (cumecs) | Plant Peak Discharge (cumecs) | Plant Off-Peak Discharge (cumecs) | No. of Turbines in Operation for Peaking | No. of Turbines in Operation for Off-Peaking | Discharge Per Turbine of Peaking Plant (cumecs) | Discharge Per Turbine of Peaking Plant (cumecs) | Spilled Discharge (cumecs) | Hunza River Flows at PH (cumecs) | TWL (masl) | Gross Head (m) | Head Loss Peaking Plant (m) | Head Loss Off-Peaking Plant (m) | Net Head Peaking Plant (m) | Net Head Off-Peaking Plant (m) | Turb Eff. For Peaking Turbines | Turb Eff. For Peaking Turbines | Peaking Turbines Output (MW) | Off-Peaking Turbines Output (MW) | Peaking Generator Efficiency | Off-Peaking Generator Efficiency | Peaking Generators Output (MW) | Off-Peaking Generators Output (MW) | Peaking Plant Energy at Generator Terminal (GWh) | Off-Peaking Plant Energy at Generator Terminal (GWh) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01-Jan | 37.00 | 2414.00 | 34.00 | 60.00 | 24.00 | 3 | 2 | 20.0 | 12.0 | 0.00 | 34.00 | 2302.13 | 111.9 | 6.000 | 0.960 | 105.9 | 110.9 | 0.930 | 0.852 | 57.83 | 22.21 | 0.975 | 0.967 | 56.39 | 21.49 | 0.226 | 0.430 |
| 02-Jan | 36.72 | 2414.00 | 33.72 | 60.00 | 23.72 | 3 | 2 | 20.0 | 11.9 | 0.00 | 33.72 | 2302.13 | 111.9 | 6.000 | 0.938 | 105.9 | 110.9 | 0.930 | 0.848 | 57.83 | 21.85 | 0.975 | 0.967 | 56.39 | 21.13 | 0.226 | 0.423 |
| 03-Jan | 36.45 | 2413.99 | 33.45 | 60.00 | 23.45 | 3 | 2 | 20.0 | 11.7 | 0.00 | 33.45 | 2302.13 | 111.9 | 6.000 | 0.916 | 105.9 | 110.9 | 0.930 | 0.844 | 57.83 | 21.50 | 0.975 | 0.966 | 56.39 | 20.78 | 0.226 | 0.416 |
| 04-Jan | 36.25 | 2413.99 | 33.25 | 60.00 | 23.25 | 3 | 2 | 20.0 | 11.6 | 0.00 | 33.25 | 2302.13 | 111.9 | 6.000 | 0.901 | 105.9 | 111.0 | 0.930 | 0.841 | 57.83 | 21.24 | 0.975 | 0.966 | 56.39 | 20.52 | 0.226 | 0.410 |
| 05-Jan | 35.70 | 2413.99 | 32.70 | 60.00 | 22.70 | 3 | 2 | 20.0 | 11.4 | 0.00 | 32.70 | 2302.13 | 111.9 | 6.000 | 0.859 | 105.9 | 111.0 | 0.930 | 0.833 | 57.83 | 20.55 | 0.975 | 0.965 | 56.39 | 19.84 | 0.226 | 0.397 |
| 06-Jan | 35.68 | 2413.99 | 32.68 | 60.00 | 22.68 | 3 | 2 | 20.0 | 11.3 | 0.00 | 32.68 | 2302.13 | 111.9 | 6.000 | 0.857 | 105.9 | 111.0 | 0.930 | 0.833 | 57.83 | 20.52 | 0.975 | 0.965 | 56.39 | 19.81 | 0.226 | 0.396 |
| 07-Jan | 36.05 | 2413.99 | 33.05 | 60.00 | 23.05 | 3 | 2 | 20.0 | 11.5 | 0.00 | 33.05 | 2302.13 | 111.9 | 6.000 | 0.885 | 105.9 | 111.0 | 0.930 | 0.838 | 57.83 | 20.99 | 0.975 | 0.966 | 56.39 | 20.27 | 0.226 | 0.405 |
| 08-Jan | 35.67 | 2413.99 | 32.67 | 60.00 | 22.67 | 3 | 2 | 20.0 | 11.3 | 0.00 | 32.67 | 2302.13 | 111.9 | 6.000 | 0.857 | 105.9 | 111.0 | 0.930 | 0.833 | 57.83 | 20.51 | 0.975 | 0.965 | 56.39 | 19.80 | 0.226 | 0.396 |
| 09-Jan | 35.47 | 2413.99 | 32.47 | 60.00 | 22.47 | 3 | 2 | 20.0 | 11.2 | 0.00 | 32.47 | 2302.13 | 111.9 | 6.000 | 0.842 | 105.9 | 111.0 | 0.930 | 0.829 | 57.83 | 20.26 | 0.975 | 0.965 | 56.39 | 19.55 | 0.226 | 0.391 |
| 10-Jan | 35.27 | 2413.99 | 32.27 | 60.00 | 22.27 | 3 | 2 | 20.0 | 11.1 | 0.00 | 32.27 | 2302.13 | 111.9 | 6.000 | 0.826 | 105.9 | 111.0 | 0.930 | 0.826 | 57.83 | 20.00 | 0.975 | 0.965 | 56.39 | 19.30 | 0.226 | 0.386 |
| 11-Jan | 35.06 | 2413.99 | 32.06 | 60.00 | 22.06 | 3 | 2 | 20.0 | 11.0 | 0.00 | 32.06 | 2302.13 | 111.9 | 6.000 | 0.811 | 105.9 | 111.0 | 0.930 | 0.823 | 57.83 | 19.74 | 0.975 | 0.965 | 56.38 | 19.04 | 0.226 | 0.381 |
| 12-Jan | 34.98 | 2413.99 | 31.98 | 60.00 | 21.98 | 3 | 2 | 20.0 | 11.0 | 0.00 | 31.98 | 2302.13 | 111.9 | 6.000 | 0.805 | 105.9 | 111.1 | 0.930 | 0.822 | 57.83 | 19.64 | 0.975 | 0.964 | 56.38 | 18.95 | 0.226 | 0.379 |
| 13-Jan | 34.80 | 2413.99 | 31.80 | 60.00 | 21.80 | 3 | 2 | 20.0 | 10.9 | 0.00 | 31.80 | 2302.13 | 111.9 | 6.000 | 0.792 | 105.9 | 111.1 | 0.930 | 0.819 | 57.83 | 19.43 | 0.975 | 0.964 | 56.38 | 18.73 | 0.226 | 0.375 |
| 14-Jan | 34.66 | 2413.98 | 31.66 | 60.00 | 21.66 | 3 | 2 | 20.0 | 10.8 | 0.00 | 31.66 | 2302.12 | 111.9 | 6.000 | 0.782 | 105.9 | 111.1 | 0.930 | 0.817 | 57.83 | 19.25 | 0.975 | 0.964 | 56.38 | 18.55 | 0.226 | 0.371 |
| 15-Jan | 34.43 | 2413.98 | 31.43 | 60.00 | 21.43 | 3 | 2 | 20.0 | 10.7 | 0.00 | 31.43 | 2302.12 | 111.9 | 6.000 | 0.766 | 105.9 | 111.1 | 0.930 | 0.814 | 57.83 | 18.97 | 0.975 | 0.964 | 56.38 | 18.28 | 0.226 | 0.366 |
| 16-Jan | 34.20 | 2413.98 | 31.20 | 60.00 | 21.20 | 3 | 2 | 20.0 | 10.6 | 0.00 | 31.20 | 2302.12 | 111.9 | 6.000 | 0.749 | 105.9 | 111.1 | 0.930 | 0.810 | 57.83 | 18.68 | 0.975 | 0.963 | 56.38 | 18.00 | 0.226 | 0.360 |
| 17-Jan | 34.06 | 2413.98 | 31.06 | 60.00 | 21.06 | 3 | 2 | 20.0 | 10.5 | 0.00 | 31.06 | 2302.12 | 111.9 | 6.000 | 0.739 | 105.9 | 111.1 | 0.930 | 0.808 | 57.83 | 18.52 | 0.975 | 0.963 | 56.38 | 17.84 | 0.226 | 0.357 |
| 18-Jan | 33.84 | 2413.98 | 30.84 | 60.00 | 20.84 | 3 | 2 | 20.0 | 10.4 | 0.00 | 30.84 | 2302.12 | 111.9 | 6.000 | 0.724 | 105.9 | 111.1 | 0.930 | 0.805 | 57.83 | 18.26 | 0.975 | 0.963 | 56.38 | 17.58 | 0.226 | 0.352 |
| 19-Jan | 33.68 | 2413.98 | 30.68 | 60.00 | 20.68 | 3 | 2 | 20.0 | 10.3 | 0.00 | 30.68 | 2302.12 | 111.9 | 6.000 | 0.713 | 105.9 | 111.1 | 0.930 | 0.802 | 57.83 | 18.06 | 0.975 | 0.962 | 56.38 | 17.38 | 0.226 | 0.348 |
| 20-Jan | 33.71 | 2413.98 | 30.71 | 60.00 | 20.71 | 3 | 2 | 20.0 | 10.4 | 0.00 | 30.71 | 2302.12 | 111.9 | 6.000 | 0.715 | 105.9 | 111.1 | 0.930 | 0.803 | 57.83 | 18.09 | 0.975 | 0.962 | 56.38 | 17.42 | 0.226 | 0.348 |
| 21-Jan | 33.63 | 2413.98 | 30.63 | 60.00 | 20.63 | 3 | 2 | 20.0 | 10.3 | 0.00 | 30.63 | 2302.12 | 111.9 | 6.000 | 0.709 | 105.9 | 111.1 | 0.930 | 0.802 | 57.83 | 18.00 | 0.975 | 0.962 | 56.38 | 17.32 | 0.226 | 0.346 |
| 22-Jan | 33.34 | 2413.98 | 30.34 | 60.00 | 20.34 | 3 | 2 | 20.0 | 10.2 | 0.00 | 30.34 | 2302.12 | 111.9 | 6.000 | 0.690 | 105.9 | 111.2 | 0.930 | 0.797 | 57.83 | 17.66 | 0.975 | 0.962 | 56.38 | 16.99 | 0.226 | 0.340 |
| 23-Jan | 33.13 | 2413.98 | 30.13 | 60.00 | 20.13 | 3 | 2 | 20.0 | 10.1 | 0.00 | 30.13 | 2302.12 | 111.9 | 6.000 | 0.675 | 105.9 | 111.2 | 0.930 | 0.794 | 57.83 | 17.40 | 0.975 | 0.962 | 56.38 | 16.73 | 0.226 | 0.335 |
| 24-Jan | 33.02 | 2413.98 | 30.02 | 60.00 | 20.02 | 3 | 2 | 20.0 | 10.0 | 0.00 | 30.02 | 2302.12 | 111.9 | 6.000 | 0.668 | 105.9 | 111.2 | 0.930 | 0.793 | 57.83 | 17.27 | 0.975 | 0.961 | 56.38 | 16.61 | 0.226 | 0.332 |
| 25-Jan | 33.00 | 2413.98 | 30.00 | 60.00 | 20.00 | 3 | 1 | 20.0 | 20.0 | 0.00 | 30.00 | 2302.12 | 111.9 | 6.000 | 0.666 | 105.9 | 111.2 | 0.930 | 0.930 | 57.83 | 19.30 | 0.975 | 0.975 | 56.38 | 18.80 | 0.226 | 0.376 |
| 26-Jan | 32.89 | 2413.98 | 29.89 | 60.00 | 19.89 | 3 | 1 | 20.0 | 19.9 | 0.00 | 29.89 | 2302.12 | 111.9 | 6.000 | 0.659 | 105.9 | 111.2 | 0.930 | 0.930 | 57.83 | 19.30 | 0.975 | 0.975 | 56.38 | 18.80 | 0.226 | 0.376 |
| 27-Jan | 35.81 | 2413.99 | 32.81 | 60.00 | 22.81 | 3 | 2 | 20.0 | 11.4 | 0.00 | 32.81 | 2302.13 | 111.9 | 6.000 | 0.867 | 105.9 | 111.0 | 0.930 | 0.835 | 57.83 | 20.68 | 0.975 | 0.966 | 56.39 | 19.97 | 0.226 | 0.399 |
| 28-Jan | 34.98 | 2413.99 | 31.98 | 60.00 | 21.98 | 3 | 2 | 20.0 | 11.0 | 0.00 | 31.98 | 2302.13 | 111.9 | 6.000 | 0.805 | 105.9 | 111.1 | 0.930 | 0.822 | 57.83 | 19.65 | 0.975 | 0.964 | 56.38 | 18.95 | 0.226 | 0.379 |
| 29-Jan | 34.14 | 2413.98 | 31.14 | 60.00 | 21.14 | 3 | 2 | 20.0 | 10.6 | 0.00 | 31.14 | 2302.12 | 111.9 | 6.000 | 0.745 | 105.9 | 111.1 | 0.930 | 0.809 | 57.83 | 18.62 | 0.975 | 0.963 | 56.38 | 17.93 | 0.226 | 0.359 |
| 30-Jan | 33.36 | 2413.98 | 30.36 | 60.00 | 20.36 | 3 | 2 | 20.0 | 10.2 | 0.00 | 30.36 | 2302.12 | 111.9 | 6.000 | 0.691 | 105.9 | 111.2 | 0.930 | 0.798 | 57.83 | 17.67 | 0.975 | 0.962 | 56.38 | 17.00 | 0.226 | 0.340 |
| 31-Jan | 32.87 | 2413.98 | 29.87 | 60.00 | 19.87 | 3 | 1 | 20.0 | 19.9 | 0.00 | 29.87 | 2302.12 | 111.9 | 6.000 | 0.658 | 105.9 | 111.2 | 0.930 | 0.930 | 57.83 | 19.30 | 0.975 | 0.975 | 56.38 | 18.80 | 0.226 | 0.376 |
| 01-Feb | 32.54 | 2413.97 | 29.54 | 60.00 | 19.54 | 3 | 1 | 20.0 | 19.5 | 0.00 | 29.54 | 2302.12 | 111.9 | 6.000 | 0.637 | 105.9 | 111.2 | 0.930 | 0.929 | 57.83 | 19.30 | 0.975 | 0.975 | 56.38 | 18.80 | 0.226 | 0.376 |
| 02-Feb | 32.37 | 2413.97 | 29.37 | 60.00 | 19.37 | 3 | 1 | 20.0 | 19.4 | 0.00 | 29.37 | 2302.12 | 111.9 | 6.000 | 0.625 | 105.9 | 111.2 | 0.930 | 0.929 | 57.83 | 19.30 | 0.975 | 0.975 | 56.38 | 18.80 | 0.226 | 0.376 |
| 03-Feb | 32.26 | 2413.97 | 29.26 | 60.00 | 19.26 | 3 | 1 | 20.0 | 19.3 | 0.00 | 29.26 | 2302.12 | 111.9 | 6.000 | 0.618 | 105.9 | 111.2 | 0.930 | 0.929 | 57.83 | 19.30 | 0.975 | 0.975 | 56.38 | 18.80 | 0.226 | 0.376 |
| 04-Feb | 32.63 | 2413.97 | 29.63 | 60.00 | 19.63 | 3 | 1 | 20.0 | 19.6 | 0.00 | 29.63 | 2302.12 | 111.9 | 6.000 | 0.642 | 105.9 | 111.2 | 0.930 | 0.929 | 57.83 | 19.30 | 0.975 | 0.975 | 56.38 | 18.80 | 0.226 | 0.376 |
| 05-Feb | 32.38 | 2413.97 | 29.38 | 60.00 | 19.38 | 3 | 1 | 20.0 | 19.4 | 0.00 | 29.38 | 2302.12 | 111.9 | 6.000 | 0.626 | 105.9 | 111.2 | 0.930 | 0.929 | 57.83 | 19.30 | 0.975 | 0.975 | 56.38 | 18.80 | 0.226 | 0.376 |
| 06-Feb | 32.15 | 2413.97 | 29.15 | 60.00 | 19.15 | 3 | 1 | 20.0 | 19.2 | 0.00 | 29.15 | 2302.12 | 111.9 | 6.000 | 0.611 | 105.9 | 111.2 | 0.930 | 0.929 | 57.83 | 19.30 | 0.975 | 0.975 | 56.38 | 18.80 | 0.226 | 0.376 |
| 07-Feb | 31.99 | 2413.97 | 28.99 | 60.00 | 18.99 | 3 | 1 | 20.0 | 19.0 | 0.00 | 28.99 | 2302.11 | 111.9 | 6.000 | 0.601 | 105.9 | 111.3 | 0.930 | 0.928 | 57.83 | 19.21 | 0.975 | 0.975 | 56.38 | 18.73 | 0.226 | 0.375 |



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| Day | River Flows at Weir (cumecs) | Head Water Level (m) | Flows less Ecological Flows (cumecs) | Plant Peak Discharge (cumecs) | Plant Off-Peak Discharge (cumecs) | No. of Turbines in Operation for Peaking | No. of Turbines in Operation for Off-Peaking | Discharge Per Turbine of Peaking Plant (cumecs) | Discharge Per Turbine of Peaking Plant (cumecs) | Spilled Discharge (cumecs) | Hunza River Flows at PH (cumecs) | TWL (masl) | Gross Head (m) | Head Loss Peaking Plant (m) | Head Loss Off-Peaking Plant (m) | Net Head Peaking Plant (m) | Net Head Off-Peaking Plant (m) | Turb Eff. For Peaking Turbines | Turb Eff. For Peaking Turbines | Peaking Turbines Output (MW) | Off-Peaking Turbines Output (MW) | Peaking Generator Efficiency | Off-Peaking Generator Efficiency | Peaking Generators Output (MW) | Off-Peaking Generators Output (MW) | Peaking Plant Energy at Generator Terminal (GWh) | Off-Peaking Plant Energy at Generator Terminal (GWh) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 08-Feb | 31.86 | 2413.97 | 28.86 | 60.00 | 18.86 | 3 | 1 | 20.0 | 18.9 | 0.00 | 28.86 | 2302.11 | 111.9 | 6.000 | 0.593 | 105.9 | 111.3 | 0.930 | 0.928 | 57.83 | 19.07 | 0.975 | 0.975 | 56.38 | 18.59 | 0.226 | 0.372 |
| 09-Feb | 31.81 | 2413.97 | 28.81 | 60.00 | 18.81 | 3 | 1 | 20.0 | 18.8 | 0.00 | 28.81 | 2302.11 | 111.9 | 6.000 | 0.590 | 105.9 | 111.3 | 0.930 | 0.928 | 57.83 | 19.02 | 0.975 | 0.975 | 56.38 | 18.54 | 0.226 | 0.371 |
| 10-Feb | 31.68 | 2413.97 | 28.68 | 60.00 | 18.68 | 3 | 1 | 20.0 | 18.7 | 0.00 | 28.68 | 2302.11 | 111.9 | 6.000 | 0.582 | 105.9 | 111.3 | 0.930 | 0.928 | 57.83 | 18.89 | 0.975 | 0.975 | 56.38 | 18.41 | 0.226 | 0.368 |
| 11-Feb | 31.52 | 2413.97 | 28.52 | 60.00 | 18.52 | 3 | 1 | 20.0 | 18.5 | 0.00 | 28.52 | 2302.11 | 111.9 | 6.000 | 0.572 | 105.9 | 111.3 | 0.930 | 0.928 | 57.83 | 18.72 | 0.975 | 0.975 | 56.38 | 18.25 | 0.226 | 0.365 |
| 12-Feb | 31.38 | 2413.97 | 28.38 | 60.00 | 18.38 | 3 | 1 | 20.0 | 18.4 | 0.00 | 28.38 | 2302.11 | 111.9 | 6.000 | 0.563 | 105.9 | 111.3 | 0.930 | 0.928 | 57.83 | 18.57 | 0.975 | 0.975 | 56.38 | 18.11 | 0.226 | 0.362 |
| 13-Feb | 31.33 | 2413.97 | 28.33 | 60.00 | 18.33 | 3 | 1 | 20.0 | 18.3 | 0.00 | 28.33 | 2302.11 | 111.9 | 6.000 | 0.560 | 105.9 | 111.3 | 0.930 | 0.927 | 57.83 | 18.53 | 0.975 | 0.975 | 56.38 | 18.06 | 0.226 | 0.361 |
| 14-Feb | 31.22 | 2413.97 | 28.22 | 60.00 | 18.22 | 3 | 1 | 20.0 | 18.2 | 0.00 | 28.22 | 2302.11 | 111.9 | 6.000 | 0.553 | 105.9 | 111.3 | 0.930 | 0.927 | 57.83 | 18.41 | 0.975 | 0.975 | 56.38 | 17.94 | 0.226 | 0.359 |
| 15-Feb | 31.05 | 2413.97 | 28.05 | 60.00 | 18.05 | 3 | 1 | 20.0 | 18.1 | 0.00 | 28.05 | 2302.11 | 111.9 | 6.000 | 0.543 | 105.9 | 111.3 | 0.930 | 0.927 | 57.83 | 18.24 | 0.975 | 0.975 | 56.38 | 17.78 | 0.226 | 0.356 |
| 16-Feb | 30.91 | 2413.96 | 27.91 | 60.00 | 17.91 | 3 | 1 | 20.0 | 17.9 | 0.00 | 27.91 | 2302.11 | 111.9 | 6.000 | 0.535 | 105.9 | 111.3 | 0.930 | 0.926 | 57.83 | 18.08 | 0.975 | 0.975 | 56.38 | 17.63 | 0.226 | 0.353 |
| 17-Feb | 30.80 | 2413.96 | 27.80 | 60.00 | 17.80 | 3 | 1 | 20.0 | 17.8 | 0.00 | 27.80 | 2302.11 | 111.9 | 6.000 | 0.528 | 105.9 | 111.3 | 0.930 | 0.926 | 57.83 | 17.97 | 0.975 | 0.975 | 56.38 | 17.52 | 0.226 | 0.350 |
| 18-Feb | 30.92 | 2413.97 | 27.92 | 60.00 | 17.92 | 3 | 1 | 20.0 | 17.9 | 0.00 | 27.92 | 2302.11 | 111.9 | 6.000 | 0.535 | 105.9 | 111.3 | 0.930 | 0.927 | 57.83 | 18.09 | 0.975 | 0.975 | 56.38 | 17.64 | 0.226 | 0.353 |
| 19-Feb | 30.75 | 2413.96 | 27.75 | 60.00 | 17.75 | 3 | 1 | 20.0 | 17.7 | 0.00 | 27.75 | 2302.11 | 111.9 | 6.000 | 0.525 | 105.9 | 111.3 | 0.930 | 0.926 | 57.83 | 17.90 | 0.975 | 0.975 | 56.38 | 17.45 | 0.226 | 0.349 |
| 20-Feb | 30.57 | 2413.96 | 27.57 | 60.00 | 17.57 | 3 | 1 | 20.0 | 17.6 | 0.00 | 27.57 | 2302.11 | 111.9 | 6.000 | 0.514 | 105.9 | 111.3 | 0.930 | 0.925 | 57.83 | 17.71 | 0.975 | 0.975 | 56.38 | 17.26 | 0.226 | 0.345 |
| 21-Feb | 30.37 | 2413.96 | 27.37 | 60.00 | 17.37 | 3 | 1 | 20.0 | 17.4 | 0.00 | 27.37 | 2302.11 | 111.9 | 6.000 | 0.503 | 105.9 | 111.4 | 0.930 | 0.923 | 57.83 | 17.48 | 0.975 | 0.975 | 56.38 | 17.04 | 0.226 | 0.341 |
| 22-Feb | 30.19 | 2413.96 | 27.19 | 60.00 | 17.19 | 3 | 1 | 20.0 | 17.2 | 0.00 | 27.19 | 2302.11 | 111.9 | 6.000 | 0.493 | 105.9 | 111.4 | 0.930 | 0.922 | 57.83 | 17.29 | 0.975 | 0.975 | 56.38 | 16.86 | 0.226 | 0.337 |
| 23-Feb | 30.00 | 2413.96 | 27.00 | 60.00 | 17.00 | 3 | 1 | 20.0 | 17.0 | 0.00 | 27.00 | 2302.11 | 111.9 | 6.000 | 0.482 | 105.9 | 111.4 | 0.930 | 0.921 | 57.83 | 17.08 | 0.975 | 0.975 | 56.38 | 16.65 | 0.226 | 0.333 |
| 24-Feb | 29.81 | 2413.96 | 26.81 | 60.00 | 16.81 | 3 | 1 | 20.0 | 16.8 | 0.00 | 26.81 | 2302.11 | 111.9 | 6.000 | 0.471 | 105.9 | 111.4 | 0.930 | 0.920 | 57.83 | 16.87 | 0.975 | 0.975 | 56.38 | 16.44 | 0.226 | 0.329 |
| 25-Feb | 29.57 | 2413.96 | 26.57 | 60.00 | 16.57 | 3 | 1 | 20.0 | 16.6 | 0.00 | 26.57 | 2302.10 | 111.9 | 6.000 | 0.458 | 105.9 | 111.4 | 0.930 | 0.919 | 57.83 | 16.61 | 0.975 | 0.974 | 56.38 | 16.18 | 0.226 | 0.324 |
| 26-Feb | 29.43 | 2413.96 | 26.43 | 60.00 | 16.43 | 3 | 1 | 20.0 | 16.4 | 0.00 | 26.43 | 2302.10 | 111.9 | 6.000 | 0.450 | 105.9 | 111.4 | 0.930 | 0.918 | 57.83 | 16.46 | 0.975 | 0.974 | 56.38 | 16.03 | 0.226 | 0.321 |
| 27-Feb | 32.51 | 2413.97 | 29.51 | 60.00 | 19.51 | 3 | 1 | 20.0 | 19.5 | 0.00 | 29.51 | 2302.12 | 111.9 | 6.000 | 0.635 | 105.9 | 111.2 | 0.930 | 0.929 | 57.83 | 19.30 | 0.975 | 0.975 | 56.38 | 18.80 | 0.226 | 0.376 |
| 28-Feb | 37.64 | 2414.00 | 34.64 | 60.00 | 24.64 | 3 | 2 | 20.0 | 12.3 | 0.00 | 34.64 | 2302.14 | 111.9 | 6.000 | 1.012 | 105.9 | 110.9 | 0.930 | 0.859 | 57.83 | 22.97 | 0.975 | 0.968 | 56.39 | 22.23 | 0.226 | 0.445 |
| 29-Feb | 0.00 | 2413.80 | 0.00 | 60.00 | -10.00 | 3 | 0 | 20.0 | 0.0 | 0.00 | 0.00 | 2302.00 | 111.8 | 6.000 | 0.167 | 105.8 | 111.6 | 0.930 | 0.000 | 57.80 | 0.00 | 0.975 | 0.000 | 56.35 | 0.00 | 0.225 | 0.000 |
| 01-Mar | 30.05 | 2413.96 | 27.05 | 60.00 | 17.05 | 3 | 1 | 20.0 | 17.0 | 0.00 | 27.05 | 2302.11 | 111.9 | 6.000 | 0.484 | 105.9 | 111.4 | 0.930 | 0.922 | 57.83 | 17.13 | 0.975 | 0.975 | 56.38 | 16.70 | 0.226 | 0.334 |
| 02-Mar | 29.73 | 2413.96 | 26.73 | 60.00 | 16.73 | 3 | 1 | 20.0 | 16.7 | 0.00 | 26.73 | 2302.11 | 111.9 | 6.000 | 0.467 | 105.9 | 111.4 | 0.930 | 0.920 | 57.83 | 16.79 | 0.975 | 0.974 | 56.38 | 16.36 | 0.226 | 0.327 |
| 03-Mar | 29.62 | 2413.96 | 26.62 | 60.00 | 16.62 | 3 | 1 | 20.0 | 16.6 | 0.00 | 26.62 | 2302.11 | 111.9 | 6.000 | 0.460 | 105.9 | 111.4 | 0.930 | 0.919 | 57.83 | 16.66 | 0.975 | 0.974 | 56.38 | 16.24 | 0.226 | 0.325 |
| 04-Mar | 29.48 | 2413.96 | 26.48 | 60.00 | 16.48 | 3 | 1 | 20.0 | 16.5 | 0.00 | 26.48 | 2302.10 | 111.9 | 6.000 | 0.453 | 105.9 | 111.4 | 0.930 | 0.918 | 57.83 | 16.51 | 0.975 | 0.974 | 56.38 | 16.08 | 0.226 | 0.322 |
| 05-Mar | 29.33 | 2413.96 | 26.33 | 60.00 | 16.33 | 3 | 1 | 20.0 | 16.3 | 0.00 | 26.33 | 2302.10 | 111.9 | 6.000 | 0.445 | 105.9 | 111.4 | 0.930 | 0.918 | 57.83 | 16.35 | 0.975 | 0.974 | 56.38 | 15.93 | 0.226 | 0.319 |
| 06-Mar | 29.93 | 2413.96 | 26.93 | 60.00 | 16.93 | 3 | 1 | 20.0 | 16.9 | 0.00 | 26.93 | 2302.11 | 111.9 | 6.000 | 0.478 | 105.9 | 111.4 | 0.930 | 0.921 | 57.83 | 17.00 | 0.975 | 0.975 | 56.38 | 16.57 | 0.226 | 0.331 |
| 07-Mar | 29.87 | 2413.96 | 26.87 | 60.00 | 16.87 | 3 | 1 | 20.0 | 16.9 | 0.00 | 26.87 | 2302.11 | 111.9 | 6.000 | 0.474 | 105.9 | 111.4 | 0.930 | 0.921 | 57.83 | 16.94 | 0.975 | 0.975 | 56.38 | 16.51 | 0.226 | 0.330 |
| 08-Mar | 29.86 | 2413.96 | 26.86 | 60.00 | 16.86 | 3 | 1 | 20.0 | 16.9 | 0.00 | 26.86 | 2302.11 | 111.9 | 6.000 | 0.474 | 105.9 | 111.4 | 0.930 | 0.921 | 57.83 | 16.92 | 0.975 | 0.975 | 56.38 | 16.49 | 0.226 | 0.330 |
| 09-Mar | 29.74 | 2413.96 | 26.74 | 60.00 | 16.74 | 3 | 1 | 20.0 | 16.7 | 0.00 | 26.74 | 2302.11 | 111.9 | 6.000 | 0.467 | 105.9 | 111.4 | 0.930 | 0.920 | 57.83 | 16.79 | 0.975 | 0.974 | 56.38 | 16.36 | 0.226 | 0.327 |
| 10-Mar | 29.65 | 2413.96 | 26.65 | 60.00 | 16.65 | 3 | 1 | 20.0 | 16.7 | 0.00 | 26.65 | 2302.11 | 111.9 | 6.000 | 0.462 | 105.9 | 111.4 | 0.930 | 0.919 | 57.83 | 16.70 | 0.975 | 0.974 | 56.38 | 16.27 | 0.226 | 0.325 |
| 11-Mar | 29.54 | 2413.96 | 26.54 | 60.00 | 16.54 | 3 | 1 | 20.0 | 16.5 | 0.00 | 26.54 | 2302.10 | 111.9 | 6.000 | 0.456 | 105.9 | 111.4 | 0.930 | 0.919 | 57.83 | 16.58 | 0.975 | 0.974 | 56.38 | 16.15 | 0.226 | 0.323 |
| 12-Mar | 29.50 | 2413.96 | 26.50 | 60.00 | 16.50 | 3 | 1 | 20.0 | 16.5 | 0.00 | 26.50 | 2302.10 | 111.9 | 6.000 | 0.454 | 105.9 | 111.4 | 0.930 | 0.919 | 57.83 | 16.53 | 0.975 | 0.974 | 56.38 | 16.10 | 0.226 | 0.322 |
| 13-Mar | 29.29 | 2413.96 | 26.29 | 60.00 | 16.29 | 3 | 1 | 20.0 | 16.3 | 0.00 | 26.29 | 2302.10 | 111.9 | 6.000 | 0.442 | 105.9 | 111.4 | 0.930 | 0.917 | 57.83 | 16.30 | 0.975 | 0.974 | 56.38 | 15.88 | 0.226 | 0.318 |
| 14-Mar | 29.25 | 2413.96 | 26.25 | 60.00 | 16.25 | 3 | 1 | 20.0 | 16.3 | 0.00 | 26.25 | 2302.10 | 111.9 | 6.000 | 0.440 | 105.9 | 111.4 | 0.930 | 0.917 | 57.83 | 16.26 | 0.975 | 0.974 | 56.38 | 15.84 | 0.226 | 0.317 |
| 15-Mar | 29.13 | 2413.96 | 26.13 | 60.00 | 16.13 | 3 | 1 | 20.0 | 16.1 | 0.00 | 26.13 | 2302.10 | 111.9 | 6.000 | 0.434 | 105.9 | 111.4 | 0.930 | 0.917 | 57.83 | 16.13 | 0.975 | 0.974 | 56.38 | 15.71 | 0.226 | 0.314 |
| 16-Mar | 29.61 | 2413.96 | 26.61 | 60.00 | 16.61 | 3 | 1 | 20.0 | 16.6 | 0.00 | 26.61 | 2302.11 | 111.9 | 6.000 | 0.460 | 105.9 | 111.4 | 0.930 | 0.919 | 57.83 | 16.65 | 0.975 | 0.974 | 56.38 | 16.22 | 0.226 | 0.324 |
| 17-Mar | 29.43 | 2413.96 | 26.43 | 60.00 | 16.43 | 3 | 1 | 20.0 | 16.4 | 0.00 | 26.43 | 2302.10 | 111.9 | 6.000 | 0.450 | 105.9 | 111.4 | 0.930 | 0.918 | 57.83 | 16.45 | 0.975 | 0.974 | 56.38 | 16.03 | 0.226 | 0.321 |




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| Day | River Flows at Weir (cumecs) | Head Water Level (m) | Flows less Ecological Flows (cumecs) | Plant Peak Discharge (cumecs) | Plant Off-Peak Discharge (cumecs) | No. of Turbines in Operation for Peaking | No. of Turbines in Operation for Off-Peaking | Discharge Per Turbine of Peaking Plant (cumecs) | Discharge Per Turbine of Peaking Plant (cumecs) | Spilled Discharge (cumecs) | Hunza River Flows at PH (cumecs) | TWL (masl) | Gross Head (m) | Head Loss Peaking Plant (m) | Head Loss Off-Peaking Plant (m) | Net Head Peaking Plant (m) | Net Head Off-Peaking Plant (m) | Turb Eff. For Peaking Turbines | Turb Eff. For Peaking Turbines | Peaking Turbines Output (MW) | Off-Peaking Turbines Output (MW) | Peaking Generator Efficiency | Off-Peaking Generator Efficiency | Peaking Generators Output (MW) | Off-Peaking Generators Output (MW) | Peaking Plant Energy at Generator Terminal (GWh) | Off-Peaking Plant Energy at Generator Terminal (GWh) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18-Mar | 29.23 | 2413.96 | 26.23 | 60.00 | 16.23 | 3 | 1 | 20.0 | 16.2 | 0.00 | 26.23 | 2302.10 | 111.9 | 6.000 | 0.439 | 105.9 | 111.4 | 0.930 | 0.917 | 57.83 | 16.24 | 0.975 | 0.974 | 56.38 | 15.82 | 0.226 | 0.316 |
| 19-Mar | 29.10 | 2413.96 | 26.10 | 60.00 | 16.10 | 3 | 1 | 20.0 | 16.1 | 0.00 | 26.10 | 2302.10 | 111.9 | 6.000 | 0.432 | 105.9 | 111.4 | 0.930 | 0.916 | 57.83 | 16.10 | 0.975 | 0.974 | 56.38 | 15.68 | 0.226 | 0.314 |
| 20-Mar | 36.43 | 2413.99 | 33.43 | 60.00 | 23.43 | 3 | 2 | 20.0 | 11.7 | 0.00 | 33.43 | 2302.13 | 111.9 | 6.000 | 0.915 | 105.9 | 110.9 | 0.930 | 0.844 | 57.83 | 21.48 | 0.975 | 0.966 | 56.39 | 20.76 | 0.226 | 0.415 |
| 21-Mar | 32.74 | 2413.97 | 29.74 | 60.00 | 19.74 | 3 | 1 | 20.0 | 19.7 | 0.00 | 29.74 | 2302.12 | 111.9 | 6.000 | 0.649 | 105.9 | 111.2 | 0.930 | 0.930 | 57.83 | 19.30 | 0.975 | 0.975 | 56.38 | 18.80 | 0.226 | 0.376 |
| 22-Mar | 31.85 | 2413.97 | 28.85 | 60.00 | 18.85 | 3 | 1 | 20.0 | 18.8 | 0.00 | 28.85 | 2302.11 | 111.9 | 6.000 | 0.592 | 105.9 | 111.3 | 0.930 | 0.928 | 57.83 | 19.06 | 0.975 | 0.975 | 56.38 | 18.58 | 0.226 | 0.372 |
| 23-Mar | 30.83 | 2413.96 | 27.83 | 60.00 | 17.83 | 3 | 1 | 20.0 | 17.8 | 0.00 | 27.83 | 2302.11 | 111.9 | 6.000 | 0.530 | 105.9 | 111.3 | 0.930 | 0.926 | 57.83 | 17.99 | 0.975 | 0.975 | 56.38 | 17.54 | 0.226 | 0.351 |
| 24-Mar | 30.06 | 2413.96 | 27.06 | 60.00 | 17.06 | 3 | 1 | 20.0 | 17.1 | 0.00 | 27.06 | 2302.11 | 111.9 | 6.000 | 0.485 | 105.9 | 111.4 | 0.930 | 0.922 | 57.83 | 17.14 | 0.975 | 0.975 | 56.38 | 16.71 | 0.226 | 0.334 |
| 25-Mar | 29.61 | 2413.96 | 26.61 | 60.00 | 16.61 | 3 | 1 | 20.0 | 16.6 | 0.00 | 26.61 | 2302.11 | 111.9 | 6.000 | 0.460 | 105.9 | 111.4 | 0.930 | 0.919 | 57.83 | 16.65 | 0.975 | 0.974 | 56.38 | 16.22 | 0.226 | 0.324 |
| 26-Mar | 29.36 | 2413.96 | 26.36 | 60.00 | 16.36 | 3 | 1 | 20.0 | 16.4 | 0.00 | 26.36 | 2302.10 | 111.9 | 6.000 | 0.446 | 105.9 | 111.4 | 0.930 | 0.918 | 57.83 | 16.38 | 0.975 | 0.974 | 56.38 | 15.95 | 0.226 | 0.319 |
| 27-Mar | 29.30 | 2413.96 | 26.30 | 60.00 | 16.30 | 3 | 1 | 20.0 | 16.3 | 0.00 | 26.30 | 2302.10 | 111.9 | 6.000 | 0.443 | 105.9 | 111.4 | 0.930 | 0.918 | 57.83 | 16.32 | 0.975 | 0.974 | 56.38 | 15.90 | 0.226 | 0.318 |
| 28-Mar | 29.26 | 2413.96 | 26.26 | 60.00 | 16.26 | 3 | 1 | 20.0 | 16.3 | 0.00 | 26.26 | 2302.10 | 111.9 | 6.000 | 0.441 | 105.9 | 111.4 | 0.930 | 0.917 | 57.83 | 16.27 | 0.975 | 0.974 | 56.38 | 15.85 | 0.226 | 0.317 |
| 29-Mar | 29.38 | 2413.96 | 26.38 | 60.00 | 16.38 | 3 | 1 | 20.0 | 16.4 | 0.00 | 26.38 | 2302.10 | 111.9 | 6.000 | 0.447 | 105.9 | 111.4 | 0.930 | 0.918 | 57.83 | 16.40 | 0.975 | 0.974 | 56.38 | 15.98 | 0.226 | 0.320 |
| 30-Mar | 29.48 | 2413.96 | 26.48 | 60.00 | 16.48 | 3 | 1 | 20.0 | 16.5 | 0.00 | 26.48 | 2302.10 | 111.9 | 6.000 | 0.453 | 105.9 | 111.4 | 0.930 | 0.919 | 57.83 | 16.51 | 0.975 | 0.974 | 56.38 | 16.09 | 0.226 | 0.322 |
| 31-Mar | 29.76 | 2413.96 | 26.76 | 60.00 | 16.76 | 3 | 1 | 20.0 | 16.8 | 0.00 | 26.76 | 2302.11 | 111.9 | 6.000 | 0.468 | 105.9 | 111.4 | 0.930 | 0.920 | 57.83 | 16.82 | 0.975 | 0.974 | 56.38 | 16.39 | 0.226 | 0.328 |
| 01-Apr | 29.79 | 2413.96 | 26.79 | 60.00 | 16.79 | 3 | 1 | 20.0 | 16.8 | 0.00 | 26.79 | 2302.11 | 111.9 | 6.000 | 0.470 | 105.9 | 111.4 | 0.930 | 0.920 | 57.83 | 16.84 | 0.975 | 0.974 | 56.38 | 16.41 | 0.226 | 0.328 |
| 02-Apr | 29.92 | 2413.96 | 26.92 | 60.00 | 16.92 | 3 | 1 | 20.0 | 16.9 | 0.00 | 26.92 | 2302.11 | 111.9 | 6.000 | 0.477 | 105.9 | 111.4 | 0.930 | 0.921 | 57.83 | 16.99 | 0.975 | 0.975 | 56.38 | 16.56 | 0.226 | 0.331 |
| 03-Apr | 30.19 | 2413.96 | 27.19 | 60.00 | 17.19 | 3 | 1 | 20.0 | 17.2 | 0.00 | 27.19 | 2302.11 | 111.9 | 6.000 | 0.492 | 105.9 | 111.4 | 0.930 | 0.922 | 57.83 | 17.29 | 0.975 | 0.975 | 56.38 | 16.85 | 0.226 | 0.337 |
| 04-Apr | 30.44 | 2413.96 | 27.44 | 60.00 | 17.44 | 3 | 1 | 20.0 | 17.4 | 0.00 | 27.44 | 2302.11 | 111.9 | 6.000 | 0.507 | 105.9 | 111.3 | 0.930 | 0.924 | 57.83 | 17.56 | 0.975 | 0.975 | 56.38 | 17.12 | 0.226 | 0.342 |
| 05-Apr | 30.65 | 2413.96 | 27.65 | 60.00 | 17.65 | 3 | 1 | 20.0 | 17.7 | 0.00 | 27.65 | 2302.11 | 111.9 | 6.000 | 0.519 | 105.9 | 111.3 | 0.930 | 0.925 | 57.83 | 17.80 | 0.975 | 0.975 | 56.38 | 17.35 | 0.226 | 0.347 |
| 06-Apr | 31.30 | 2413.97 | 28.30 | 60.00 | 18.30 | 3 | 1 | 20.0 | 18.3 | 0.00 | 28.30 | 2302.11 | 111.9 | 6.000 | 0.558 | 105.9 | 111.3 | 0.930 | 0.927 | 57.83 | 18.49 | 0.975 | 0.975 | 56.38 | 18.03 | 0.226 | 0.361 |
| 07-Apr | 32.04 | 2413.97 | 29.04 | 60.00 | 19.04 | 3 | 1 | 20.0 | 19.0 | 0.00 | 29.04 | 2302.11 | 111.9 | 6.000 | 0.604 | 105.9 | 111.3 | 0.930 | 0.929 | 57.83 | 19.26 | 0.975 | 0.975 | 56.38 | 18.78 | 0.226 | 0.376 |
| 08-Apr | 32.54 | 2413.97 | 29.54 | 60.00 | 19.54 | 3 | 1 | 20.0 | 19.5 | 0.00 | 29.54 | 2302.12 | 111.9 | 6.000 | 0.636 | 105.9 | 111.2 | 0.930 | 0.929 | 57.83 | 19.30 | 0.975 | 0.975 | 56.38 | 18.80 | 0.226 | 0.376 |
| 09-Apr | 33.12 | 2413.98 | 30.12 | 60.00 | 20.12 | 3 | 2 | 20.0 | 10.1 | 0.00 | 30.12 | 2302.12 | 111.9 | 6.000 | 0.675 | 105.9 | 111.2 | 0.930 | 0.794 | 57.83 | 17.39 | 0.975 | 0.962 | 56.38 | 16.73 | 0.226 | 0.335 |
| 10-Apr | 33.58 | 2413.98 | 30.58 | 60.00 | 20.58 | 3 | 2 | 20.0 | 10.3 | 0.00 | 30.58 | 2302.12 | 111.9 | 6.000 | 0.706 | 105.9 | 111.2 | 0.930 | 0.801 | 57.83 | 17.94 | 0.975 | 0.962 | 56.38 | 17.26 | 0.226 | 0.345 |
| 11-Apr | 34.16 | 2413.98 | 31.16 | 60.00 | 21.16 | 3 | 2 | 20.0 | 10.6 | 0.00 | 31.16 | 2302.12 | 111.9 | 6.000 | 0.746 | 105.9 | 111.1 | 0.930 | 0.810 | 57.83 | 18.64 | 0.975 | 0.963 | 56.38 | 17.95 | 0.226 | 0.359 |
| 12-Apr | 34.76 | 2413.99 | 31.76 | 60.00 | 21.76 | 3 | 2 | 20.0 | 10.9 | 0.00 | 31.76 | 2302.13 | 111.9 | 6.000 | 0.789 | 105.9 | 111.1 | 0.930 | 0.819 | 57.83 | 19.38 | 0.975 | 0.964 | 56.38 | 18.68 | 0.226 | 0.374 |
| 13-Apr | 35.32 | 2413.99 | 32.32 | 60.00 | 22.32 | 3 | 2 | 20.0 | 11.2 | 0.00 | 32.32 | 2302.13 | 111.9 | 6.000 | 0.830 | 105.9 | 111.0 | 0.930 | 0.827 | 57.83 | 20.07 | 0.975 | 0.965 | 56.39 | 19.36 | 0.226 | 0.387 |
| 14-Apr | 35.96 | 2413.99 | 32.96 | 60.00 | 22.96 | 3 | 2 | 20.0 | 11.5 | 0.00 | 32.96 | 2302.13 | 111.9 | 6.000 | 0.878 | 105.9 | 111.0 | 0.930 | 0.837 | 57.83 | 20.87 | 0.975 | 0.966 | 56.39 | 20.16 | 0.226 | 0.403 |
| 15-Apr | 37.17 | 2414.00 | 34.17 | 60.00 | 24.17 | 3 | 2 | 20.0 | 12.1 | 0.00 | 34.17 | 2302.13 | 111.9 | 6.000 | 0.974 | 105.9 | 110.9 | 0.930 | 0.854 | 57.83 | 22.41 | 0.975 | 0.967 | 56.39 | 21.69 | 0.226 | 0.434 |
| 16-Apr | 38.24 | 2414.00 | 35.24 | 60.00 | 25.24 | 3 | 2 | 20.0 | 12.6 | 0.00 | 35.24 | 2302.14 | 111.9 | 6.000 | 1.061 | 105.9 | 110.8 | 0.930 | 0.865 | 57.83 | 23.68 | 0.975 | 0.969 | 56.39 | 22.93 | 0.226 | 0.459 |
| 17-Apr | 39.03 | 2414.01 | 36.03 | 60.00 | 26.03 | 3 | 2 | 20.0 | 13.0 | 0.00 | 36.03 | 2302.14 | 111.9 | 6.000 | 1.129 | 105.9 | 110.7 | 0.930 | 0.873 | 57.83 | 24.63 | 0.975 | 0.969 | 56.39 | 23.88 | 0.226 | 0.478 |
| 18-Apr | 39.60 | 2414.01 | 36.60 | 60.00 | 26.60 | 3 | 2 | 20.0 | 13.3 | 0.00 | 36.60 | 2302.14 | 111.9 | 6.000 | 1.179 | 105.9 | 110.7 | 0.930 | 0.879 | 57.83 | 25.32 | 0.975 | 0.970 | 56.39 | 24.57 | 0.226 | 0.491 |
| 19-Apr | 40.33 | 2414.01 | 37.33 | 60.00 | 27.33 | 3 | 2 | 20.0 | 13.7 | 0.00 | 37.33 | 2302.15 | 111.9 | 6.000 | 1.245 | 105.9 | 110.6 | 0.930 | 0.886 | 57.83 | 26.22 | 0.975 | 0.971 | 56.39 | 25.45 | 0.226 | 0.509 |
| 20-Apr | 41.31 | 2414.02 | 38.31 | 60.00 | 28.31 | 3 | 2 | 20.0 | 14.2 | 0.00 | 38.31 | 2302.15 | 111.9 | 6.000 | 1.336 | 105.9 | 110.5 | 0.930 | 0.894 | 57.84 | 27.40 | 0.975 | 0.972 | 56.39 | 26.62 | 0.226 | 0.532 |
| 21-Apr | 42.77 | 2414.03 | 39.77 | 60.00 | 29.77 | 3 | 2 | 20.0 | 14.9 | 0.00 | 39.77 | 2302.16 | 111.9 | 6.000 | 1.477 | 105.9 | 110.4 | 0.930 | 0.903 | 57.84 | 29.05 | 0.975 | 0.973 | 56.39 | 28.26 | 0.226 | 0.565 |
| 22-Apr | 44.24 | 2414.03 | 41.24 | 60.00 | 31.24 | 3 | 2 | 20.0 | 15.6 | 0.00 | 41.24 | 2302.16 | 111.9 | 6.000 | 1.627 | 105.9 | 110.2 | 0.930 | 0.911 | 57.84 | 30.73 | 0.975 | 0.974 | 56.39 | 29.92 | 0.226 | 0.598 |
| 23-Apr | 45.59 | 2414.04 | 42.59 | 60.00 | 32.59 | 3 | 2 | 20.0 | 16.3 | 0.00 | 42.59 | 2302.17 | 111.9 | 6.000 | 1.771 | 105.9 | 110.1 | 0.930 | 0.917 | 57.84 | 32.23 | 0.975 | 0.974 | 56.39 | 31.40 | 0.226 | 0.628 |
| 24-Apr | 47.71 | 2414.05 | 44.71 | 60.00 | 34.71 | 3 | 2 | 20.0 | 17.4 | 0.00 | 44.71 | 2302.18 | 111.9 | 6.000 | 2.008 | 105.9 | 109.9 | 0.930 | 0.923 | 57.84 | 34.48 | 0.975 | 0.975 | 56.39 | 33.61 | 0.226 | 0.672 |
| 25-Apr | 50.49 | 2414.07 | 47.49 | 60.00 | 37.49 | 3 | 2 | 20.0 | 18.7 | 0.00 | 47.49 | 2302.19 | 111.9 | 6.000 | 2.342 | 105.9 | 109.5 | 0.930 | 0.928 | 57.84 | 37.31 | 0.975 | 0.975 | 56.40 | 36.38 | 0.226 | 0.728 |



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| Day | River Flows at Weir (cumecs) | Head Water Level (m) | Flows less Ecological Flows (cumecs) | Plant Peak Discharge (cumecs) | Plant Off-Peak Discharge (cumecs) | No. of Turbines in Operation for Peaking | No. of Turbines in Operation for Off-Peaking | Discharge Per Turbine of Peaking Plant (cumecs) | Discharge Per Turbine of Peaking Plant (cumecs) | Spilled Discharge (cumecs) | Hunza River Flows at PH (cumecs) | TWL (masl) | Gross Head (m) | Head Loss Peaking Plant (m) | Head Loss Off-Peaking Plant (m) | Net Head Peaking Plant (m) | Net Head Off-Peaking Plant (m) | Turb Eff. For Peaking Turbines | Turb Eff. For Peaking Turbines | Peaking Turbines Output (MW) | Off-Peaking Turbines Output (MW) | Peaking Generator Efficiency | Off-Peaking Generator Efficiency | Peaking Generators Output (MW) | Off-Peaking Generators Output (MW) | Peaking Plant Energy at Generator Terminal (GWh) | Off-Peaking Plant Energy at Generator Terminal (GWh) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 26-Apr | 54.49 | 2414.09 | 51.49 | 60.00 | 41.49 | 3 | 3 | 20.0 | 13.8 | 0.00 | 51.49 | 2302.20 | 111.9 | 6.000 | 2.869 | 105.9 | 109.0 | 0.930 | 0.889 | 57.85 | 39.38 | 0.975 | 0.971 | 56.40 | 38.23 | 0.226 | 0.765 |
| 27-Apr | 57.02 | 2414.10 | 54.02 | 60.00 | 44.02 | 3 | 3 | 20.0 | 14.7 | 0.00 | 54.02 | 2302.21 | 111.9 | 6.000 | 3.229 | 105.9 | 108.7 | 0.930 | 0.900 | 57.85 | 42.16 | 0.975 | 0.972 | 56.40 | 40.98 | 0.226 | 0.820 |
| 28-Apr | 59.72 | 2414.12 | 56.72 | 60.00 | 46.72 | 3 | 3 | 20.0 | 15.6 | 0.00 | 56.72 | 2302.22 | 111.9 | 6.000 | 3.639 | 105.9 | 108.3 | 0.930 | 0.911 | 57.85 | 45.11 | 0.975 | 0.973 | 56.40 | 43.90 | 0.226 | 0.878 |
| 29-Apr | 61.67 | 2414.13 | 58.67 | 60.00 | 48.67 | 3 | 3 | 20.0 | 16.2 | 0.00 | 58.67 | 2302.23 | 111.9 | 6.000 | 3.948 | 105.9 | 107.9 | 0.930 | 0.917 | 57.85 | 47.17 | 0.975 | 0.974 | 56.40 | 45.94 | 0.226 | 0.919 |
| 30-Apr | 63.23 | 2414.133 | 60.23 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 0.23 | 60.47 | 2302.236 | 111.9 | 6.000 | 6.000 | 105.90 | 105.9 | 0.930 | 0.930 | 57.85 | 57.85 | 0.975 | 0.975 | 56.40 | 56.40 | 0.226 | 1.128 |
| 01-May | 62.54 | 2414.13 | 59.54 | 60.00 | 49.54 | 3 | 3 | 20.0 | 16.5 | 0.00 | 59.54 | 2302.23 | 111.9 | 6.000 | 4.091 | 105.9 | 107.8 | 0.930 | 0.919 | 57.85 | 48.04 | 0.975 | 0.974 | 56.40 | 46.79 | 0.226 | 0.936 |
| 02-May | 63.96 | 2414.14 | 60.96 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 0.96 | 61.93 | 2302.24 | 111.9 | 6.000 | 6.000 | 105.9 | 105.9 | 0.930 | 0.930 | 57.85 | 57.85 | 0.975 | 0.975 | 56.40 | 56.40 | 0.226 | 1.128 |
| 03-May | 65.60 | 2414.15 | 62.60 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 2.60 | 65.21 | 2302.25 | 111.9 | 6.000 | 6.000 | 105.9 | 105.9 | 0.930 | 0.930 | 57.85 | 57.85 | 0.975 | 0.975 | 56.40 | 56.40 | 0.226 | 1.128 |
| 04-May | 68.38 | 2414.16 | 65.38 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 5.38 | 70.75 | 2302.28 | 111.9 | 6.000 | 6.000 | 105.9 | 105.9 | 0.930 | 0.930 | 57.84 | 57.84 | 0.975 | 0.975 | 56.40 | 56.40 | 0.226 | 1.128 |
| 05-May | 73.71 | 2414.19 | 70.71 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 10.71 | 81.41 | 2302.32 | 111.9 | 6.000 | 6.000 | 105.9 | 105.9 | 0.930 | 0.930 | 57.84 | 57.84 | 0.975 | 0.975 | 56.39 | 56.39 | 0.226 | 1.128 |
| 06-May | 76.77 | 2414.20 | 73.77 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 13.77 | 87.54 | 2302.34 | 111.9 | 6.000 | 6.000 | 105.9 | 105.9 | 0.930 | 0.930 | 57.83 | 57.83 | 0.975 | 0.975 | 56.39 | 56.39 | 0.226 | 1.128 |
| 07-May | 81.48 | 2414.23 | 78.48 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 18.48 | 96.96 | 2302.37 | 111.9 | 6.000 | 6.000 | 105.9 | 105.9 | 0.930 | 0.930 | 57.83 | 57.83 | 0.975 | 0.975 | 56.38 | 56.38 | 0.226 | 1.128 |
| 08-May | 86.87 | 2414.25 | 83.87 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 23.87 | 107.74 | 2302.41 | 111.8 | 6.000 | 6.000 | 105.8 | 105.8 | 0.930 | 0.930 | 57.82 | 57.82 | 0.975 | 0.975 | 56.37 | 56.37 | 0.225 | 1.127 |
| 09-May | 92.09 | 2414.28 | 89.09 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 29.09 | 118.17 | 2302.45 | 111.8 | 6.000 | 6.000 | 105.8 | 105.8 | 0.930 | 0.930 | 57.81 | 57.81 | 0.975 | 0.975 | 56.37 | 56.37 | 0.225 | 1.127 |
| 10-May | 94.32 | 2414.29 | 91.32 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 31.32 | 122.63 | 2302.47 | 111.8 | 6.000 | 6.000 | 105.8 | 105.8 | 0.930 | 0.930 | 57.81 | 57.81 | 0.975 | 0.975 | 56.36 | 56.36 | 0.225 | 1.127 |
| 11-May | 95.00 | 2414.29 | 92.00 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 32.00 | 123.99 | 2302.47 | 111.8 | 6.000 | 6.000 | 105.8 | 105.8 | 0.930 | 0.930 | 57.81 | 57.81 | 0.975 | 0.975 | 56.36 | 56.36 | 0.225 | 1.127 |
| 12-May | 98.47 | 2414.31 | 95.47 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 35.47 | 130.95 | 2302.50 | 111.8 | 6.000 | 6.000 | 105.8 | 105.8 | 0.930 | 0.930 | 57.80 | 57.80 | 0.975 | 0.975 | 56.36 | 56.36 | 0.225 | 1.127 |
| 13-May | 102.49 | 2414.33 | 99.49 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 39.49 | 138.98 | 2302.53 | 111.8 | 6.000 | 6.000 | 105.8 | 105.8 | 0.930 | 0.930 | 57.80 | 57.80 | 0.975 | 0.975 | 56.35 | 56.35 | 0.225 | 1.127 |
| 14-May | 108.04 | 2414.36 | 105.04 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 45.04 | 150.08 | 2302.57 | 111.8 | 6.000 | 6.000 | 105.8 | 105.8 | 0.930 | 0.930 | 57.79 | 57.79 | 0.975 | 0.975 | 56.35 | 56.35 | 0.225 | 1.127 |
| 15-May | 117.41 | 2414.41 | 114.41 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 54.41 | 168.83 | 2302.64 | 111.8 | 6.000 | 6.000 | 105.8 | 105.8 | 0.930 | 0.930 | 57.78 | 57.78 | 0.975 | 0.975 | 56.34 | 56.34 | 0.225 | 1.127 |
| 16-May | 125.00 | 2414.44 | 122.00 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 62.00 | 183.99 | 2302.69 | 111.8 | 6.000 | 6.000 | 105.8 | 105.8 | 0.930 | 0.930 | 57.77 | 57.77 | 0.975 | 0.975 | 56.33 | 56.33 | 0.225 | 1.127 |
| 17-May | 129.41 | 2414.47 | 126.41 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 66.41 | 192.82 | 2302.72 | 111.7 | 6.000 | 6.000 | 105.7 | 105.7 | 0.930 | 0.930 | 57.77 | 57.77 | 0.975 | 0.975 | 56.32 | 56.32 | 0.225 | 1.126 |
| 18-May | 135.64 | 2414.50 | 132.64 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 72.64 | 205.29 | 2302.76 | 111.7 | 6.000 | 6.000 | 105.7 | 105.7 | 0.930 | 0.930 | 57.76 | 57.76 | 0.975 | 0.975 | 56.32 | 56.32 | 0.225 | 1.126 |
| 19-May | 137.53 | 2414.50 | 134.53 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 74.53 | 209.06 | 2302.78 | 111.7 | 6.000 | 6.000 | 105.7 | 105.7 | 0.930 | 0.930 | 57.76 | 57.76 | 0.975 | 0.975 | 56.31 | 56.31 | 0.225 | 1.126 |
| 20-May | 140.59 | 2414.52 | 137.59 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 77.59 | 215.17 | 2302.80 | 111.7 | 6.000 | 6.000 | 105.7 | 105.7 | 0.930 | 0.930 | 57.76 | 57.76 | 0.975 | 0.975 | 56.31 | 56.31 | 0.225 | 1.126 |
| 21-May | 143.80 | 2414.54 | 140.80 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 80.80 | 221.60 | 2302.82 | 111.7 | 6.000 | 6.000 | 105.7 | 105.7 | 0.930 | 0.930 | 57.75 | 57.75 | 0.975 | 0.975 | 56.31 | 56.31 | 0.225 | 1.126 |
| 22-May | 148.08 | 2414.56 | 145.08 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 85.08 | 230.16 | 2302.85 | 111.7 | 6.000 | 6.000 | 105.7 | 105.7 | 0.930 | 0.930 | 57.75 | 57.75 | 0.975 | 0.975 | 56.30 | 56.30 | 0.225 | 1.126 |
| 23-May | 156.90 | 2414.60 | 153.90 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 93.90 | 247.80 | 2302.91 | 111.7 | 6.000 | 6.000 | 105.7 | 105.7 | 0.930 | 0.930 | 57.74 | 57.74 | 0.975 | 0.975 | 56.29 | 56.29 | 0.225 | 1.126 |
| 24-May | 161.08 | 2414.62 | 158.08 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 98.08 | 256.17 | 2302.94 | 111.7 | 6.000 | 6.000 | 105.7 | 105.7 | 0.930 | 0.930 | 57.73 | 57.73 | 0.975 | 0.975 | 56.29 | 56.29 | 0.225 | 1.126 |
| 25-May | 165.74 | 2414.64 | 162.74 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 102.74 | 265.48 | 2302.97 | 111.7 | 6.000 | 6.000 | 105.7 | 105.7 | 0.930 | 0.930 | 57.73 | 57.73 | 0.975 | 0.975 | 56.28 | 56.28 | 0.225 | 1.126 |
| 26-May | 165.32 | 2414.64 | 162.32 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 102.32 | 264.63 | 2302.97 | 111.7 | 6.000 | 6.000 | 105.7 | 105.7 | 0.930 | 0.930 | 57.73 | 57.73 | 0.975 | 0.975 | 56.28 | 56.28 | 0.225 | 1.126 |
| 27-May | 168.03 | 2414.65 | 165.03 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 105.03 | 270.06 | 2302.98 | 111.7 | 6.000 | 6.000 | 105.7 | 105.7 | 0.930 | 0.930 | 57.73 | 57.73 | 0.975 | 0.975 | 56.28 | 56.28 | 0.225 | 1.126 |
| 28-May | 170.22 | 2414.66 | 167.22 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 107.22 | 274.43 | 2303.00 | 111.7 | 6.000 | 6.000 | 105.7 | 105.7 | 0.930 | 0.930 | 57.72 | 57.72 | 0.975 | 0.975 | 56.28 | 56.28 | 0.225 | 1.126 |
| 29-May | 177.16 | 2414.69 | 174.16 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 114.16 | 288.32 | 2303.04 | 111.7 | 6.000 | 6.000 | 105.7 | 105.7 | 0.930 | 0.930 | 57.72 | 57.72 | 0.975 | 0.975 | 56.27 | 56.27 | 0.225 | 1.125 |
| 30-May | 185.90 | 2414.73 | 182.90 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 122.90 | 305.81 | 2303.10 | 111.6 | 6.000 | 6.000 | 105.6 | 105.6 | 0.930 | 0.930 | 57.71 | 57.71 | 0.975 | 0.975 | 56.26 | 56.26 | 0.225 | 1.125 |
| 31-May | 194.18 | 2414.77 | 191.18 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 131.18 | 322.37 | 2303.15 | 111.6 | 6.000 | 6.000 | 105.6 | 105.6 | 0.930 | 0.930 | 57.70 | 57.70 | 0.975 | 0.975 | 56.26 | 56.26 | 0.225 | 1.125 |
| 01-Jun | 203.87 | 2414.82 | 200.87 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 140.87 | 341.74 | 2303.21 | 111.6 | 6.000 | 6.000 | 105.6 | 105.6 | 0.930 | 0.930 | 57.69 | 57.69 | 0.975 | 0.975 | 56.25 | 56.25 | 0.225 | 1.125 |
| 02-Jun | 213.49 | 2414.86 | 210.49 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 150.49 | 360.97 | 2303.27 | 111.6 | 6.000 | 6.000 | 105.6 | 105.6 | 0.930 | 0.930 | 57.68 | 57.68 | 0.975 | 0.975 | 56.24 | 56.24 | 0.225 | 1.125 |
| 03-Jun | 223.75 | 2414.91 | 220.75 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 160.75 | 381.49 | 2303.34 | 111.6 | 6.000 | 6.000 | 105.6 | 105.6 | 0.930 | 0.930 | 57.67 | 57.67 | 0.975 | 0.975 | 56.23 | 56.23 | 0.225 | 1.125 |




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| Day | River Flows at Weir (cumecs) | Head Water Level (m) | Flows less Ecological Flows (cumecs) | Plant Peak Discharge (cumecs) | Plant Off-Peak Discharge (cumecs) | No. of Turbines in Operation for Peaking | No. of Turbines in Operation for Off-Peaking | Discharge Per Turbine of Peaking Plant (cumecs) | Discharge Per Turbine of Peaking Plant (cumecs) | Spilled Discharge (cumecs) | Hunza River Flows at PH (cumecs) | TWL (masl) | Gross Head (m) | Head Loss Peaking Plant (m) | Head Loss Off-Peaking Plant (m) | Net Head Peaking Plant (m) | Net Head Off-Peaking Plant (m) | Turb Eff. For Peaking Turbines | Turb Eff. For Peaking Turbines | Peaking Turbines Output (MW) | Off-Peaking Turbines Output (MW) | Peaking Generator Efficiency | Off-Peaking Generator Efficiency | Peaking Generators Output (MW) | Off-Peaking Generators Output (MW) | Peaking Plant Energy at Generator Terminal (GWh) | Off-Peaking Plant Energy at Generator Terminal (GWh) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 04-Jun | 235.51 | 2414.96 | 232.51 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 172.51 | 405.02 | 2303.41 | 111.6 | 6.000 | 6.000 | 105.6 | 105.6 | 0.930 | 0.930 | 57.66 | 57.66 | 0.975 | 0.975 | 56.22 | 56.22 | 0.225 | 1.124 |
| 05-Jun | 244.36 | 2415.00 | 241.36 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 181.36 | 422.73 | 2303.46 | 111.5 | 6.000 | 6.000 | 105.5 | 105.5 | 0.930 | 0.930 | 57.66 | 57.66 | 0.975 | 0.975 | 56.21 | 56.21 | 0.225 | 1.124 |
| 06-Jun | 255.78 | 2415.05 | 252.78 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 192.78 | 445.57 | 2303.53 | 111.5 | 6.000 | 6.000 | 105.5 | 105.5 | 0.930 | 0.930 | 57.65 | 57.65 | 0.975 | 0.975 | 56.20 | 56.20 | 0.225 | 1.124 |
| 07-Jun | 272.48 | 2415.12 | 269.48 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 209.48 | 478.96 | 2303.62 | 111.5 | 6.000 | 6.000 | 105.5 | 105.5 | 0.930 | 0.930 | 57.63 | 57.63 | 0.975 | 0.975 | 56.19 | 56.19 | 0.225 | 1.124 |
| 08-Jun | 290.15 | 2415.20 | 287.15 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 227.15 | 514.30 | 2303.72 | 111.5 | 6.000 | 6.000 | 105.5 | 105.5 | 0.930 | 0.930 | 57.62 | 57.62 | 0.975 | 0.975 | 56.18 | 56.18 | 0.225 | 1.124 |
| 09-Jun | 305.32 | 2415.26 | 302.32 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 242.32 | 544.63 | 2303.81 | 111.5 | 6.000 | 6.000 | 105.5 | 105.5 | 0.930 | 0.930 | 57.61 | 57.61 | 0.975 | 0.975 | 56.17 | 56.17 | 0.225 | 1.123 |
| 10-Jun | 315.04 | 2415.30 | 312.04 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 252.04 | 564.08 | 2303.86 | 111.4 | 6.000 | 6.000 | 105.4 | 105.4 | 0.930 | 0.930 | 57.60 | 57.60 | 0.975 | 0.975 | 56.16 | 56.16 | 0.225 | 1.123 |
| 11-Jun | 328.60 | 2415.36 | 325.60 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 265.60 | 591.19 | 2303.93 | 111.4 | 6.000 | 6.000 | 105.4 | 105.4 | 0.930 | 0.930 | 57.59 | 57.59 | 0.975 | 0.975 | 56.15 | 56.15 | 0.225 | 1.123 |
| 12-Jun | 346.03 | 2415.43 | 343.03 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 283.03 | 626.06 | 2304.02 | 111.4 | 6.000 | 6.000 | 105.4 | 105.4 | 0.930 | 0.930 | 57.58 | 57.58 | 0.975 | 0.975 | 56.14 | 56.14 | 0.225 | 1.123 |
| 13-Jun | 357.49 | 2415.47 | 354.49 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 294.49 | 648.99 | 2304.08 | 111.4 | 6.000 | 6.000 | 105.4 | 105.4 | 0.930 | 0.930 | 57.58 | 57.58 | 0.975 | 0.975 | 56.14 | 56.14 | 0.225 | 1.123 |
| 14-Jun | 362.55 | 2415.49 | 359.55 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 299.55 | 659.10 | 2304.10 | 111.4 | 6.000 | 6.000 | 105.4 | 105.4 | 0.930 | 0.930 | 57.57 | 57.57 | 0.975 | 0.975 | 56.13 | 56.13 | 0.225 | 1.123 |
| 15-Jun | 373.63 | 2415.54 | 370.63 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 310.63 | 681.26 | 2304.16 | 111.4 | 6.000 | 6.000 | 105.4 | 105.4 | 0.930 | 0.930 | 57.57 | 57.57 | 0.975 | 0.975 | 56.13 | 56.13 | 0.225 | 1.123 |
| 16-Jun | 384.26 | 2415.58 | 381.26 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 321.26 | 702.53 | 2304.21 | 111.4 | 6.000 | 6.000 | 105.4 | 105.4 | 0.930 | 0.930 | 57.56 | 57.56 | 0.975 | 0.975 | 56.12 | 56.12 | 0.224 | 1.122 |
| 17-Jun | 394.86 | 2415.62 | 391.86 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 331.86 | 723.72 | 2304.26 | 111.4 | 6.000 | 6.000 | 105.4 | 105.4 | 0.930 | 0.930 | 57.56 | 57.56 | 0.975 | 0.975 | 56.12 | 56.12 | 0.224 | 1.122 |
| 18-Jun | 407.56 | 2415.67 | 404.56 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 344.56 | 749.12 | 2304.32 | 111.3 | 6.000 | 6.000 | 105.3 | 105.3 | 0.930 | 0.930 | 57.55 | 57.55 | 0.975 | 0.975 | 56.11 | 56.11 | 0.224 | 1.122 |
| 19-Jun | 423.16 | 2415.73 | 420.16 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 360.16 | 780.32 | 2304.39 | 111.3 | 6.000 | 6.000 | 105.3 | 105.3 | 0.930 | 0.930 | 57.54 | 57.54 | 0.975 | 0.975 | 56.10 | 56.10 | 0.224 | 1.122 |
| 20-Jun | 436.37 | 2415.78 | 433.37 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 373.37 | 806.74 | 2304.45 | 111.3 | 6.000 | 6.000 | 105.3 | 105.3 | 0.930 | 0.930 | 57.54 | 57.54 | 0.975 | 0.975 | 56.10 | 56.10 | 0.224 | 1.122 |
| 21-Jun | 450.67 | 2415.83 | 447.67 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 387.67 | 835.35 | 2304.51 | 111.3 | 6.000 | 6.000 | 105.3 | 105.3 | 0.930 | 0.930 | 57.53 | 57.53 | 0.975 | 0.975 | 56.09 | 56.09 | 0.224 | 1.122 |
| 22-Jun | 473.04 | 2415.91 | 470.04 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 410.04 | 880.09 | 2304.61 | 111.3 | 6.000 | 6.000 | 105.3 | 105.3 | 0.930 | 0.930 | 57.52 | 57.52 | 0.975 | 0.975 | 56.08 | 56.08 | 0.224 | 1.122 |
| 23-Jun | 497.41 | 2415.99 | 494.41 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 434.41 | 928.83 | 2304.71 | 111.3 | 6.000 | 6.000 | 105.3 | 105.3 | 0.930 | 0.930 | 57.51 | 57.51 | 0.975 | 0.975 | 56.08 | 56.08 | 0.224 | 1.122 |
| 24-Jun | 524.33 | 2416.08 | 521.33 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 461.33 | 982.66 | 2304.82 | 111.3 | 6.000 | 6.000 | 105.3 | 105.3 | 0.930 | 0.930 | 57.51 | 57.51 | 0.975 | 0.975 | 56.07 | 56.07 | 0.224 | 1.121 |
| 25-Jun | 544.53 | 2416.15 | 541.53 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 481.53 | 1023.06 | 2304.89 | 111.3 | 6.000 | 6.000 | 105.3 | 105.3 | 0.930 | 0.930 | 57.50 | 57.50 | 0.975 | 0.975 | 56.06 | 56.06 | 0.224 | 1.121 |
| 26-Jun | 578.18 | 2416.25 | 575.18 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 515.18 | 1090.35 | 2305.02 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.49 | 57.49 | 0.975 | 0.975 | 56.05 | 56.05 | 0.224 | 1.121 |
| 27-Jun | 602.59 | 2416.33 | 599.59 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 539.59 | 1139.18 | 2305.10 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.48 | 57.48 | 0.975 | 0.975 | 56.05 | 56.05 | 0.224 | 1.121 |
| 28-Jun | 623.54 | 2416.39 | 620.54 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 560.54 | 1181.08 | 2305.17 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.48 | 57.48 | 0.975 | 0.975 | 56.04 | 56.04 | 0.224 | 1.121 |
| 29-Jun | 632.91 | 2416.42 | 629.91 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 569.91 | 1199.82 | 2305.20 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.48 | 57.48 | 0.975 | 0.975 | 56.04 | 56.04 | 0.224 | 1.121 |
| 30-Jun | 657.89 | 2416.49 | 654.89 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 594.89 | 1249.77 | 2305.29 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.47 | 57.47 | 0.975 | 0.975 | 56.03 | 56.03 | 0.224 | 1.121 |
| 01-Jul | 660.45 | 2416.49 | 657.45 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 597.45 | 1254.90 | 2305.29 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.47 | 57.47 | 0.975 | 0.975 | 56.03 | 56.03 | 0.224 | 1.121 |
| 02-Jul | 661.30 | 2416.50 | 658.30 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 598.30 | 1256.60 | 2305.30 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.47 | 57.47 | 0.975 | 0.975 | 56.03 | 56.03 | 0.224 | 1.121 |
| 03-Jul | 655.99 | 2416.48 | 652.99 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 592.99 | 1245.98 | 2305.28 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.47 | 57.47 | 0.975 | 0.975 | 56.03 | 56.03 | 0.224 | 1.121 |
| 04-Jul | 654.61 | 2416.48 | 651.61 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 591.61 | 1243.22 | 2305.28 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.47 | 57.47 | 0.975 | 0.975 | 56.03 | 56.03 | 0.224 | 1.121 |
| 05-Jul | 646.73 | 2416.46 | 643.73 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 583.73 | 1227.47 | 2305.25 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.47 | 57.47 | 0.975 | 0.975 | 56.04 | 56.04 | 0.224 | 1.121 |
| 06-Jul | 654.97 | 2416.48 | 651.97 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 591.97 | 1243.94 | 2305.28 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.47 | 57.47 | 0.975 | 0.975 | 56.03 | 56.03 | 0.224 | 1.121 |
| 07-Jul | 659.57 | 2416.49 | 656.57 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 596.57 | 1253.15 | 2305.29 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.47 | 57.47 | 0.975 | 0.975 | 56.03 | 56.03 | 0.224 | 1.121 |
| 08-Jul | 677.32 | 2416.54 | 674.32 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 614.32 | 1288.65 | 2305.35 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.47 | 57.47 | 0.975 | 0.975 | 56.03 | 56.03 | 0.224 | 1.121 |
| 09-Jul | 692.59 | 2416.58 | 689.59 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 629.59 | 1319.17 | 2305.39 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.46 | 57.46 | 0.975 | 0.975 | 56.03 | 56.03 | 0.224 | 1.121 |
| 10-Jul | 702.09 | 2416.61 | 699.09 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 639.09 | 1338.18 | 2305.42 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.46 | 57.46 | 0.975 | 0.975 | 56.02 | 56.02 | 0.224 | 1.120 |
| 11-Jul | 720.70 | 2416.65 | 717.70 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 657.70 | 1375.40 | 2305.48 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.46 | 57.46 | 0.975 | 0.975 | 56.02 | 56.02 | 0.224 | 1.120 |
| 12-Jul | 742.10 | 2416.71 | 739.10 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 679.10 | 1418.19 | 2305.54 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.45 | 57.45 | 0.975 | 0.975 | 56.02 | 56.02 | 0.224 | 1.120 |



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| Day | River Flows at Weir (cumecs) | Head Water Level (m) | Flows less Ecological Flows (cumecs) | Plant Peak Discharge (cumecs) | Plant Off-Peak Discharge (cumecs) | No. of Turbines in Operation for Peaking | No. of Turbines in Operation for Off-Peaking | Discharge Per Turbine of Peaking Plant (cumecs) | Discharge Per Turbine of Peaking Plant (cumecs) | Spilled Discharge (cumecs) | Hunza River Flows at PH (cumecs) | TWL (masl) | Gross Head (m) | Head Loss Peaking Plant (m) | Head Loss Off-Peaking Plant (m) | Net Head Peaking Plant (m) | Net Head Off-Peaking Plant (m) | Turb Eff. For Peaking Turbines | Turb Eff. For Peaking Turbines | Peaking Turbines Output (MW) | Off-Peaking Turbines Output (MW) | Peaking Generator Efficiency | Off-Peaking Generator Efficiency | Peaking Generators Output (MW) | Off-Peaking Generators Output (MW) | Peaking Plant Energy at Generator Terminal (GWh) | Off-Peaking Plant Energy at Generator Terminal (GWh) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13-Jul | 770.25 | 2416.77 | 767.25 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 707.25 | 1474.50 | 2305.61 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.45 | 57.45 | 0.975 | 0.975 | 56.01 | 56.01 | 0.224 | 1.120 |
| 14-Jul | 785.54 | 2416.81 | 782.54 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 722.54 | 1505.08 | 2305.65 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.44 | 57.44 | 0.975 | 0.975 | 56.01 | 56.01 | 0.224 | 1.120 |
| 15-Jul | 784.33 | 2416.81 | 781.33 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 721.33 | 1502.66 | 2305.65 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.44 | 57.44 | 0.975 | 0.975 | 56.01 | 56.01 | 0.224 | 1.120 |
| 16-Jul | 789.25 | 2416.82 | 786.25 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 726.25 | 1512.50 | 2305.66 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.44 | 57.44 | 0.975 | 0.975 | 56.01 | 56.01 | 0.224 | 1.120 |
| 17-Jul | 780.04 | 2416.80 | 777.04 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 717.04 | 1494.09 | 2305.64 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.45 | 57.45 | 0.975 | 0.975 | 56.01 | 56.01 | 0.224 | 1.120 |
| 18-Jul | 769.65 | 2416.77 | 766.65 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 706.65 | 1473.31 | 2305.61 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.45 | 57.45 | 0.975 | 0.975 | 56.01 | 56.01 | 0.224 | 1.120 |
| 19-Jul | 766.45 | 2416.76 | 763.45 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 703.45 | 1466.91 | 2305.60 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.45 | 57.45 | 0.975 | 0.975 | 56.01 | 56.01 | 0.224 | 1.120 |
| 20-Jul | 778.75 | 2416.79 | 775.75 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 715.75 | 1491.51 | 2305.64 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.45 | 57.45 | 0.975 | 0.975 | 56.01 | 56.01 | 0.224 | 1.120 |
| 21-Jul | 797.94 | 2416.84 | 794.94 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 734.94 | 1529.88 | 2305.69 | 111.1 | 6.000 | 6.000 | 105.1 | 105.1 | 0.930 | 0.930 | 57.44 | 57.44 | 0.975 | 0.975 | 56.00 | 56.00 | 0.224 | 1.120 |
| 22-Jul | 804.41 | 2416.85 | 801.41 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 741.41 | 1542.83 | 2305.70 | 111.1 | 6.000 | 6.000 | 105.1 | 105.1 | 0.930 | 0.930 | 57.44 | 57.44 | 0.975 | 0.975 | 56.00 | 56.00 | 0.224 | 1.120 |
| 23-Jul | 802.78 | 2416.85 | 799.78 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 739.78 | 1539.56 | 2305.70 | 111.1 | 6.000 | 6.000 | 105.1 | 105.1 | 0.930 | 0.930 | 57.44 | 57.44 | 0.975 | 0.975 | 56.00 | 56.00 | 0.224 | 1.120 |
| 24-Jul | 783.86 | 2416.80 | 780.86 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 720.86 | 1501.72 | 2305.65 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.44 | 57.44 | 0.975 | 0.975 | 56.01 | 56.01 | 0.224 | 1.120 |
| 25-Jul | 774.21 | 2416.78 | 771.21 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 711.21 | 1482.43 | 2305.62 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.45 | 57.45 | 0.975 | 0.975 | 56.01 | 56.01 | 0.224 | 1.120 |
| 26-Jul | 756.13 | 2416.74 | 753.13 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 693.13 | 1446.25 | 2305.58 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.45 | 57.45 | 0.975 | 0.975 | 56.01 | 56.01 | 0.224 | 1.120 |
| 27-Jul | 746.31 | 2416.72 | 743.31 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 683.31 | 1426.61 | 2305.55 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.45 | 57.45 | 0.975 | 0.975 | 56.02 | 56.02 | 0.224 | 1.120 |
| 28-Jul | 776.14 | 2416.79 | 773.14 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 713.14 | 1486.29 | 2305.63 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.45 | 57.45 | 0.975 | 0.975 | 56.01 | 56.01 | 0.224 | 1.120 |
| 29-Jul | 790.43 | 2416.82 | 787.43 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 727.43 | 1514.86 | 2305.67 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.44 | 57.44 | 0.975 | 0.975 | 56.01 | 56.01 | 0.224 | 1.120 |
| 30-Jul | 802.87 | 2416.85 | 799.87 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 739.87 | 1539.74 | 2305.70 | 111.1 | 6.000 | 6.000 | 105.1 | 105.1 | 0.930 | 0.930 | 57.44 | 57.44 | 0.975 | 0.975 | 56.00 | 56.00 | 0.224 | 1.120 |
| 31-Jul | 808.63 | 2416.86 | 805.63 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 745.63 | 1551.26 | 2305.72 | 111.1 | 6.000 | 6.000 | 105.1 | 105.1 | 0.930 | 0.930 | 57.44 | 57.44 | 0.975 | 0.975 | 56.00 | 56.00 | 0.224 | 1.120 |
| 01-Aug | 802.45 | 2416.85 | 799.45 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 739.45 | 1538.91 | 2305.70 | 111.1 | 6.000 | 6.000 | 105.1 | 105.1 | 0.930 | 0.930 | 57.44 | 57.44 | 0.975 | 0.975 | 56.00 | 56.00 | 0.224 | 1.120 |
| 02-Aug | 811.70 | 2416.87 | 808.70 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 748.70 | 1557.41 | 2305.72 | 111.1 | 6.000 | 6.000 | 105.1 | 105.1 | 0.930 | 0.930 | 57.44 | 57.44 | 0.975 | 0.975 | 56.00 | 56.00 | 0.224 | 1.120 |
| 03-Aug | 828.50 | 2416.90 | 825.50 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 765.50 | 1591.00 | 2305.77 | 111.1 | 6.000 | 6.000 | 105.1 | 105.1 | 0.930 | 0.930 | 57.43 | 57.43 | 0.975 | 0.975 | 56.00 | 56.00 | 0.224 | 1.120 |
| 04-Aug | 846.97 | 2416.94 | 843.97 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 783.97 | 1627.94 | 2305.81 | 111.1 | 6.000 | 6.000 | 105.1 | 105.1 | 0.930 | 0.930 | 57.43 | 57.43 | 0.975 | 0.975 | 55.99 | 55.99 | 0.224 | 1.120 |
| 05-Aug | 845.96 | 2416.94 | 842.96 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 782.96 | 1625.92 | 2305.81 | 111.1 | 6.000 | 6.000 | 105.1 | 105.1 | 0.930 | 0.930 | 57.43 | 57.43 | 0.975 | 0.975 | 55.99 | 55.99 | 0.224 | 1.120 |
| 06-Aug | 842.46 | 2416.93 | 839.46 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 779.46 | 1618.92 | 2305.80 | 111.1 | 6.000 | 6.000 | 105.1 | 105.1 | 0.930 | 0.930 | 57.43 | 57.43 | 0.975 | 0.975 | 55.99 | 55.99 | 0.224 | 1.120 |
| 07-Aug | 847.37 | 2416.94 | 844.37 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 784.37 | 1628.73 | 2305.81 | 111.1 | 6.000 | 6.000 | 105.1 | 105.1 | 0.930 | 0.930 | 57.43 | 57.43 | 0.975 | 0.975 | 55.99 | 55.99 | 0.224 | 1.120 |
| 08-Aug | 849.86 | 2416.94 | 846.86 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 786.86 | 1633.71 | 2305.82 | 111.1 | 6.000 | 6.000 | 105.1 | 105.1 | 0.930 | 0.930 | 57.43 | 57.43 | 0.975 | 0.975 | 55.99 | 55.99 | 0.224 | 1.120 |
| 09-Aug | 834.10 | 2416.91 | 831.10 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 771.10 | 1602.20 | 2305.78 | 111.1 | 6.000 | 6.000 | 105.1 | 105.1 | 0.930 | 0.930 | 57.43 | 57.43 | 0.975 | 0.975 | 56.00 | 56.00 | 0.224 | 1.120 |
| 10-Aug | 801.56 | 2416.84 | 798.56 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 738.56 | 1537.13 | 2305.70 | 111.1 | 6.000 | 6.000 | 105.1 | 105.1 | 0.930 | 0.930 | 57.44 | 57.44 | 0.975 | 0.975 | 56.00 | 56.00 | 0.224 | 1.120 |
| 11-Aug | 776.38 | 2416.79 | 773.38 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 713.38 | 1486.77 | 2305.63 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.45 | 57.45 | 0.975 | 0.975 | 56.01 | 56.01 | 0.224 | 1.120 |
| 12-Aug | 764.57 | 2416.76 | 761.57 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 701.57 | 1463.14 | 2305.60 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.45 | 57.45 | 0.975 | 0.975 | 56.01 | 56.01 | 0.224 | 1.120 |
| 13-Aug | 750.55 | 2416.73 | 747.55 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 687.55 | 1435.10 | 2305.56 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.45 | 57.45 | 0.975 | 0.975 | 56.01 | 56.01 | 0.224 | 1.120 |
| 14-Aug | 739.47 | 2416.70 | 736.47 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 676.47 | 1412.93 | 2305.53 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.45 | 57.45 | 0.975 | 0.975 | 56.02 | 56.02 | 0.224 | 1.120 |
| 15-Aug | 723.97 | 2416.66 | 720.97 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 660.97 | 1381.95 | 2305.48 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.46 | 57.46 | 0.975 | 0.975 | 56.02 | 56.02 | 0.224 | 1.120 |
| 16-Aug | 717.83 | 2416.65 | 714.83 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 654.83 | 1369.65 | 2305.47 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.46 | 57.46 | 0.975 | 0.975 | 56.02 | 56.02 | 0.224 | 1.120 |
| 17-Aug | 709.87 | 2416.63 | 706.87 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 646.87 | 1353.75 | 2305.44 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.46 | 57.46 | 0.975 | 0.975 | 56.02 | 56.02 | 0.224 | 1.120 |
| 18-Aug | 706.82 | 2416.62 | 703.82 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 643.82 | 1347.65 | 2305.43 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.46 | 57.46 | 0.975 | 0.975 | 56.02 | 56.02 | 0.224 | 1.120 |
| 19-Aug | 694.53 | 2416.59 | 691.53 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 631.53 | 1323.06 | 2305.40 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.46 | 57.46 | 0.975 | 0.975 | 56.03 | 56.03 | 0.224 | 1.121 |
| 20-Aug | 693.48 | 2416.58 | 690.48 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 630.48 | 1320.95 | 2305.40 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.46 | 57.46 | 0.975 | 0.975 | 56.03 | 56.03 | 0.224 | 1.121 |



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| Day | River Flows at Weir (cumecs) | Head Water Level (m) | Flows less Ecological Flows (cumecs) | Plant Peak Discharge (cumecs) | Plant Off-Peak Discharge (cumecs) | No. of Turbines in Operation for Peaking | No. of Turbines in Operation for Off-Peaking | Discharge Per Turbine of Peaking Plant (cumecs) | Discharge Per Turbine of Peaking Plant (cumecs) | Spilled Discharge (cumecs) | Hunza River Flows at PH (cumecs) | TWL (masl) | Gross Head (m) | Head Loss Peaking Plant (m) | Head Loss Off-Peaking Plant (m) | Net Head Peaking Plant (m) | Net Head Off-Peaking Plant (m) | Turb Eff. For Peaking Turbines | Turb Eff. For Peaking Turbines | Peaking Turbines Output (MW) | Off-Peaking Turbines Output (MW) | Peaking Generator Efficiency | Off-Peaking Generator Efficiency | Peaking Generators Output (MW) | Off-Peaking Generators Output (MW) | Peaking Plant Energy at Generator Terminal (GWh) | Off-Peaking Plant Energy at Generator Terminal (GWh) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21-Aug | 676.34 | 2416.54 | 673.34 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 613.34 | 1286.68 | 2305.34 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.47 | 57.47 | 0.975 | 0.975 | 56.03 | 56.03 | 0.224 | 1.121 |
| 22-Aug | 643.71 | 2416.45 | 640.71 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 580.71 | 1221.42 | 2305.24 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.47 | 57.47 | 0.975 | 0.975 | 56.04 | 56.04 | 0.224 | 1.121 |
| 23-Aug | 618.04 | 2416.37 | 615.04 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 555.04 | 1170.08 | 2305.16 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.48 | 57.48 | 0.975 | 0.975 | 56.04 | 56.04 | 0.224 | 1.121 |
| 24-Aug | 600.94 | 2416.32 | 597.94 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 537.94 | 1135.87 | 2305.10 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.48 | 57.48 | 0.975 | 0.975 | 56.05 | 56.05 | 0.224 | 1.121 |
| 25-Aug | 598.01 | 2416.31 | 595.01 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 535.01 | 1130.03 | 2305.09 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.48 | 57.48 | 0.975 | 0.975 | 56.05 | 56.05 | 0.224 | 1.121 |
| 26-Aug | 579.70 | 2416.26 | 576.70 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 516.70 | 1093.39 | 2305.02 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.49 | 57.49 | 0.975 | 0.975 | 56.05 | 56.05 | 0.224 | 1.121 |
| 27-Aug | 562.07 | 2416.20 | 559.07 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 499.07 | 1058.14 | 2304.96 | 111.2 | 6.000 | 6.000 | 105.2 | 105.2 | 0.930 | 0.930 | 57.49 | 57.49 | 0.975 | 0.975 | 56.06 | 56.06 | 0.224 | 1.121 |
| 28-Aug | 540.16 | 2416.13 | 537.16 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 477.16 | 1014.32 | 2304.88 | 111.3 | 6.000 | 6.000 | 105.3 | 105.3 | 0.930 | 0.930 | 57.50 | 57.50 | 0.975 | 0.975 | 56.06 | 56.06 | 0.224 | 1.121 |
| 29-Aug | 532.33 | 2416.11 | 529.33 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 469.33 | 998.66 | 2304.85 | 111.3 | 6.000 | 6.000 | 105.3 | 105.3 | 0.930 | 0.930 | 57.50 | 57.50 | 0.975 | 0.975 | 56.06 | 56.06 | 0.224 | 1.121 |
| 30-Aug | 528.74 | 2416.10 | 525.74 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 465.74 | 991.49 | 2304.83 | 111.3 | 6.000 | 6.000 | 105.3 | 105.3 | 0.930 | 0.930 | 57.50 | 57.50 | 0.975 | 0.975 | 56.07 | 56.07 | 0.224 | 1.121 |
| 31-Aug | 519.88 | 2416.07 | 516.88 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 456.88 | 973.76 | 2304.80 | 111.3 | 6.000 | 6.000 | 105.3 | 105.3 | 0.930 | 0.930 | 57.51 | 57.51 | 0.975 | 0.975 | 56.07 | 56.07 | 0.224 | 1.121 |
| 01-Sep | 497.53 | 2415.99 | 494.53 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 434.53 | 929.06 | 2304.71 | 111.3 | 6.000 | 6.000 | 105.3 | 105.3 | 0.930 | 0.930 | 57.51 | 57.51 | 0.975 | 0.975 | 56.08 | 56.08 | 0.224 | 1.122 |
| 02-Sep | 479.19 | 2415.93 | 476.19 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 416.19 | 892.37 | 2304.64 | 111.3 | 6.000 | 6.000 | 105.3 | 105.3 | 0.930 | 0.930 | 57.52 | 57.52 | 0.975 | 0.975 | 56.08 | 56.08 | 0.224 | 1.122 |
| 03-Sep | 473.67 | 2415.91 | 470.67 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 410.67 | 881.35 | 2304.61 | 111.3 | 6.000 | 6.000 | 105.3 | 105.3 | 0.930 | 0.930 | 57.52 | 57.52 | 0.975 | 0.975 | 56.08 | 56.08 | 0.224 | 1.122 |
| 04-Sep | 465.79 | 2415.88 | 462.79 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 402.79 | 865.58 | 2304.58 | 111.3 | 6.000 | 6.000 | 105.3 | 105.3 | 0.930 | 0.930 | 57.53 | 57.53 | 0.975 | 0.975 | 56.09 | 56.09 | 0.224 | 1.122 |
| 05-Sep | 448.80 | 2415.82 | 445.80 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 385.80 | 831.60 | 2304.51 | 111.3 | 6.000 | 6.000 | 105.3 | 105.3 | 0.930 | 0.930 | 57.53 | 57.53 | 0.975 | 0.975 | 56.09 | 56.09 | 0.224 | 1.122 |
| 06-Sep | 428.23 | 2415.75 | 425.23 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 365.23 | 790.47 | 2304.41 | 111.3 | 6.000 | 6.000 | 105.3 | 105.3 | 0.930 | 0.930 | 57.54 | 57.54 | 0.975 | 0.975 | 56.10 | 56.10 | 0.224 | 1.122 |
| 07-Sep | 415.61 | 2415.70 | 412.61 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 352.61 | 765.22 | 2304.36 | 111.3 | 6.000 | 6.000 | 105.3 | 105.3 | 0.930 | 0.930 | 57.55 | 57.55 | 0.975 | 0.975 | 56.11 | 56.11 | 0.224 | 1.122 |
| 08-Sep | 404.69 | 2415.66 | 401.69 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 341.69 | 743.38 | 2304.31 | 111.4 | 6.000 | 6.000 | 105.4 | 105.4 | 0.930 | 0.930 | 57.55 | 57.55 | 0.975 | 0.975 | 56.11 | 56.11 | 0.224 | 1.122 |
| 09-Sep | 390.08 | 2415.60 | 387.08 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 327.08 | 714.16 | 2304.24 | 111.4 | 6.000 | 6.000 | 105.4 | 105.4 | 0.930 | 0.930 | 57.56 | 57.56 | 0.975 | 0.975 | 56.12 | 56.12 | 0.224 | 1.122 |
| 10-Sep | 380.13 | 2415.56 | 377.13 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 317.13 | 694.27 | 2304.19 | 111.4 | 6.000 | 6.000 | 105.4 | 105.4 | 0.930 | 0.930 | 57.56 | 57.56 | 0.975 | 0.975 | 56.12 | 56.12 | 0.224 | 1.122 |
| 11-Sep | 369.24 | 2415.52 | 366.24 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 306.24 | 672.48 | 2304.14 | 111.4 | 6.000 | 6.000 | 105.4 | 105.4 | 0.930 | 0.930 | 57.57 | 57.57 | 0.975 | 0.975 | 56.13 | 56.13 | 0.225 | 1.123 |
| 12-Sep | 361.17 | 2415.49 | 358.17 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 298.17 | 656.34 | 2304.10 | 111.4 | 6.000 | 6.000 | 105.4 | 105.4 | 0.930 | 0.930 | 57.57 | 57.57 | 0.975 | 0.975 | 56.14 | 56.14 | 0.225 | 1.123 |
| 13-Sep | 353.60 | 2415.46 | 350.60 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 290.60 | 641.19 | 2304.06 | 111.4 | 6.000 | 6.000 | 105.4 | 105.4 | 0.930 | 0.930 | 57.58 | 57.58 | 0.975 | 0.975 | 56.14 | 56.14 | 0.225 | 1.123 |
| 14-Sep | 340.02 | 2415.40 | 337.02 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 277.02 | 614.05 | 2303.99 | 111.4 | 6.000 | 6.000 | 105.4 | 105.4 | 0.930 | 0.930 | 57.59 | 57.59 | 0.975 | 0.975 | 56.15 | 56.15 | 0.225 | 1.123 |
| 15-Sep | 327.78 | 2415.36 | 324.78 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 264.78 | 589.56 | 2303.93 | 111.4 | 6.000 | 6.000 | 105.4 | 105.4 | 0.930 | 0.930 | 57.59 | 57.59 | 0.975 | 0.975 | 56.15 | 56.15 | 0.225 | 1.123 |
| 16-Sep | 313.17 | 2415.29 | 310.17 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 250.17 | 560.33 | 2303.85 | 111.4 | 6.000 | 6.000 | 105.4 | 105.4 | 0.930 | 0.930 | 57.60 | 57.60 | 0.975 | 0.975 | 56.16 | 56.16 | 0.225 | 1.123 |
| 17-Sep | 299.12 | 2415.24 | 296.12 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 236.12 | 532.23 | 2303.77 | 111.5 | 6.000 | 6.000 | 105.5 | 105.5 | 0.930 | 0.930 | 57.61 | 57.61 | 0.975 | 0.975 | 56.17 | 56.17 | 0.225 | 1.123 |
| 18-Sep | 282.21 | 2415.16 | 279.21 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 219.21 | 498.43 | 2303.68 | 111.5 | 6.000 | 6.000 | 105.5 | 105.5 | 0.930 | 0.930 | 57.63 | 57.63 | 0.975 | 0.975 | 56.18 | 56.18 | 0.225 | 1.124 |
| 19-Sep | 269.78 | 2415.11 | 266.78 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 206.78 | 473.56 | 2303.61 | 111.5 | 6.000 | 6.000 | 105.5 | 105.5 | 0.930 | 0.930 | 57.63 | 57.63 | 0.975 | 0.975 | 56.19 | 56.19 | 0.225 | 1.124 |
| 20-Sep | 261.51 | 2415.08 | 258.51 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 198.51 | 457.02 | 2303.56 | 111.5 | 6.000 | 6.000 | 105.5 | 105.5 | 0.930 | 0.930 | 57.64 | 57.64 | 0.975 | 0.975 | 56.20 | 56.20 | 0.225 | 1.124 |
| 21-Sep | 248.62 | 2415.02 | 245.62 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 185.62 | 431.25 | 2303.49 | 111.5 | 6.000 | 6.000 | 105.5 | 105.5 | 0.930 | 0.930 | 57.65 | 57.65 | 0.975 | 0.975 | 56.21 | 56.21 | 0.225 | 1.124 |
| 22-Sep | 235.32 | 2414.96 | 232.32 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 172.32 | 404.64 | 2303.41 | 111.6 | 6.000 | 6.000 | 105.6 | 105.6 | 0.930 | 0.930 | 57.66 | 57.66 | 0.975 | 0.975 | 56.22 | 56.22 | 0.225 | 1.124 |
| 23-Sep | 225.05 | 2414.91 | 222.05 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 162.05 | 384.11 | 2303.35 | 111.6 | 6.000 | 6.000 | 105.6 | 105.6 | 0.930 | 0.930 | 57.67 | 57.67 | 0.975 | 0.975 | 56.23 | 56.23 | 0.225 | 1.125 |
| 24-Sep | 216.61 | 2414.88 | 213.61 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 153.61 | 367.23 | 2303.29 | 111.6 | 6.000 | 6.000 | 105.6 | 105.6 | 0.930 | 0.930 | 57.68 | 57.68 | 0.975 | 0.975 | 56.24 | 56.24 | 0.225 | 1.125 |
| 25-Sep | 206.93 | 2414.83 | 203.93 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 143.93 | 347.87 | 2303.23 | 111.6 | 6.000 | 6.000 | 105.6 | 105.6 | 0.930 | 0.930 | 57.69 | 57.69 | 0.975 | 0.975 | 56.25 | 56.25 | 0.225 | 1.125 |
| 26-Sep | 196.79 | 2414.79 | 193.79 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 133.79 | 327.57 | 2303.17 | 111.6 | 6.000 | 6.000 | 105.6 | 105.6 | 0.930 | 0.930 | 57.70 | 57.70 | 0.975 | 0.975 | 56.25 | 56.25 | 0.225 | 1.125 |
| 27-Sep | 189.26 | 2414.75 | 186.26 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 126.26 | 312.53 | 2303.12 | 111.6 | 6.000 | 6.000 | 105.6 | 105.6 | 0.930 | 0.930 | 57.70 | 57.70 | 0.975 | 0.975 | 56.26 | 56.26 | 0.225 | 1.125 |
| 28-Sep | 181.50 | 2414.71 | 178.50 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 118.50 | 296.99 | 2303.07 | 111.6 | 6.000 | 6.000 | 105.6 | 105.6 | 0.930 | 0.930 | 57.71 | 57.71 | 0.975 | 0.975 | 56.27 | 56.27 | 0.225 | 1.125 |




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| Day | River Flows at Weir (cumecs) | Head Water Level (m) | Flows less Ecological Flows (cumecs) | Plant Peak Discharge (cumecs) | Plant Off-Peak Discharge (cumecs) | No. of Turbines in Operation for Peaking | No. of Turbines in Operation for Off-Peaking | Discharge Per Turbine of Peaking Plant (cumecs) | Discharge Per Turbine of Peaking Plant (cumecs) | Spilled Discharge (cumecs) | Hunza River Flows at PH (cumecs) | TWL (masl) | Gross Head (m) | Head Loss Peaking Plant (m) | Head Loss Off-Peaking Plant (m) | Net Head Peaking Plant (m) | Net Head Off-Peaking Plant (m) | Turb Eff. For Peaking Turbines | Turb Eff. For Peaking Turbines | Peaking Turbines Output (MW) | Off-Peaking Turbines Output (MW) | Peaking Generator Efficiency | Off-Peaking Generator Efficiency | Peaking Generators Output (MW) | Off-Peaking Generators Output (MW) | Peaking Plant Energy at Generator Terminal (GWh) | Off-Peaking Plant Energy at Generator Terminal (GWh) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 29-Sep | 174.93 | 2414.68 | 171.93 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 111.93 | 283.86 | 2303.03 | 111.7 | 6.000 | 6.000 | 105.7 | 105.7 | 0.930 | 0.930 | 57.72 | 57.72 | 0.975 | 0.975 | 56.28 | 56.28 | 0.225 | 1.126 |
| 30-Sep | 169.48 | 2414.66 | 166.48 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 106.48 | 272.96 | 2302.99 | 111.7 | 6.000 | 6.000 | 105.7 | 105.7 | 0.930 | 0.930 | 57.72 | 57.72 | 0.975 | 0.975 | 56.28 | 56.28 | 0.225 | 1.126 |
| 01-Oct | 163.54 | 2414.63 | 160.54 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 100.54 | 261.07 | 2302.95 | 111.7 | 6.000 | 6.000 | 105.7 | 105.7 | 0.930 | 0.930 | 57.73 | 57.73 | 0.975 | 0.975 | 56.29 | 56.29 | 0.225 | 1.126 |
| 02-Oct | 157.52 | 2414.60 | 154.52 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 94.52 | 249.04 | 2302.91 | 111.7 | 6.000 | 6.000 | 105.7 | 105.7 | 0.930 | 0.930 | 57.74 | 57.74 | 0.975 | 0.975 | 56.29 | 56.29 | 0.225 | 1.126 |
| 03-Oct | 152.27 | 2414.58 | 149.27 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 89.27 | 238.54 | 2302.88 | 111.7 | 6.000 | 6.000 | 105.7 | 105.7 | 0.930 | 0.930 | 57.74 | 57.74 | 0.975 | 0.975 | 56.30 | 56.30 | 0.225 | 1.126 |
| 04-Oct | 146.89 | 2414.55 | 143.89 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 83.89 | 227.77 | 2302.84 | 111.7 | 6.000 | 6.000 | 105.7 | 105.7 | 0.930 | 0.930 | 57.75 | 57.75 | 0.975 | 0.975 | 56.30 | 56.30 | 0.225 | 1.126 |
| 05-Oct | 141.89 | 2414.53 | 138.89 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 78.89 | 217.78 | 2302.81 | 111.7 | 6.000 | 6.000 | 105.7 | 105.7 | 0.930 | 0.930 | 57.75 | 57.75 | 0.975 | 0.975 | 56.31 | 56.31 | 0.225 | 1.126 |
| 06-Oct | 137.84 | 2414.51 | 134.84 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 74.84 | 209.68 | 2302.78 | 111.7 | 6.000 | 6.000 | 105.7 | 105.7 | 0.930 | 0.930 | 57.76 | 57.76 | 0.975 | 0.975 | 56.31 | 56.31 | 0.225 | 1.126 |
| 07-Oct | 132.51 | 2414.48 | 129.51 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 69.51 | 199.02 | 2302.74 | 111.7 | 6.000 | 6.000 | 105.7 | 105.7 | 0.930 | 0.930 | 57.76 | 57.76 | 0.975 | 0.975 | 56.32 | 56.32 | 0.225 | 1.126 |
| 08-Oct | 127.83 | 2414.46 | 124.83 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 64.83 | 189.66 | 2302.71 | 111.7 | 6.000 | 6.000 | 105.7 | 105.7 | 0.930 | 0.930 | 57.77 | 57.77 | 0.975 | 0.975 | 56.33 | 56.33 | 0.225 | 1.127 |
| 09-Oct | 123.23 | 2414.44 | 120.23 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 60.23 | 180.46 | 2302.68 | 111.8 | 6.000 | 6.000 | 105.8 | 105.8 | 0.930 | 0.930 | 57.77 | 57.77 | 0.975 | 0.975 | 56.33 | 56.33 | 0.225 | 1.127 |
| 10-Oct | 118.75 | 2414.41 | 115.75 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 55.75 | 171.51 | 2302.65 | 111.8 | 6.000 | 6.000 | 105.8 | 105.8 | 0.930 | 0.930 | 57.78 | 57.78 | 0.975 | 0.975 | 56.34 | 56.34 | 0.225 | 1.127 |
| 11-Oct | 115.50 | 2414.40 | 112.50 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 52.50 | 164.99 | 2302.62 | 111.8 | 6.000 | 6.000 | 105.8 | 105.8 | 0.930 | 0.930 | 57.78 | 57.78 | 0.975 | 0.975 | 56.34 | 56.34 | 0.225 | 1.127 |
| 12-Oct | 111.50 | 2414.38 | 108.50 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 48.50 | 157.00 | 2302.59 | 111.8 | 6.000 | 6.000 | 105.8 | 105.8 | 0.930 | 0.930 | 57.79 | 57.79 | 0.975 | 0.975 | 56.34 | 56.34 | 0.225 | 1.127 |
| 13-Oct | 108.09 | 2414.36 | 105.09 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 45.09 | 150.17 | 2302.57 | 111.8 | 6.000 | 6.000 | 105.8 | 105.8 | 0.930 | 0.930 | 57.79 | 57.79 | 0.975 | 0.975 | 56.35 | 56.35 | 0.225 | 1.127 |
| 14-Oct | 104.39 | 2414.34 | 101.39 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 41.39 | 142.78 | 2302.54 | 111.8 | 6.000 | 6.000 | 105.8 | 105.8 | 0.930 | 0.930 | 57.80 | 57.80 | 0.975 | 0.975 | 56.35 | 56.35 | 0.225 | 1.127 |
| 15-Oct | 101.55 | 2414.33 | 98.55 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 38.55 | 137.10 | 2302.52 | 111.8 | 6.000 | 6.000 | 105.8 | 105.8 | 0.930 | 0.930 | 57.80 | 57.80 | 0.975 | 0.975 | 56.36 | 56.36 | 0.225 | 1.127 |
| 16-Oct | 98.45 | 2414.31 | 95.45 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 35.45 | 130.89 | 2302.50 | 111.8 | 6.000 | 6.000 | 105.8 | 105.8 | 0.930 | 0.930 | 57.80 | 57.80 | 0.975 | 0.975 | 56.36 | 56.36 | 0.225 | 1.127 |
| 17-Oct | 95.07 | 2414.30 | 92.07 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 32.07 | 124.14 | 2302.47 | 111.8 | 6.000 | 6.000 | 105.8 | 105.8 | 0.930 | 0.930 | 57.81 | 57.81 | 0.975 | 0.975 | 56.36 | 56.36 | 0.225 | 1.127 |
| 18-Oct | 92.62 | 2414.28 | 89.62 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 29.62 | 119.23 | 2302.46 | 111.8 | 6.000 | 6.000 | 105.8 | 105.8 | 0.930 | 0.930 | 57.81 | 57.81 | 0.975 | 0.975 | 56.37 | 56.37 | 0.225 | 1.127 |
| 19-Oct | 89.95 | 2414.27 | 86.95 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 26.95 | 113.90 | 2302.44 | 111.8 | 6.000 | 6.000 | 105.8 | 105.8 | 0.930 | 0.930 | 57.82 | 57.82 | 0.975 | 0.975 | 56.37 | 56.37 | 0.225 | 1.127 |
| 20-Oct | 88.06 | 2414.26 | 85.06 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 25.06 | 110.11 | 2302.42 | 111.8 | 6.000 | 6.000 | 105.8 | 105.8 | 0.930 | 0.930 | 57.82 | 57.82 | 0.975 | 0.975 | 56.37 | 56.37 | 0.225 | 1.127 |
| 21-Oct | 85.42 | 2414.25 | 82.42 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 22.42 | 104.83 | 2302.40 | 111.8 | 6.000 | 6.000 | 105.8 | 105.8 | 0.930 | 0.930 | 57.82 | 57.82 | 0.975 | 0.975 | 56.38 | 56.38 | 0.226 | 1.128 |
| 22-Oct | 82.99 | 2414.23 | 79.99 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 19.99 | 99.99 | 2302.39 | 111.8 | 6.000 | 6.000 | 105.8 | 105.8 | 0.930 | 0.930 | 57.82 | 57.82 | 0.975 | 0.975 | 56.38 | 56.38 | 0.226 | 1.128 |
| 23-Oct | 80.99 | 2414.22 | 77.99 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 17.99 | 95.97 | 2302.37 | 111.9 | 6.000 | 6.000 | 105.9 | 105.9 | 0.930 | 0.930 | 57.83 | 57.83 | 0.975 | 0.975 | 56.38 | 56.38 | 0.226 | 1.128 |
| 24-Oct | 79.17 | 2414.21 | 76.17 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 16.17 | 92.33 | 2302.36 | 111.9 | 6.000 | 6.000 | 105.9 | 105.9 | 0.930 | 0.930 | 57.83 | 57.83 | 0.975 | 0.975 | 56.38 | 56.38 | 0.226 | 1.128 |
| 25-Oct | 77.26 | 2414.21 | 74.26 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 14.26 | 88.52 | 2302.34 | 111.9 | 6.000 | 6.000 | 105.9 | 105.9 | 0.930 | 0.930 | 57.83 | 57.83 | 0.975 | 0.975 | 56.39 | 56.39 | 0.226 | 1.128 |
| 26-Oct | 75.66 | 2414.20 | 72.66 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 12.66 | 85.32 | 2302.33 | 111.9 | 6.000 | 6.000 | 105.9 | 105.9 | 0.930 | 0.930 | 57.83 | 57.83 | 0.975 | 0.975 | 56.39 | 56.39 | 0.226 | 1.128 |
| 27-Oct | 73.66 | 2414.19 | 70.66 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 10.66 | 81.33 | 2302.32 | 111.9 | 6.000 | 6.000 | 105.9 | 105.9 | 0.930 | 0.930 | 57.84 | 57.84 | 0.975 | 0.975 | 56.39 | 56.39 | 0.226 | 1.128 |
| 28-Oct | 72.72 | 2414.18 | 69.72 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 9.72 | 79.44 | 2302.31 | 111.9 | 6.000 | 6.000 | 105.9 | 105.9 | 0.930 | 0.930 | 57.84 | 57.84 | 0.975 | 0.975 | 56.39 | 56.39 | 0.226 | 1.128 |
| 29-Oct | 71.30 | 2414.17 | 68.30 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 8.30 | 76.61 | 2302.30 | 111.9 | 6.000 | 6.000 | 105.9 | 105.9 | 0.930 | 0.930 | 57.84 | 57.84 | 0.975 | 0.975 | 56.39 | 56.39 | 0.226 | 1.128 |
| 30-Oct | 70.05 | 2414.17 | 67.05 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 7.05 | 74.10 | 2302.29 | 111.9 | 6.000 | 6.000 | 105.9 | 105.9 | 0.930 | 0.930 | 57.84 | 57.84 | 0.975 | 0.975 | 56.40 | 56.40 | 0.226 | 1.128 |
| 31-Oct | 68.76 | 2414.16 | 65.76 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 5.76 | 71.53 | 2302.28 | 111.9 | 6.000 | 6.000 | 105.9 | 105.9 | 0.930 | 0.930 | 57.84 | 57.84 | 0.975 | 0.975 | 56.40 | 56.40 | 0.226 | 1.128 |
| 01-Nov | 67.37 | 2414.15 | 64.37 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 4.37 | 68.75 | 2302.27 | 111.9 | 6.000 | 6.000 | 105.9 | 105.9 | 0.930 | 0.930 | 57.85 | 57.85 | 0.975 | 0.975 | 56.40 | 56.40 | 0.226 | 1.128 |
| 02-Nov | 66.40 | 2414.15 | 63.40 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 3.40 | 66.81 | 2302.26 | 111.9 | 6.000 | 6.000 | 105.9 | 105.9 | 0.930 | 0.930 | 57.85 | 57.85 | 0.975 | 0.975 | 56.40 | 56.40 | 0.226 | 1.128 |
| 03-Nov | 65.82 | 2414.15 | 62.82 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 2.82 | 65.64 | 2302.26 | 111.9 | 6.000 | 6.000 | 105.9 | 105.9 | 0.930 | 0.930 | 57.85 | 57.85 | 0.975 | 0.975 | 56.40 | 56.40 | 0.226 | 1.128 |
| 04-Nov | 64.61 | 2414.14 | 61.61 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 1.61 | 63.22 | 2302.25 | 111.9 | 6.000 | 6.000 | 105.9 | 105.9 | 0.930 | 0.930 | 57.85 | 57.85 | 0.975 | 0.975 | 56.40 | 56.40 | 0.226 | 1.128 |
| 05-Nov | 63.35 | 2414.13 | 60.35 | 60.00 | 60.00 | 3 | 3 | 20.0 | 20.0 | 0.35 | 60.70 | 2302.24 | 111.9 | 6.000 | 6.000 | 105.9 | 105.9 | 0.930 | 0.930 | 57.85 | 57.85 | 0.975 | 0.975 | 56.40 | 56.40 | 0.226 | 1.128 |
| 06-Nov | 62.30 | 2414.13 | 59.30 | 60.00 | 49.30 | 3 | 3 | 20.0 | 16.4 | 0.00 | 59.30 | 2302.23 | 111.9 | 6.000 | 4.051 | 105.9 | 107.8 | 0.930 | 0.918 | 57.85 | 47.80 | 0.975 | 0.974 | 56.40 | 46.55 | 0.226 | 0.931 |



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| Day | River Flows at Weir (cumecs) | Head Water Level (m) | Flows less Ecological Flows (cumecs) | Plant Peak Discharge (cumecs) | Plant Off-Peak Discharge (cumecs) | No. of Turbines in Operation for Peaking | No. of Turbines in Operation for Off-Peaking | Discharge Per Turbine of Peaking Plant (cumecs) | Discharge Per Turbine of Peaking Plant (cumecs) | Spilled Discharge (cumecs) | Hunza River Flows at PH (cumecs) | TWL (masl) | Gross Head (m) | Head Loss Peaking Plant (m) | Head Loss Off-Peaking Plant (m) | Net Head Peaking Plant (m) | Net Head Off-Peaking Plant (m) | Turb Eff. For Peaking Turbines | Turb Eff. For Peaking Turbines | Peaking Turbines Output (MW) | Off-Peaking Turbines Output (MW) | Peaking Generator Efficiency | Off-Peaking Generator Efficiency | Peaking Generators Output (MW) | Off-Peaking Generators Output (MW) | Peaking Plant Energy at Generator Terminal (GWh) | Off-Peaking Plant Energy at Generator Terminal (GWh) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 07-Nov | 61.45 | 2414.12 | 58.45 | 60.00 | 48.45 | 3 | 3 | 20.0 | 16.2 | 0.00 | 58.45 | 2302.23 | 111.9 | 6.000 | 3.913 | 105.9 | 108.0 | 0.930 | 0.917 | 57.85 | 46.95 | 0.975 | 0.974 | 56.40 | 45.72 | 0.226 | 0.914 |
| 08-Nov | 60.40 | 2414.12 | 57.40 | 60.00 | 47.40 | 3 | 3 | 20.0 | 15.8 | 0.00 | 57.40 | 2302.22 | 111.9 | 6.000 | 3.744 | 105.9 | 108.1 | 0.930 | 0.913 | 57.85 | 45.84 | 0.975 | 0.973 | 56.40 | 44.63 | 0.226 | 0.893 |
| 09-Nov | 59.65 | 2414.11 | 56.65 | 60.00 | 46.65 | 3 | 3 | 20.0 | 15.6 | 0.00 | 56.65 | 2302.22 | 111.9 | 6.000 | 3.627 | 105.9 | 108.3 | 0.930 | 0.911 | 57.85 | 45.03 | 0.975 | 0.973 | 56.40 | 43.82 | 0.226 | 0.876 |
| 10-Nov | 58.64 | 2414.11 | 55.64 | 60.00 | 45.64 | 3 | 3 | 20.0 | 15.2 | 0.00 | 55.64 | 2302.22 | 111.9 | 6.000 | 3.471 | 105.9 | 108.4 | 0.930 | 0.907 | 57.85 | 43.92 | 0.975 | 0.973 | 56.40 | 42.72 | 0.226 | 0.854 |
| 11-Nov | 57.70 | 2414.10 | 54.70 | 60.00 | 44.70 | 3 | 3 | 20.0 | 14.9 | 0.00 | 54.70 | 2302.21 | 111.9 | 6.000 | 3.330 | 105.9 | 108.6 | 0.930 | 0.903 | 57.85 | 42.90 | 0.975 | 0.972 | 56.40 | 41.71 | 0.226 | 0.834 |
| 12-Nov | 56.82 | 2414.10 | 53.82 | 60.00 | 43.82 | 3 | 3 | 20.0 | 14.6 | 0.00 | 53.82 | 2302.21 | 111.9 | 6.000 | 3.201 | 105.9 | 108.7 | 0.930 | 0.900 | 57.85 | 41.95 | 0.975 | 0.972 | 56.40 | 40.78 | 0.226 | 0.816 |
| 13-Nov | 56.23 | 2414.10 | 53.23 | 60.00 | 43.23 | 3 | 3 | 20.0 | 14.4 | 0.00 | 53.23 | 2302.21 | 111.9 | 6.000 | 3.115 | 105.9 | 108.8 | 0.930 | 0.897 | 57.85 | 41.32 | 0.975 | 0.972 | 56.40 | 40.15 | 0.226 | 0.803 |
| 14-Nov | 55.58 | 2414.09 | 52.58 | 60.00 | 42.58 | 3 | 3 | 20.0 | 14.2 | 0.00 | 52.58 | 2302.21 | 111.9 | 6.000 | 3.021 | 105.9 | 108.9 | 0.930 | 0.895 | 57.85 | 40.61 | 0.975 | 0.971 | 56.40 | 39.45 | 0.226 | 0.789 |
| 15-Nov | 54.96 | 2414.09 | 51.96 | 60.00 | 41.96 | 3 | 3 | 20.0 | 14.0 | 0.00 | 51.96 | 2302.20 | 111.9 | 6.000 | 2.935 | 105.9 | 109.0 | 0.930 | 0.892 | 57.85 | 39.94 | 0.975 | 0.971 | 56.40 | 38.79 | 0.226 | 0.776 |
| 16-Nov | 54.21 | 2414.09 | 51.21 | 60.00 | 41.21 | 3 | 3 | 20.0 | 13.7 | 0.00 | 51.21 | 2302.20 | 111.9 | 6.000 | 2.831 | 105.9 | 109.1 | 0.930 | 0.887 | 57.84 | 39.04 | 0.975 | 0.971 | 56.40 | 37.90 | 0.226 | 0.758 |
| 17-Nov | 53.56 | 2414.08 | 50.56 | 60.00 | 40.56 | 3 | 3 | 20.0 | 13.5 | 0.00 | 50.56 | 2302.20 | 111.9 | 6.000 | 2.742 | 105.9 | 109.1 | 0.930 | 0.883 | 57.84 | 38.27 | 0.975 | 0.970 | 56.40 | 37.13 | 0.226 | 0.743 |
| 18-Nov | 53.03 | 2414.08 | 50.03 | 60.00 | 40.03 | 3 | 3 | 20.0 | 13.3 | 0.00 | 50.03 | 2302.20 | 111.9 | 6.000 | 2.671 | 105.9 | 109.2 | 0.930 | 0.879 | 57.84 | 37.64 | 0.975 | 0.970 | 56.40 | 36.51 | 0.226 | 0.730 |
| 19-Nov | 52.20 | 2414.08 | 49.20 | 60.00 | 39.20 | 3 | 2 | 20.0 | 19.6 | 0.00 | 49.20 | 2302.19 | 111.9 | 6.000 | 2.561 | 105.9 | 109.3 | 0.930 | 0.929 | 57.84 | 38.60 | 0.975 | 0.975 | 56.40 | 37.60 | 0.226 | 0.752 |
| 20-Nov | 51.62 | 2414.07 | 48.62 | 60.00 | 38.62 | 3 | 2 | 20.0 | 19.3 | 0.00 | 48.62 | 2302.19 | 111.9 | 6.000 | 2.486 | 105.9 | 109.4 | 0.930 | 0.929 | 57.84 | 38.43 | 0.975 | 0.975 | 56.40 | 37.47 | 0.226 | 0.749 |
| 21-Nov | 51.23 | 2414.07 | 48.23 | 60.00 | 38.23 | 3 | 2 | 20.0 | 19.1 | 0.00 | 48.23 | 2302.19 | 111.9 | 6.000 | 2.436 | 105.9 | 109.4 | 0.930 | 0.929 | 57.84 | 38.04 | 0.975 | 0.975 | 56.40 | 37.09 | 0.226 | 0.742 |
| 22-Nov | 50.59 | 2414.07 | 47.59 | 60.00 | 37.59 | 3 | 2 | 20.0 | 18.8 | 0.00 | 47.59 | 2302.19 | 111.9 | 6.000 | 2.355 | 105.9 | 109.5 | 0.930 | 0.928 | 57.84 | 37.42 | 0.975 | 0.975 | 56.40 | 36.48 | 0.226 | 0.730 |
| 23-Nov | 50.04 | 2414.07 | 47.04 | 60.00 | 37.04 | 3 | 2 | 20.0 | 18.5 | 0.00 | 47.04 | 2302.18 | 111.9 | 6.000 | 2.287 | 105.9 | 109.6 | 0.930 | 0.928 | 57.84 | 36.87 | 0.975 | 0.975 | 56.40 | 35.95 | 0.226 | 0.719 |
| 24-Nov | 49.50 | 2414.06 | 46.50 | 60.00 | 36.50 | 3 | 2 | 20.0 | 18.2 | 0.00 | 46.50 | 2302.18 | 111.9 | 6.000 | 2.220 | 105.9 | 109.7 | 0.930 | 0.927 | 57.84 | 36.34 | 0.975 | 0.975 | 56.40 | 35.42 | 0.226 | 0.708 |
| 25-Nov | 48.99 | 2414.06 | 45.99 | 60.00 | 35.99 | 3 | 2 | 20.0 | 18.0 | 0.00 | 45.99 | 2302.18 | 111.9 | 6.000 | 2.159 | 105.9 | 109.7 | 0.930 | 0.927 | 57.84 | 35.84 | 0.975 | 0.975 | 56.39 | 34.94 | 0.226 | 0.699 |
| 26-Nov | 48.44 | 2414.06 | 45.44 | 60.00 | 35.44 | 3 | 2 | 20.0 | 17.7 | 0.00 | 45.44 | 2302.18 | 111.9 | 6.000 | 2.094 | 105.9 | 109.8 | 0.930 | 0.925 | 57.84 | 35.25 | 0.975 | 0.975 | 56.39 | 34.37 | 0.226 | 0.687 |
| 27-Nov | 47.86 | 2414.05 | 44.86 | 60.00 | 34.86 | 3 | 2 | 20.0 | 17.4 | 0.00 | 44.86 | 2302.18 | 111.9 | 6.000 | 2.025 | 105.9 | 109.9 | 0.930 | 0.924 | 57.84 | 34.63 | 0.975 | 0.975 | 56.39 | 33.76 | 0.226 | 0.675 |
| 28-Nov | 47.28 | 2414.05 | 44.28 | 60.00 | 34.28 | 3 | 2 | 20.0 | 17.1 | 0.00 | 44.28 | 2302.17 | 111.9 | 6.000 | 1.959 | 105.9 | 109.9 | 0.930 | 0.922 | 57.84 | 34.02 | 0.975 | 0.975 | 56.39 | 33.16 | 0.226 | 0.663 |
| 29-Nov | 46.71 | 2414.05 | 43.71 | 60.00 | 33.71 | 3 | 2 | 20.0 | 16.9 | 0.00 | 43.71 | 2302.17 | 111.9 | 6.000 | 1.894 | 105.9 | 110.0 | 0.930 | 0.921 | 57.84 | 33.42 | 0.975 | 0.974 | 56.39 | 32.56 | 0.226 | 0.651 |
| 30-Nov | 46.22 | 2414.05 | 43.22 | 60.00 | 33.22 | 3 | 2 | 20.0 | 16.6 | 0.00 | 43.22 | 2302.17 | 111.9 | 6.000 | 1.839 | 105.9 | 110.0 | 0.930 | 0.919 | 57.84 | 32.89 | 0.975 | 0.974 | 56.39 | 32.05 | 0.226 | 0.641 |
| 01-Dec | 45.87 | 2414.04 | 42.87 | 60.00 | 32.87 | 3 | 2 | 20.0 | 16.4 | 0.00 | 42.87 | 2302.17 | 111.9 | 6.000 | 1.800 | 105.9 | 110.1 | 0.930 | 0.918 | 57.84 | 32.52 | 0.975 | 0.974 | 56.39 | 31.68 | 0.226 | 0.634 |
| 02-Dec | 45.42 | 2414.04 | 42.42 | 60.00 | 32.42 | 3 | 2 | 20.0 | 16.2 | 0.00 | 42.42 | 2302.17 | 111.9 | 6.000 | 1.752 | 105.9 | 110.1 | 0.930 | 0.917 | 57.84 | 32.05 | 0.975 | 0.974 | 56.39 | 31.22 | 0.226 | 0.624 |
| 03-Dec | 44.89 | 2414.04 | 41.89 | 60.00 | 31.89 | 3 | 2 | 20.0 | 15.9 | 0.00 | 41.89 | 2302.16 | 111.9 | 6.000 | 1.695 | 105.9 | 110.2 | 0.930 | 0.915 | 57.84 | 31.49 | 0.975 | 0.974 | 56.39 | 30.66 | 0.226 | 0.613 |
| 04-Dec | 44.45 | 2414.04 | 41.45 | 60.00 | 31.45 | 3 | 2 | 20.0 | 15.7 | 0.00 | 41.45 | 2302.16 | 111.9 | 6.000 | 1.648 | 105.9 | 110.2 | 0.930 | 0.913 | 57.84 | 30.97 | 0.975 | 0.974 | 56.39 | 30.15 | 0.226 | 0.603 |
| 05-Dec | 44.10 | 2414.03 | 41.10 | 60.00 | 31.10 | 3 | 2 | 20.0 | 15.5 | 0.00 | 41.10 | 2302.16 | 111.9 | 6.000 | 1.612 | 105.9 | 110.3 | 0.930 | 0.911 | 57.84 | 30.57 | 0.975 | 0.973 | 56.39 | 29.76 | 0.226 | 0.595 |
| 06-Dec | 43.71 | 2414.03 | 40.71 | 60.00 | 30.71 | 3 | 2 | 20.0 | 15.4 | 0.00 | 40.71 | 2302.16 | 111.9 | 6.000 | 1.572 | 105.9 | 110.3 | 0.930 | 0.908 | 57.84 | 30.13 | 0.975 | 0.973 | 56.39 | 29.32 | 0.226 | 0.586 |
| 07-Dec | 43.27 | 2414.03 | 40.27 | 60.00 | 30.27 | 3 | 2 | 20.0 | 15.1 | 0.00 | 40.27 | 2302.16 | 111.9 | 6.000 | 1.527 | 105.9 | 110.3 | 0.930 | 0.906 | 57.84 | 29.62 | 0.975 | 0.973 | 56.39 | 28.81 | 0.226 | 0.576 |
| 08-Dec | 42.94 | 2414.03 | 39.94 | 60.00 | 29.94 | 3 | 2 | 20.0 | 15.0 | 0.00 | 39.94 | 2302.16 | 111.9 | 6.000 | 1.494 | 105.9 | 110.4 | 0.930 | 0.904 | 57.84 | 29.24 | 0.975 | 0.973 | 56.39 | 28.44 | 0.226 | 0.569 |
| 09-Dec | 42.50 | 2414.03 | 39.50 | 60.00 | 29.50 | 3 | 2 | 20.0 | 14.8 | 0.00 | 39.50 | 2302.16 | 111.9 | 6.000 | 1.451 | 105.9 | 110.4 | 0.930 | 0.901 | 57.84 | 28.74 | 0.975 | 0.972 | 56.39 | 27.95 | 0.226 | 0.559 |
| 10-Dec | 42.24 | 2414.02 | 39.24 | 60.00 | 29.24 | 3 | 2 | 20.0 | 14.6 | 0.00 | 39.24 | 2302.15 | 111.9 | 6.000 | 1.425 | 105.9 | 110.4 | 0.930 | 0.900 | 57.84 | 28.44 | 0.975 | 0.972 | 56.39 | 27.65 | 0.226 | 0.553 |
| 11-Dec | 41.89 | 2414.02 | 38.89 | 60.00 | 28.89 | 3 | 2 | 20.0 | 14.4 | 0.00 | 38.89 | 2302.15 | 111.9 | 6.000 | 1.391 | 105.9 | 110.5 | 0.930 | 0.898 | 57.84 | 28.05 | 0.975 | 0.972 | 56.39 | 27.26 | 0.226 | 0.545 |
| 12-Dec | 41.46 | 2414.02 | 38.46 | 60.00 | 28.46 | 3 | 2 | 20.0 | 14.2 | 0.00 | 38.46 | 2302.15 | 111.9 | 6.000 | 1.350 | 105.9 | 110.5 | 0.930 | 0.895 | 57.84 | 27.57 | 0.975 | 0.972 | 56.39 | 26.79 | 0.226 | 0.536 |
| 13-Dec | 41.20 | 2414.02 | 38.20 | 60.00 | 28.20 | 3 | 2 | 20.0 | 14.1 | 0.00 | 38.20 | 2302.15 | 111.9 | 6.000 | 1.326 | 105.9 | 110.5 | 0.930 | 0.894 | 57.84 | 27.28 | 0.975 | 0.972 | 56.39 | 26.50 | 0.226 | 0.530 |
| 14-Dec | 40.89 | 2414.02 | 37.89 | 60.00 | 27.89 | 3 | 2 | 20.0 | 13.9 | 0.00 | 37.89 | 2302.15 | 111.9 | 6.000 | 1.297 | 105.9 | 110.6 | 0.930 | 0.891 | 57.84 | 26.92 | 0.975 | 0.971 | 56.39 | 26.15 | 0.226 | 0.523 |
| 15-Dec | 40.64 | 2414.02 | 37.64 | 60.00 | 27.64 | 3 | 2 | 20.0 | 13.8 | 0.00 | 37.64 | 2302.15 | 111.9 | 6.000 | 1.274 | 105.9 | 110.6 | 0.930 | 0.889 | 57.83 | 26.61 | 0.975 | 0.971 | 56.39 | 25.84 | 0.226 | 0.517 |




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| Day | River Flows at Weir (cumecs) | Head Water Level (m) | Flows less Ecological Flows (cumecs) | Plant Peak Discharge (cumecs) | Plant Off-Peak Discharge (cumecs) | No. of Turbines in Operation for Peaking | No. of Turbines in Operation for Off-Peaking | Discharge Per Turbine of Peaking Plant (cumecs) | Discharge Per Turbine of Peaking Plant (cumecs) | Spilled Discharge (cumecs) | Hunza River Flows at PH (cumecs) | TWL (masl) | Gross Head (m) | Head Loss Peaking Plant (m) | Head Loss Off-Peaking Plant (m) | Net Head Peaking Plant (m) | Net Head Off-Peaking Plant (m) | Turb Eff. For Peaking Turbines | Turb Eff. For Peaking Turbines | Peaking Turbines Output (MW) | Off-Peaking Turbines Output (MW) | Peaking Generator Efficiency | Off-Peaking Generator Efficiency | Peaking Generators Output (MW) | Off-Peaking Generators Output (MW) | Peaking Plant Energy at Generator Terminal (GWh) | Off-Peaking Plant Energy at Generator Terminal (GWh) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16-Dec | 40.53 | 2414.02 | 37.53 | 60.00 | 27.53 | 3 | 2 | 20.0 | 13.8 | 0.00 | 37.53 | 2302.15 | 111.9 | 6.000 | 1.263 | 105.9 | 110.6 | 0.930 | 0.888 | 57.83 | 26.47 | 0.975 | 0.971 | 56.39 | 25.70 | 0.226 | 0.514 |
| 17-Dec | 40.22 | 2414.01 | 37.22 | 60.00 | 27.22 | 3 | 2 | 20.0 | 13.6 | 0.00 | 37.22 | 2302.15 | 111.9 | 6.000 | 1.235 | 105.9 | 110.6 | 0.930 | 0.885 | 57.83 | 26.08 | 0.975 | 0.971 | 56.39 | 25.32 | 0.226 | 0.506 |
| 18-Dec | 40.05 | 2414.01 | 37.05 | 60.00 | 27.05 | 3 | 2 | 20.0 | 13.5 | 0.00 | 37.05 | 2302.15 | 111.9 | 6.000 | 1.220 | 105.9 | 110.6 | 0.930 | 0.883 | 57.83 | 25.88 | 0.975 | 0.971 | 56.39 | 25.12 | 0.226 | 0.502 |
| 19-Dec | 39.71 | 2414.01 | 36.71 | 60.00 | 26.71 | 3 | 2 | 20.0 | 13.4 | 0.00 | 36.71 | 2302.14 | 111.9 | 6.000 | 1.189 | 105.9 | 110.7 | 0.930 | 0.880 | 57.83 | 25.46 | 0.975 | 0.970 | 56.39 | 24.70 | 0.226 | 0.494 |
| 20-Dec | 39.28 | 2414.01 | 36.28 | 60.00 | 26.28 | 3 | 2 | 20.0 | 13.1 | 0.00 | 36.28 | 2302.14 | 111.9 | 6.000 | 1.151 | 105.9 | 110.7 | 0.930 | 0.875 | 57.83 | 24.93 | 0.975 | 0.970 | 56.39 | 24.18 | 0.226 | 0.484 |
| 21-Dec | 38.84 | 2414.01 | 35.84 | 60.00 | 25.84 | 3 | 2 | 20.0 | 12.9 | 0.00 | 35.84 | 2302.14 | 111.9 | 6.000 | 1.113 | 105.9 | 110.8 | 0.930 | 0.871 | 57.83 | 24.41 | 0.975 | 0.969 | 56.39 | 23.66 | 0.226 | 0.473 |
| 22-Dec | 38.52 | 2414.01 | 35.52 | 60.00 | 25.52 | 3 | 2 | 20.0 | 12.8 | 0.00 | 35.52 | 2302.14 | 111.9 | 6.000 | 1.085 | 105.9 | 110.8 | 0.930 | 0.868 | 57.83 | 24.01 | 0.975 | 0.969 | 56.39 | 23.27 | 0.226 | 0.465 |
| 23-Dec | 38.29 | 2414.00 | 35.29 | 60.00 | 25.29 | 3 | 2 | 20.0 | 12.6 | 0.00 | 35.29 | 2302.14 | 111.9 | 6.000 | 1.066 | 105.9 | 110.8 | 0.930 | 0.865 | 57.83 | 23.75 | 0.975 | 0.969 | 56.39 | 23.00 | 0.226 | 0.460 |
| 24-Dec | 38.04 | 2414.00 | 35.04 | 60.00 | 25.04 | 3 | 2 | 20.0 | 12.5 | 0.00 | 35.04 | 2302.14 | 111.9 | 6.000 | 1.045 | 105.9 | 110.8 | 0.930 | 0.863 | 57.83 | 23.44 | 0.975 | 0.969 | 56.39 | 22.70 | 0.226 | 0.454 |
| 25-Dec | 37.75 | 2414.00 | 34.75 | 60.00 | 24.75 | 3 | 2 | 20.0 | 12.4 | 0.00 | 34.75 | 2302.14 | 111.9 | 6.000 | 1.021 | 105.9 | 110.8 | 0.930 | 0.860 | 57.83 | 23.09 | 0.975 | 0.968 | 56.39 | 22.36 | 0.226 | 0.447 |
| 26-Dec | 37.46 | 2414.00 | 34.46 | 60.00 | 24.46 | 3 | 2 | 20.0 | 12.2 | 0.00 | 34.46 | 2302.14 | 111.9 | 6.000 | 0.997 | 105.9 | 110.9 | 0.930 | 0.857 | 57.83 | 22.75 | 0.975 | 0.968 | 56.39 | 22.02 | 0.226 | 0.440 |
| 27-Dec | 37.05 | 2414.00 | 34.05 | 60.00 | 24.05 | 3 | 2 | 20.0 | 12.0 | 0.00 | 34.05 | 2302.13 | 111.9 | 6.000 | 0.964 | 105.9 | 110.9 | 0.930 | 0.853 | 57.83 | 22.28 | 0.975 | 0.967 | 56.39 | 21.55 | 0.226 | 0.431 |
| 28-Dec | 36.75 | 2414.00 | 33.75 | 60.00 | 23.75 | 3 | 2 | 20.0 | 11.9 | 0.00 | 33.75 | 2302.13 | 111.9 | 6.000 | 0.940 | 105.9 | 110.9 | 0.930 | 0.849 | 57.83 | 21.89 | 0.975 | 0.967 | 56.39 | 21.17 | 0.226 | 0.423 |
| 29-Dec | 36.55 | 2413.99 | 33.55 | 60.00 | 23.55 | 3 | 2 | 20.0 | 11.8 | 0.00 | 33.55 | 2302.13 | 111.9 | 6.000 | 0.924 | 105.9 | 110.9 | 0.930 | 0.846 | 57.83 | 21.63 | 0.975 | 0.967 | 56.39 | 20.91 | 0.226 | 0.418 |
| 30-Dec | 36.25 | 2413.99 | 33.25 | 60.00 | 23.25 | 3 | 2 | 20.0 | 11.6 | 0.00 | 33.25 | 2302.13 | 111.9 | 6.000 | 0.901 | 105.9 | 111.0 | 0.930 | 0.841 | 57.83 | 21.24 | 0.975 | 0.966 | 56.39 | 20.53 | 0.226 | 0.411 |
| 31-Dec | 36.01 | 2413.99 | 33.01 | 60.00 | 23.01 | 3 | 2 | 20.0 | 11.5 | 0.00 | 33.01 | 2302.13 | 111.9 | 6.000 | 0.883 | 105.9 | 111.0 | 0.930 | 0.838 | 57.83 | 20.94 | 0.975 | 0.966 | 56.39 | 20.23 | 0.226 | 0.405 |
| **Note: Plant Auxiliary Load, Scheduled & Forced Outages are not considered** | | | | | | | | | | | | | | | | | | | | | | | | | | **82.392** | **294.764** |



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**Table 11.2: Comparison of FSR (2021) and Review Report Parameters**

| Description | Feasibility Study Report, 2021, Conducted by WAPDA | Review Report (AHMC) |
|---|---|---|
| Plant Design Discharge ($m^3/s$) | 60 | 60 |
| Gross Head (m) | 112 | 111.9 ~112 |
| Installed Capacity (MW) | 54 | 56.4 |
| Mean Annual Energy (GWh) | 373.69 | 377.16* |
| Plant Factor (%) | 79 | 76.3 |

*(Using mean of daily flow data for the years 1966 to 2015)

**Table 11.3 Comparison of FSR (2021) and FSR (2017) Parameters**

| Power and Energy Parameters | As in Feasibility Study 2017, Conducted through Consultants | As in Feasibility Study, 2021, Conducted by WAPDA |
|---|---|---|
| Design Discharge ($m^3/s$) | 40 | 60 |
| Gross Head (m) | 106 | 112 |
| Power Capacity (MW) | 32.5 | 54 |
| Mean Annual Energy (GWh) | 256.66 | 373.69 |
| Plant Factor (%) | 92.7 | 79 |

## 11.2 GOVERNOR SYSTEM

Feasibility study states compressed air charged bladder type pressure accumulator for governor pressure oil system, however as per present international practice, Nitrogen charged bladder type pressure accumulators are more frequently used for such purpose. Hence, we recommend to keep both the options open for the contractor.

## 11.3 INLET VALVE

Butterfly type valves to serve as shut off for turbines mentioned in the feasibility study report (FSR) are suitable regarding head, cost, maintenance and performance.

Under clause 11.13, the word “cast steel” written against sealing system need to be replaced with “Rubber seal / Stainless steel seat”.



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In clauses 9.11.2 & 15.8.11, spherical valves need to be replaced with butterfly valves.

## 11.4 MECHANICAL AUXILIARY SYSTEMS

Mechanical auxiliary systems play vital role in almost every hydropower plant for its successful operation. Some of the mechanical auxiliary systems mentioned in the feasibility study report have been rationalized / added which are specified in the subsequent paragraphs.

### 11.4.1 Cooling Water System

Feasibility study report is silent about the provision of cooling water system which is considered integral part of a hydropower plant mechanical auxiliary system. A cooling water system will be installed in the powerhouse to supply sufficient cooling water for:

- Generator oil coolers.
- Oil coolers of turbine and Generator bearings.
- Turbine shaft seal.
- Governor (if required).

An open loop cooling system shall be provided for Attabad Hydropower station. Cooling water shall be directly taken from each penstock branch and run through a Coarse - Duplex Strainer and connected to a common raw water header through isolating valves.

Each unit will be equipped with its own cooling water system, but these will be interconnected to facilitate maintenance of the system and the operation during part-load operation during the winter season.

Water for the shaft seal will be taken from the downstream side of the cooling water filter system, passed through a fine-filter and then transferred to the shaft seal for cooling.

### 11.4.2 Oil Handling System

In the feasibility study report, stationary type oil filtration plant (centralized oil purification / handling system) is provided for turbine oil system. We do not anticipate to have centralized oil handling system for such size of plants and recommend to eliminate it. Instead, mobile / portable oil purifier provided to filter / purify the lubricating / hydraulic oil is sufficient. We also recommend to use common grade of oil for the unit lubrication and governor pressurized oil system to facilitate the delivery of oil when replacement oil is required. Provision will be made to guard against water pollution resulting from accidental oil spills in the powerhouse.

### 11.4.3 Fire Protection System

In clause 11.14.11, feasibility study states: “Oil storage rooms shall also be provided with $CO^2$ filled cylinders with auto release system initiated by smoke and fire detectors installed in the room”. We do not agree to provide auto release $CO^2$ for oil storage area due to safety hazard for humans and recommend to replace it with automatic water spray system. Water spray system shall also be provided for cable gallery. Additionally, foam fire-extinguishers will be provided at strategic locations in the oil storage and cable gallery areas.

In table 11.4 of feasibility report serial number 2 & 3, fire protection system for GIS building and Penstock Valve House are mentioned whereas there is no GIS building and Penstock valve house in the project. This needs to be corrected.

NFPA 851, Recommended Practice for Fire Protection for Hydroelectric Generating Plants mentioned in the report has been merged with NFPA 850, Recommended Practice for Fire



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Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations. Hence NFPA 850 will be applied.

- **Fire Water Supply**

Overhead tank/s to fulfill water requirement as per NFPA-850 will be provided. The contractor shall submit overhead tank/s design along with proposal for its location for approval of the owner / owner's representative.

## 11.5 POWERHOUSE (PH) LAYOUT

Discrepancy regarding powerhouse dimensions is found, in clause 9.11.2 of Main Report Powerhouse dimensions are L-63 x W-20 x H-35 meters whereas in drawings the dimensions are L-45 x W-17.8 x H-22.5 meters (from foundation to crane corbel level).

After analyses of these dimensions, we recommend following changes / improvements:

- PH length (including loading/unloading bay) of 45m mentioned in the drawings should be increased to 52m. Unit center to center distance should be increased from 10m to 11m.
- Inner width of machine hall 14.5m should be increased to 15m, however total width of PH has to be increased from 17.8m to 29m excluding upstream and downstream walls for creating sufficient space to adjust auxiliary E&M equipment and other necessary areas in the PH.
- Machine hall floor level should be changed from 2306.2 m to 2308.0m, however other levels seem appropriate.
- In PH X-section drawing, the height of PH from foundation to crane corbel should be increased from 22.5m to 23.0m (revised corbel level will become 2322m). The height from crane corbel to roof inner level is not mentioned, however after consulting manufacturers' catalogues, we recommend that it should be at least 3.5m for EOT crane installation and availability of sufficient head space for its future maintenance. Inner roof level will be 2325.5m.
- The provision of draft tube stoplogs upstream of draft tube gates as shown in the powerhouse layout drawings are considered unnecessary.

## 11.6 PENSTOCK

Fewer details are provided in the feasibility study report regarding penstock. Certain shortcomings are also noted which are mentioned hereunder.

- Inconsistencies found with regards to penstock diameter and length in the main report and drawings which need correction.
- Material for steel penstock is missing. We recommend that material of penstock including branches and manifold shall be pressure vessel steel conforming to ASTM A516 Gr-70 or other equivalent international standard subject to approval of the owner or owner's representative. If thickness of any part of the penstock exceeds 38mm, normalized material shall be provided.
- Nothing is mentioned about length of each penstock branch, however diameter of 2.1m is specified which shall be rounded off to 2.0m. Each branch ends at connection with main inlet valve of 1.83m dia. via reducer.
- Sleeve type expansion joints are missing which shall be provided after each anchor block.



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- Hold down straps for exposed penstock are missing which shall be provided.

## 11.7 HYDRAULIC STEEL STRUCTURES

### 11.7.1 General

This section includes the function, performance criteria and certain shortcomings which are mentioned in the subsequent paragraphs. Fewer details are provided in the feasibility study report regarding gates, stoplogs and trashracks. Also, proper description of civil structure for installation of Hydraulic steel structures (HSS) are not provided. However, all the civil structures for which Hydraulic steel structure will be installed are as flowing:

1. Power Intake Structure

- Power Intake Gates
- Power intake Stoplogs
- Power Intake Trash rack

2. Weir Structure

- Flushing Section Gate
- Flushing Section Stoplogs

3. Tailrace Structure

- Draft Tube Gate

### 11.7.2 Power Intake Structure

Twin intakes have been provided with gates and a set of stoplogs for control of water intake into the power waterway system. Two bays are provided at each waterway structure with trash rack required at the entrance to prevent entry of debris into the power waterway system. Hence, as per Vol-II -drawings there will be four sets of trash racks whereas in main report only one set is mentioned. The equipment provided at power intake will be as following:

1. Two (2) hydraulically operated fixed wheel gates.
2. One (1) set of stoplogs at upstream of Gate.
3. Four (4) sets of Trash racks at entrance of each bay.
4. One Trashrack cleaning machine.
5. One gantry crane operating on a runway spanning the entire structure will be provided for maintenance of intake gates and stoplogs.

- **Power Intake Gates**

Power intake Gates must control the flow into the headrace tunnel during filling of the waterways and isolate the reservoir from the waterway for inspection and maintenance of the waterway. Therefore, at each power intake structure one Fixed Wheel Gate will be installed, which will act as Emergency gate and fulfilling aforementioned controls. Each gate will be operated by oil hydraulic servomotor. For each set of maintenance / service gates a common oil pressure unit has been considered. Moreover, the oil pressure units will be interconnected to each other in order to promote safety.

Main Data:

| | |
|---|---|
| Type of Gate | Fixed Wheel Gate |
| Number of Gate Openings | Two (2) |
| Number of Gates | Two (2), one in each waterway |



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| | |
|---|---|
| Number of embedded parts | Two sets |
| Type of Hoist | Hydraulic Cylinder |
| Approximate head on gate sill | ~18.5m |
| Sealing | Four Sided |

- **Power Intake Stoplogs**

One set of steel stoplogs will be provided at immediately upstream of each intake gate. It will be lowered when inspection or maintenance of the intake gate is required. The upper panel of stoplog will be provided with a filling valve in order to rise the stoplogs under balance condition. The stop log will be raised and lowered by a rail mounted gantry crane.

Main Data:

| | |
|---|---|
| Type of Stoplogs | Vertical Slide |
| Number of Sets | One set |
| Handling of Stoplogs | 25t Gantry Crane with lifting beam |
| Approximate head on gate sill | ~18.5m |
| Sealing | Four Sided |

- **Power Intake Trash rack**

A trash rack will cover the entrance to each power intake. The trash racks will be of the non-withdrawal type, consisting of fixed inclined trash rack panels supported by streamlined cross beams. The trash rack panels and the corresponding supporting structures will be designed to withstand the design pressure with a safety factor of 1.5. The bars of the trash racks will be spaced so as to block floating debris large enough to damage the turbines. This way floating debris is prevented from entering the waterway.

A trash rack cleaning machine mounted on rails on the intake structure deck will remove trash and debris collected by the trash racks.

| | |
|---|---|
| Type of Trash rack | Inclined, Fixed type |
| Number of Sets | 4 sets |
| Handling of Trash racks | initially with mobile crane and afterwards with the help of winch machine provided with cleaning machine |
| Cleaning of Trash racks | Trash rack Cleaning Machine (pay load capacity = 1 Ton) |

### 11.7.3 Weir (Sediment Flushing Channel / Under sluice)

Following hydraulic steel structures are provided in the FSR:

1. Three (3) hydraulically operated Radial gates.

2. One Set of Stoplogs at upstream of Gate.

3. One set of Stoplog at downstream of Gate



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As the under sluices utilized for sediment flushing are being avoided in the proposed alternative layout due to geotechnical issues in this review report, therefore, above gates and stoplogs will be excluded.

- **Alternative Flushing Tunnel**

To flush out sediment that is likely to be deposited in front of the intake structure, a new tunnel of 5.5m diameter is proposed in this review report. The flushing tunnel intake will be placed near the power tunnel intake at a distance of about 7m and at a lower level than the power intake structure. It is proposed that flushing tunnel intake will be similar to power tunnel intake and have following hydraulic steel structures (starting from upstream).

- One set of vertical lift maintenance stoplogs, (welded steel structure) handled by Gantry crane / EOT crane.
- One vertical lift fixed wheel gate to control water having hydraulic type hoist (quantity of the gates will be decided during detail design stage).
- One no. gantry / EOT crane (for installation and handling of stoplogs; installation of gate and its removal for future maintenance).

During detail design stage, the EPC Contractor will design and prepare arrangement of flushing tunnel intake structure (including HSS design) viewing best engineering practices subject to approval of the Employer / MC.

### 11.7.4 Tail race Structure

- **Draft tube Gate**

The draft tube of each turbine unit will be provided with (01) vertical lift bulkhead gate in order to dewater the turbine for installation, maintenance, inspection and repair of turbines. The operation shall be under balance head condition (created through filling valves) with the help of electric overhead travelling crane. The provision of draft tube stoplogs is uncertain/confusing as mention in main report clause 11.15.7.2 and also depicted /shown on drawing (AFS-PH-435), but not included in scope at any other part of report. Provision of stoplog along with bulkhead gate will be unnecessary as the draft tube gate will be enough to fulfill the above mentioned requirements.

| | |
|---|---|
| Type of Gate | Vertical lift bulkhead type with filling valve |
| Number of Gate Openings | Three (3) |
| Number of Gates | Three (3) |
| Number of embedded parts | Three sets |
| Type of Hoist | Overhead travelling crane with lifting beam |
| Approximate head on gate sill | ~12m |
| Sealing | Four Sided |

## 11.8 SUMMARY OF REVIEW FINDINGS

A summary of Review findings for Hydromechanical studies is presented in Table 11.4



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| TABLE 11.4: Summary of Hydraulic Steel Structures Mentioned in the FSR (2021) and Shortcomings Identified in the Review Remarks | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Description** | **Type of HSS** | **Qty.** | **Embedded Parts Qty.** | **Clear Opening Dimensions (W x H)** | **Water Level (m)** | **Sill Elevation (m)** | **Head (m)** | **Type of Hoist** | **Shortcomings Identified in the FSR and Review Report Remarks** |
| **Power Intake** | | | | | | | | | |
| Power intake gate | Fixed Wheel Gate | 2 Nos. | 2 Set | 4m x 5m | | El. 2402.50 | 18.5 | Hydraulic cylinders | |
| Power intake Trashrack | Inclined Fixed/non-withdrawal type | 1 set | 1 Set | 4.5m x 5m | | El. 2404.0 | | Mobile crane | There are 4 no. of bays/ intakes for which at least 4 sets of trash racks are required, whereas in main report table 11-9 only 1 set is mentioned. |
| Power intake Stoplogs | Vertical slide | 2 set | 2 Set | 4m x 5m | | El. 2402.50 | 18.5 | Gantry crane (rail mounted) or mobile crane by lifting beam | |
| Trash rack cleaning machine | | | | | | | | | |
| Gantry Crane (25t) | Electrically operated Gantry Crane | 1 | | | | | | | |



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| TABLE 11.4: Summary of Hydraulic Steel Structures Mentioned in the FSR (2021) and Shortcomings Identified in the Review Remarks | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Description** | **Type of HSS** | **Qty.** | **Embedded Parts Qty.** | **Clear Opening Dimensions (W x H)** | **Water Level (m)** | **Sill Elevation (m)** | **Head (m)** | **Type of Hoist** | **Shortcomings Identified in the FSR and Review Report Remarks** |
| **Weir (Sediment Flushing Channel / Under sluice)** | | | | | | | | | |
| ***As the under sluices utilized for sediment flushing are being avoided in the proposed alternative layout due to geotechnical issues in this review report, therefore, above gates and stoplogs will be excluded.*** | | | | | | | | | |
| **Alternate Flushing Tunnel** | | | | | | | | | |
| Stoplogs | Vertical Slide Type | 1 set | 1 Set | | | | | Gantry / EOT Crane | The Gantry crane provided for handling of power intake stoplogs same will be utilize for handling of flushing tunnel stoplogs. |
| Intake Gate | Fixed Wheel Gate | 1 no. | 1 Set | | | | | Hydraulic cylinders | |
| Gantry / EOT Crane | Electrically operated | 1 no. | | | | | | | |
| **Tailrace Structure** | | | | | | | | | |
| Draft tube Bulkhead Gate with filling valves | Vertical lift Bulkhead | 4 | 3 | 3m (H) | | El.2295.00 | | Overhead Travelling Crane | For three draft tube openings, four gates are provided which need to be corrected as three.<br>It is written: “One electrically operated overhead travelling crane will be provided for handling the draft tube gates and inlet stoplogs of tailrace tunnels with the help of lifting beams.”<br>This is incorrect, there are no tailrace tunnels and so the stoplogs. This need correction. |



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# 12 REVIEW OF ELECTRICAL EQUIPMENT STUDIES

## 12.1 GENERAL

Electrical equipment general layout / arrangement drawings are missing in Feasibility Study Report (FSR). The same will be added during preparation of Draft EPC Tender Documents. It is assumed that there is no problem regarding transportation of heavy construction and permanent equipment as mentioned in Section 1.6 of FSR, “Access to the Project Area”

Reference Standards details for each electrical equipment are missing in FSR. All equipment under these Technical Specifications will be manufactured and tested in accordance with the latest revision of IEC/IEEE/BS/ASTM international standards. The same will be added for each Electrical Powerhouse Equipment during Draft EPC Tender Documents.

In general, there are many contradictory statements in the Feasibility Study Report (FSR). Discrepancies found during Feasibility Review for each Electrical Powerhouse Equipment are described in following sections.

## 12.2 REVIEW OF POWERHOUSE ELECTRICAL WORKS STUDIES

The Electrical Equipment/Components of the Powerhouse are as below.

- Generators & Excitation System(s)
- Generator Circuit Breaker(s)
- Power Transformer(s)
- Station Service Transformer(s)
- Unit Auxiliary Transformer(s)
- Medium & Low Voltage Switchgear(s)
- Control & Instrumentation System
- Protection & Relay System
- DC & UPS System
- Cables
- Illumination & Small Power System
- Emergency Diesel Generator (EDG)
- Electrical Workshop
- Earthing and Lightning Protection System
- Fire Detection and Alarm System

### 12.2.1 Generator & Excitation System

Under section 12.3, of FSR, it is mentioned that *“A flywheel of suitable inertia will also be mounted on the same shaft to keep the constant speed of the generator & avoiding the fluctuations/harmonics resulting from varying loads and switching surges.”* This statement is not valid for Project of this size and will be deleted.

Under section 12.3, following specified in FSR *“Generator terminals are connected by isolated phase bus (IPB) to Generator circuit breaker (GCB).”* Isolated phase bus duct is utilized for large size generators with higher current rating. This section needs to be reviewed during preparation of Draft EPC Tender Documents.



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Under Table 12-1, power factor 0.85 is specified. As per requirement of Pakistan Grid Code, power factor range for generator should be 0.8 lagging to 0.9 leading. Power factor needs to be corrected during preparation of Draft EPC Tender Documents.

Under Section 12.3.2, following is specified in FSR, *"The generators are capable to run at 15% continuous overload without exceeding the temperature limits of class F insulation."* This statement is not supported in any international standard and it shall be deleted.

Under Table 12-1, Nominal capacity of each generator is given as 21.2MVA (18MW). Considering the efficiency of turbine 93% instead of 91.5%, the generators nominal capacity and associated equipment rating will be revised and provided in the draft EPC bidding documents.

### 12.2.2 Generator Circuit Breaker

Under 12.1, 2nd para, 2 GCBs are mentioned, whereas in 3rd para, it is mentioned that *"The generators shall be connected to their respective unit transformers (three phase) through GCB (3 GCBs).* However, all three generators are connected through circuit breakers (commonly known as GCB) to Unit transformers and the same shall be provided in the draft bidding documents.

### 12.2.3 Power Transformer

Under Section 12.5, following specified in FSR, *"An allowance of 10% continuous overload is also proposed."* This statement needs to be checked and verified in accordance with requirement specified in IEC 60076.

Under Table 12-2, transformer nominal capacity 22MVA specified. This is not standard rating for power transformer. MC will provide the generator step-up transformer rating in the draft EPC bidding documents in accordance with the generator rated capacity.

Under Table 12-2, OFF Load Tap changer is specified. It is highly recommended to specify an ON-Load Tap Changer for power transformer and the same shall be proposed during preparation of Draft EPC Tender Documents.

There is no explosion prevention system specified for power transformer. The same will be considered during preparation of Draft EPC Tender Documents.

### 12.2.4 Station Service Transformer

Under section 12.6, one (01) No. Station Service Transformer has been proposed with 2 MVA capacity, 11/132 kV voltage rating, ONAN cooling and Dry/Oil Type. ONAN cooling with Dry type is not correct. This section needs to be reviewed during preparation of Draft EPC Tender Documents.

### 12.2.5 Unit Auxiliary Transformers

Under section 12.7, two (02) No. Unit Auxiliary Transformers have been proposed each with 630 kVA capacity, 11/0.4 kV voltage rating and ONAN cooling type.

For Unit Auxiliary Transformers, MC recommend to use Dry Type Transformers. MC will provide the three-unit auxiliary transformers along with the vector group in the draft EPC bidding documents.

Under section 12.7, two (02) No. Auxiliary Transformers have been proposed each with 400 kVA capacity, 11/0.4 kV voltage rating and ONAN cooling type.



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Impedance of 4% for these type of transformers needs to be reviewed during preparation of Draft EPC Tender Documents. Vector Group is also missing for these transformers.

### 12.2.6 Medium & Low Voltage System

- **Powerhouse**

Under section 12.8.2, it has been mentioned that switchgear planned to be located in a separate room in the 132 kV switchyard. This statement needs to be reviewed during preparation of Draft EPC Tender Documents.

Under Section 12.8.2, it has been mentioned that there are some 11kV feeders to supply power to rural areas. In this regard, MC will not consider the provision of 11kV feeders from Attabad plant in draft EPC bidding documents. It is recommended to power-up the nearby rural areas from the local grid.

Under section 12.8.2, There are some important parameters of MV Switchgear which are missing and needs to be specified e.g. LSIG Digital Trips, Protection Class, Busbar Material, Continuous Current of Bus and Bus bar Insulation etc.

The details of CT, PT etc. are missing in the report which needs to be augmented during preparation of Draft EPC Tender Documents.

Under section 12.8.2, Single Line Diagram and Rated Short Circuit Current needs to be verified during preparation of Draft EPC Tender Documents.

- **Medium and Low Voltage AC Supply**

Under Main Single Line Diagram, 0.85 Power Factor has been specified which needs to be corrected as 0.8 lagging, 0.9 leading as per NEPRA Grid Code.

Under section 12.8.3, there are some important parameters of LV Switchgear which are missing and needs to be specified e.g. LSIG Digital Trips, Protection Class, Busbar Material, Continuous Current of Bus, Bus bar Insulation and Separation class as per IEC for LV Switchgear etc.

Further, Station Service Transformer capacities and quantities will be verified during preparation of Draft EPC Tender Documents.

There is nothing stated in FSR about Motor Control Centres (MCCs). We recommend to add the details of the same during preparation of Draft EPC Tender Documents.

### 12.2.7 Control & Instrumentation System

Under Section 12.19.2, MC will not consider the provision of control and instrumentation system for the spillway/weir in the draft EPC bidding documents as it is mentioned in section (18) that the ungated spillways shall be proposed.

Under Section 12.19.3, comprehensive detail is mentioned regarding interface of Attabad Lake HPP with Existing NTDC/NPCC SCADA System. However, in Section 13.2 of this report it is mentioned that entire region of Gilgit Baltistan is not connected with the national grid due to its mountainous terrain. Even there is no any Regional Load Dispatch Centre available in the entire region. This mismatch needs to be clarified.

MC understand that currently there is no Regional Load Dispatch Centre or NTDC/NPCC SCADA System exists/available in the entire region. At this stage, we only require to have provision of SCADA System for providing future interlinking with Regional Load Dispatch



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Centre or NTDC/NPCC SCADA System (future provision). The tele-control gateway shall be used for communication with Regional Load Dispatch Centre or NTDC/NPCC SCADA System.

General description regarding the design philosophy of the Plant Control System (PCS) and main functions/features of the Unit Local Control Panels (ULCPs), Local Control Panels (LCPs), Operator Workstation, Engineering Workstation etc. are not specified. The same will be specified during preparation of Draft EPC Tender Documents.

Automatic Load Frequency Control (ALFC) of generators from the NPCC is mentioned. We recommended that this requirement is not necessary for Attabad Lake HPP.

Under Section 12.19.1, it is mentioned that the generating unit operation will be carried out **remotely** from the machine hall floor level of the **underground powerhouse**. However, in Section 7.1, it is mentioned that **surface powerhouse** is viable at site.

MC will provide the specifications for surface powerhouse in the draft EPC bidding documents.

### 12.2.8 Protection Equipment

Under Section 12.9.2, it is specified that all relays shall preferably be of the same make (manufacturer) to build a uniform modular system. While the next para specified that general principal for the protection is that all parts of installation are covered by two high speed protection schemes which are independent to avoid common mode failures. These two requirements contradict each other and shall be corrected. Protection schemes whether “Primary & Backup” OR “Duplicate Protection” will be re-evaluated during preparation of Draft EPC Tender Documents.

Instrument transformers requirements for protection equipment is not specified.

There are some protections, which are not specified in FSR. All required protections shall be considered during preparation of Draft EPC Tender Documents.

### 12.2.9 DC & UPS System

Under section 12.13, one 220V battery system, with one main distribution switchgear and battery charger is proposed in FSR. The proposed scheme in FSR and as shown on single line diagram is not suitable and reliable. Moreover, there is no backup system for Emergency Lighting System covered in FSR.

We recommend 220 V DC supply system with two (02) no. DC distribution boards, two (02) no. Rectifiers, one (01) no. battery bank of ample capacity and two (02) no. battery chargers. Where 48 V DC or 24 V DC voltage is required, DC/DC converters shall be used. 220 V DC distribution boards shall be fed from 400 VAC switchgear through rectifiers.

Regarding UPS, we recommend one (01) no. 230 V AC UPS System. Normally UPS will be fed from 400 AC Switchgear. In case of failure of normal power supply, UPS will be fed from 220 V DC supply system through two (02) No. DC/AC inverters. The recommended scheme for UPS will be specified during preparation of Draft EPC Tender Documents.

### 12.2.10 Cables

Under Section 12.14, technical parameters of cables are missing. We recommend to add the technical parameters of cables during preparation of Draft EPC Tender Documents.



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### 12.2.11 Illumination & Small Power System

Under Section 12.15, LED lighting system is mentioned in the start of the section. However, technical details of fluorescent light fittings are mentioned in this section.

MC will provide the specifications of LED lighting system in the draft EPC bidding documents.

### 12.2.12 Emergency Diesel Generator

Under section 12.16, capacities and quantities of emergency diesel generators will be re-evaluated during preparation of Draft EPC Tender Documents keeping in view the loads of each area.

### 12.2.13 Electrical Workshop

Workshop details will be re-evaluated during preparation of Draft EPC Tender Documents.

### 12.2.14 Earthing & Lightning System

Under section 12.18, earthing system has been specified. Moreover, there is no earth resistance value specified. Further, lightning protection system is not covered in FSR which is an essential part of building/outdoor equipment protection.

We recommend earthing and lightning protection system for the powerhouse, switchyard and intake area with earthing resistance less than 1 ohm for each specific area. EPC contractor shall measure the earth resistivity and will perform earthing calculation in accordance with IEEE 80-2000 standard. The same will be specified during preparation of Draft EPC Tender Documents.

### 12.2.15 Fire Detection & Alarm System

Fire Detection & Alarm System is not specified in the FSR which will be added during preparation of Draft EPC Tender Documents.

### 12.2.16 Drawings

- **Single Line Diagrams**

Single Line Diagrams for Powerhouse, AC Distribution and other drawings needs to be reviewed / updated during preparation of Draft EPC Tender Documents.

- **Plant Control System Drawing (Asf-Em-455)**

The Plant Control System (PCS) drawing is not in-line / coordinated with the requirements specified in the relevant section of the FSR. Separate Control System for Auxiliaries and DC System are shown in the drawing and there is no description regarding the functionality of these Control Systems. Moreover, separate Control System for Intake/Tailrace is shown in the drawing which is incorrect as intake and tailrace are two separate and distant structures of the Project.

The updated / revised drawing of Conceptual Layout of Plant Control System (PCS) will be added during preparation of Draft EPC Tender Documents.

## 12.3 REVIEW OF SWITCHYARD STUDIES

### 12.3.1 Review Findings

Following are the review findings and comments for Switchyard studies carried out at Feasibility stage.



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- Short circuit study is not available with us. However, we have considered short circuit rating of the equipment as 40kA as per latest practice of NTDC.
- Only the time frame of seven (07) months is mentioned for the construction of 132kV Switchyard. Kindly clarify us regarding the total time frame required/estimated for the completion of the 132kV Switchyard including preparation of Tender Documents, Evaluation of Bids, Award of Contract, Construction phase and Defects Liability Period etc.
- Proposed switchyard will be of 'Conventional AIS' type as mentioned in the Switchyard Main Single Line Diagram. It is noted that the word 'GIS' is mentioned at several places in the Feasibility Report for the type of 132kV Switchyard. We have considered 132kV AIS switchyard keeping in view the availability of land and difference in GIS price.
- The location of the switchyard shall be finalized during the detail design stage. However, the tentative location of 132kV switchyard will be provided in the draft EPC bidding documents.
- Bus coupler should be included as two different supplies will be connected with the 11kV busbar.
- Bus coupler should be provided for LV AC (400V) system.
- MC will provide the scope of remote end line bays (including Step-Down Transformers) in the Transmission lines (Lot-II) of draft EPC bidding documents.
- 132kV switchyard /switchgear control system will be based on IEC 61850 for SAS system with provision to control from DCS of power house.
- DC distribution panel to be provided in switchyard control room even D.C. supply feeder will be provided from power house.
- Clearances and equipment insulation levels to be coordinated with the altitude of switchyard area from sea level.
- 132/11kV power transformer MVA rating shall be coordinated with colony and other present & future load requirement as exact load of the power transformer is not available with us.
- MC understand that three (03) transmission line circuits (one double circuit transmission line circuit and one single circuit) with twin bundle rail conductor for 67MVA is more than requirement. Single circuit with single rail conductor per phase is enough for power evacuation. For (N-1) contingency maximum two circuit (one double circuit or two single circuit transmission lines) will serve the purpose. However, T/L Expert should decide the number of lines keeping in view the actual power transmission envisaged for future. We have considered single rail conductor/per phase for transmission line and 132kV switchyard equipment rating will be as under:
- 132kV Circuit Breaker (CB) 1250 A with 40kA short circuit rating
- 132kV Disconnector Switch (DS) 1250 A with 40kA short circuit rating
- 132kV Current Transformer (CT) 1250 A with 40kA short circuit rating
- 132kV busbar rating 2000 A with 40kA short circuit rating
- In case of any change in short circuit level and number of lines the configuration of 132kV switchyard and equipment rating have to be revised accordingly.



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- Table 14-17 i.e. 'cost estimate for 132kV Switchyard Equipment' of 'Volume-I main report of feasibility study of Attabad lake HPP' indicates US $ price column as per the dollar exchange rate of 157 PKR. Prices should be revised as per the latest dollar exchange rate. Moreover, the cost of power transformer, tariff metering equipment and civil works shall be included.

### 12.3.2 Main Single Line Diagram and Protection Single Line Diagram

- **Main Single Line Diagram (ASF-EM-451)**
- Current transformers (CTs) have not been indicated on the main single line diagram (ASF-EM-451). The same shall also be included.
- 132kV Bus bars ratings have not been indicated on the drawing. These shall be as 2000A, 40kA and 145kV current carrying capacity, short circuit level and rated voltage level respectively.
- 132kV Bus bar VTs have not been indicated on the main single line diagram (ASF-EM-451). The same should be included.
- It is not clear whether tariff metering of 132/11kV power transformer will required or not.
- Disconnector switch at HV side of step-up transformer shall also to be included.
- Line earth switch shall be shifted toward line side.
- VT for synchronism check to be provided on HV side of step-up transformer.
- Line trap and CCVT have not been indicated on the main single line diagram (ASF-EM-451). The same should be indicated on the drawing.
- Secure metering system (SMS) equipment such as CTs and CVTs for main and backup tariff metering system to be included at HV side of each unit transformer.
- **Protection Single Line Diagram**

Protection scheme to be revised as detailed below.

**132kV Transmission Line Protection**

- Distance Set-I with built-in autoreclosure, fault recorder, over current, stub protection.
- Distance Set-II with built-in autoreclosure fault recorder, over current, stub protection.

**132/11kV Transformer**

- Transformer differential protection and over current protection shall also be included/indicated on the drawing.
- REF shall also be included/indicated on the drawing.

### 12.3.3 11/132kV Unit Transformer

- Differential Set-I with built in overflux thermal overload, REF, HV, neutral over current voltage restraint over current.
- Differential Set-II with built in overflux, thermal overload, neutral over current, HV over current, LV over current voltage restraint over current.
- Over current protection to protect stub area in case of both differential relays are out of service shall also be included/indicated on the drawing.



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- Overall generator transformer differential is not required as per adopted scheme.
- Circuit breaker failure protection scheme should be included.
- 132kV centralized busbar protection should be included.
- Trip circuit supervision protection should also be included.

### 12.4 REVIEW OF DISTRIBUTION STUDIES

Following are the review findings and comments on Distribution studies carried out at Feasibility stage.

- Sizes of the Distribution Transformers/DG sets shall be finalized at the detailed designing stage keeping in view the exact normal/emergency load requirements to be fed from the referred Transformers/DG Sets.
- WAPDA Standards/Specifications shall be followed for finalization of the basic design parameters of the electrical equipment/material.
- Technical specifications of the electrical equipment/material shall be prepared at the detailed design stage clearly indicating following parameters:
- Supplier details w.r.t their in house testing procedures, machinery/ skilled staff, testing equipment/tools to ensure after sales services support.
- Warranty/guarantee procedures/requirements to ensure maintenance/trouble free operation of the equipment and system thereof.
- Manufacturing standards of the material/equipment to check the compliance of the product as per applicable international standards.
- Operation & Maintenance setup of the manufacturer/supplier in the vicinity of the project for smooth operation of the system.
- Valid authorizations of the manufacturers (outside the country) for the local suppliers for warranty claims and to establish genuineness of the product.
- Factory Acceptance Tests (FATs) and Site Acceptance Tests (SATs) details to confirm/verify the delivered material in line with the project requirements.
- Requisite applicable type/routine test reports/certificates to check tested values/results in line with the parameters declared in the brochures/technical data of the equipment/material.
- Payment terms /measurements of the installed/delivered material.
- Ratings/sizing of the electrical components/equipment/material like Transformers, DG Sets, cables, Switchgear components, light fixtures, switches, sockets, wiring, conduits/pipes and all allied/associated accessories shall be finalized at detailed designing stage.
- In addition to the recommended lux levels, other lighting requirements like uniformities, Glares etc. shall also be defined for the particular areas/rooms/buildings.
- In various areas fluorescent and High Pressure Sodium Vapour Light fixtures/lamps are mentioned. Keeping in view the energy efficiency aspects (low wattage & higher efficacy) LED indoor as well as outdoor light fixtures shall be proposed for the subject project.



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- Separate earthing arrangements shall be made for metallic parts of the equipment/structure and the Circuit Protective Conductor (CPC).
- Costs of the electrical works cannot be reviewed as quantities/ratings of the electrical equipment/material are not available at this stage.
- Complete architectural plans of the colony/ buildings including external areas shall be required from EPC contractor for detail design review.

## 12.5 REVIEW OF SCADA AND TELECOM STUDIES

### 12.5.1 Functional Overview / Scope of Work

The following to be included in the SCADA and Telecommunication system hall.

- An In-plant Instrumentation and Control system allowing monitoring and control of the plant (referred hereafter as the station) including generators, all auxiliaries, the associated switchgear, and 132 kV switchyard.
- Establishment of end-to-end digital power line carrier (DPLC) and protection signaling links.
- Installation of Power line coupling equipment for coupling the DPLC equipment to the overhead transmission lines.
- Main Distribution Frame (MDF) for interconnection of PAX to DPLC and DAM/CC/ ADM equipment for speech communication.
- Establishment of duplicated data communication links between Attabad switchyard and NPCC Islamabad.
- Establish complete fiber optic & digital protection signaling links using OPGW to be supplied.
- Operational telephone exchange (PAX) system at Attabad S/S including interconnecting and interface equipment required at Attabad S/S and the peripheral substations for complete integration with NTDC telephone network provided for NPCC.
- SCADA system for remote monitoring and control of Attabad switchyard from NPCC. Database modification and augmentation in mimic display at NPCC.
- Interconnection of SCADA Data Gateway (SDG), telephone PAX and protection relays to the DPLC and optical fiber equipment for communication over DPLC and Fiber Optic links.
- Establishment of two data links from Attabad Substation to NPCC Islamabad on physically separate routes. Scope includes the works to be done at the intermediate substations.
- 48V DC power system at Attabad S/S for powering the equipment.
- Extension and interconnection with the existing PAXs at peripheral substations.
- Site Survey by the Contractor of the existing facilities to determine required interface works and submittal of the Site Survey Report within four weeks of Contract Award. The Survey Report shall be comprehensive and provide detailed information of existing facilities.



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- Engineering, design and supply of any devices required for proper interface and working of fully functional telecommunication and SCADA systems even if not specifically mentioned in Scope of Work/Price Schedules.

- Co-ordination with other contractor(s) shall also be deemed to be included in Contractor's scope of work.

### 12.5.2 Station Instrumentation and Control (I&C) System

This section covers the design, supply, installation, testing and commissioning of Monitoring and Control system (MCS) for 132 kV Attabad substation. Monitoring & Control system for 132kV substation shall include control, monitoring, fault recording, events recording and supervision functions complete with equipment interfaces for the entire substation including but not limited to following.

- Control of substation equipment including circuit breakers, disconnectors and earthing switches to be included.
- Interfacing with protection relays to be included.
- Measurements of voltages, currents, frequency, watts, and VARs through transducers.
- Measurement of status indications.
- Alarm annunciations.
- Interfacing with station voltage regulation equipment for indication and control.
- Event logging and fault recording functions based on inputs from relays and other substation devices/equipment.

### 12.5.3 Recommendations

1. As per Clause 12.19.4, two alternatives have been discussed for SCADA / Tele-Control by NPCC. Please be noted that as per NTDC's latest requirement all new substations / powerhouses shall be connected via Gateway instead of Remote Terminal Unit (RTU). Therefore, it is recommended to connect the powerhouse/ switchyard (SCADA) via Gateway as discussed in Alternative-2.

2. As per Clause 12.19.8, it has been stated that, "The equipment for teleprotection will have the flexibility for transmission over any communication medium i.e. PLC or OPGW." Please note that, the equipment related to Fiber Optic System (SDH, PDH, AFOC, ODF etc.) is missing in the feasibility report. It is recommended to include complete details of the Fiber Optic System equipment.

3. As per Clause 12.19.9, it is stated that, the Public Address system shall be required at powerhouse only. It is recommended to install the PAS system in 132kV Switchyard & Residential camp also.

4. As per Clause 12.19.12 wherein it is stated that, CCTV system shall be required for the powerhouse. It is recommended to install the CCTV system at switchyard, residential camp & complete powerhouse for the fool-proof security.

5. It is recommended to provide internet & TV Services (Triple Services including Telephone) for the residential camp.

6. Please note that it is recommended to install a separate Telephone exchange (PABX/PAX) for the powerhouse & switchyard.



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7. As per Clause 12.19.7.3, it is stated that, “The control room will be additionally connected to the public telephone system to guarantee the communication with the power plant in case of failure of the PLC system”. It is recommended an additional public telephone system (external connection) for powerhouse, switchyard & residential camp. It is recommended to provide public telephone system for the external communication.

8. It is recommended to provide a separate LAN within Powerhouse, switchyard & residential camp.

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# 13 REVIEW OF TRANSMISSION LINE STUDY

Transmission line studies for Attabad Hydropower project carried out at Feasibility stage have been reviewed and following are the review findings.

## 13.1 TRANSMISSION LINES FROM ATTABAD LAKE HPP

The capacity of the double circuit transmission line is sufficient for evacuation of the 54 MW power of the proposed ALHPP and future generation of power.

In order to meet 'N-1' reliability criteria, double circuit 70km transmission line will also be necessary because in case of contingency outage of one circuit, the complete power will be lost. The option of single circuit is also otherwise not feasible because system voltage and stability will remain at stake even under normal operating conditions, if full capacity of about 130 MW on single circuit line at (40° C min. at wind vel. Of 0 m/s with Current carrying capacity of 626 Amperes for Rail conductor considering Power factor as 0.9.at 132 kV) is utilized with future local generation.

Hence keeping in view the 'N-1' contingency criterion as well as possibility of induction of additional power from future power projects in the area, double circuit transmission line is also recommended up to the existing 33Kv Grid station at Sost.

However, keeping in view the need of Power in current scenario, 132kV Single Circuit Transmission Line is sufficient to fulfill the Power requirements. Therefore, the scope of 132kV Single Circuit T/Line to Sost Grid has been considered in the EPC Contract.

## 13.2 TYPE OF TOWERS AND BASIC DATA

ZM family of towers are recommend to be used only for the 132Kv transmission line to be constructed in normal terrain. Because of steep gorges area and uncertainty of length of different spans at this stage when no detailed survey has been carried out, and the route may involve crossing of valleys, rivers etc., it would become very difficult to manage to construct the line with ZM type towers, rather we expect to install heavier towers of 220Kv on most of the locations. It is therefore recommended to use mix of 220Kv towers EA, EG & JKD types with few ZM type tower locations especially when ACSR Rail conductor is used. These 220Kv towers would also help covering long spans while maintaining the required strength of the line. Accordingly the cost estimate of the line should also be revised..

The Deflection Angle of ZM-1 mentioned as 30° is a typographical error.

The deflection Angle is **0-2°** for ZM-1 Type Tower.

## 13.3 INSULATORS

Normally 80KN insulators are used in case of LYNX conductor. For Rail conductor 100 KN insulators are recommended in suspension and 120 KN in Tension assemblies because of long spans in crossings and abnormal/steep hilly terrain. Also to cater for ice loading , after study, we might require to increase the length of strings that would necessitate to use 220kV towers. Additional quantity of insulators as such required for these lines should also be valued in the cost estimate.



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## 13.4 LOAD FLOW STUDIES

The evacuation of power generated at Attabad Lake HPP, is proposed through a 27km, 132kV double circuit of Rail conductor, from ALHPP to the existing (to be upgraded to 132/66/11 kV) Aliabad Grid station and further disperse the power in the Regional Grid Network (RGN).

Along with double circuit 132 kV transmission line to Aliabad, a 132 kV single circuit, with Rail Conductor, of 70 km transmission line is also proposed up to the existing 33kV grid station Sost which is already in operation to cater for the domestic electricity demand and likely to be upgraded to 132/33/11 kV grid station.

Review of the proposed Power Evacuation scheme has revealed that the proposed Double circuit of Rail Conductor at 132kV from ALHPP to Aliabad Grid Station would capable of evacuation of the power generated at ALHPP and upcoming Power Projects in the area, in addition to satisfying the N-1 criterion, as Rail Conductor can carry 20MVA power.

Presently Gilgit-Baltistan area grid of 140 MW capacities is operating in many islands and is not connected to any grid system. Presently the power network is based on Off-Grid and the aim of the project is to bring them on On-Grid in the region and readiness for further connection to the National Grid.

Because of non-availability of Data of any Regional Grid Network and it's inter connection with National Grid, Load Flow Studies cannot be performed at this stage. However Load flow Studies should in added in the EPC scope, which should be performed prior to the COD of the Project.



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# 14 REVIEW OF PROJECT QUANTITIES AND COST ESTIMATES

## 14.1 GENERAL

Project Quantities and Cost Estimate studies are under Chapter 14: Project Quantities and Cost Estimates of Volume-1: Main Report of the Feasibility study 2021. It presents the estimation of quantities for Attabad Lake Hydropower Project on the basis of feasibility drawings. Following are the review findings for quantity and cost estimation of various works of the project.

### 14.1.1 Rate Assumption

Escalation allowance by EPC shall be taken care of while quoting the rates for material, manpower and equipment as feasibility rates are based on WAPDA CSR of March 2021.

### 14.1.2 Price Index

For Local & Foreign cost component the rate of 1 US$. EPC shall consider the actual conversion rate of local currency rate at the time of bidding while quoting his rates.

### 14.1.3 Development of Unit Rates

Review of Unit Rate development for Labor Cost and Material cost during the course of Feasibility studies is given hereunder.

**Labor Cost**

The rates of wages for the skilled, un-skilled and operators for various construction equipment are based on market wages in Hunza District of March 2021 shall be considered by EPC at the time of bidding.

**Material Cost**

The material cost considered in the feasibility study is based on the prevailing rates of March 2021 which shall be adjusted as per the material cost at the time of bidding by EPC Contractor.

### 14.1.4 Rate Analysis

The rate analysis was worked out for FSR by assuming that,

- Work will be carried out for 8 hours per day and
- 26 working days per month

The EPC Contractor will work at site as per his planning which may exceed to round the clock working in two shifts and work throughout the month during summer season keeping in view the Project construction timelines.

## 14.2 QUANTITY AND COST ESTIMATE OF MAIN WEIR AND FLUSHING SECTION

The estimated cost for the construction of Main Weir as per MC modified Alternative-I A proposal will be on much lower side as mentioned in Feasibility study for which needs to be confirmed by EPC Contractor after finalizing detail design.

The estimated cost for the construction of sediment flushing section as per MC modified Alternative-I A proposal for the construction of flushing tunnel will be quite on lower side as mentioned in Feasibility study for which needs to be confirmed by EPC Contractor after finalizing detail design.



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## 14.3 QUANTITY AND COST ESTIMATE OF GEOTECHNICAL WORKS

Table 14-2 (Feasibility Report Volume 1) shows that the quantity of excavation at Main Weir, Cofferdams and in under sluices is 92.78% of total excavation. This aspect is illustrated in Table 14.1.

**Table 14.1 Review of Quantity Estimates for Excavation Works**

| Description | Reported Quantities | Proportion of work |
|---|---|---|
| **Project Excavations** | **cum** | **%** |
| Main Weir | 1,008,000 | 38.87 |
| Under Sluices | 1,400,000 | 53.98 |
| Power Intake, Low Pressure Headrace Tunnel, Surge Tank and Penstock | 98,160 | 3.78 |
| Powerhouse and Tailrace Channel | 87,044 | 3.35 |
| **TOTAL** | **2,593,204** | **100** |

The accuracy of the excavation estimates is unlikely due to availability of cross-sections 50 m apart. Furthermore, disturbance of slided mass can result in further sliding which may increase the quantity of excavation.

The main risks for the increase in estimated cost for the proposed alternative from geotechnical point of view are listed below.

a. The increase in the cost of soil improvement to be applied under the project components.

b. The risk of increase in excavation volumes in the weir location. Especially on the right bank.

c. The risk of slopewash movement in the neighbourhood of powerhouse triggered by the construction activities.

## 14.4 QUANTITY AND COST ESTIMATE OF HYDROMECHANICAL WORKS

- Steel penstock per ton. Cost mentioned in the table 14-11 of Feasibility report is on lower side and need to be increased.

- Review Comments on hydro-mechanical equipment cost given in Table-14-14 of Feasibility report are given below.
  i. Cost of hydraulic steel structures is on lower side and need to be increased,
  ii. Cost of power intake stoplogs is missing which need to be included,
  iii. Cost of weir gates and stoplogs is missing which need to be included.

- Review Comments on hydro-mechanical equipment cost given in Table-14-15 of Feasibility report are given below.
  i. Cost of hydro-mechanical equipment is a bit on lower side and need to be increased,
  ii. Workshop equipment cost is considerably low and need to be increased,
  iii. Cost of spare parts and erection & testing equipment and maintenance tools is missing which need to be included,
  iv. Cost of two (02) powerhouse elevators is considered whereas its quantity mentioned in the clause 11.14.18 is one (1). It needs correction.



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## 14.5 QUANTITY AND COST ESTIMATE OF TRANSMISSION LINE WORKS

- It is recommended that instead of cost estimates made on some thumb rule, the detailed survey should be carried out at the earliest well before the Tender of the project for EPC contract is floated, and the quantities closer to the actual requirement should be given in the BOQ.
- More time will be required for carrying out the detailed survey due to difficult mountainous area.
- It will reduce the time period of the EPC contract.
- Proper BOQ and Cost Estimate of the Transmission line could be prepared after detailed survey, however a tentative Cost Estimate could be prepared on estimated quantities.
- It is also advisable that as soon as the detailed survey of line is completed, soil investigations should also be arranged to determine the type of foundation required and estimate the cost involved in closer margin.

## 14.6 QUANTITY AND COST ESTIMATE OF PENSTOCK

The length of steel Penstock will be shortened due to relocation of Powerhouse as per MC alternative proposal, hence the estimated cost for the construction of steel Penstock will be reduced as mentioned in the Feasibility Study for which needs to be confirmed by EPC after finalizing detail design.

## 14.7 QUANTITY AND COST ESTIMATE OF POWERHOUSE AND TAILRACE CHANNEL

The length of the Tailrace Channel will be increased due to the relocation of Powerhouse as per MC proposal, hence the cost for construction of Tailrace Channel will be increased to some extent as mentioned in the Feasibility Study for which needs to be confirmed by EPC after finalizing detail design.

## 14.8 REVIEW OF ANNEXURE A EQUIPMENT, MATERIAL AND LABOUR RATES

The cost of construction Equipment, cost of construction material and labour rates listed in this Annexure are on lower side and EPC contractor has to evaluate these costing as per his requirement as per the prevailing market rates for these resources.

## 14.9 COMPARISON OF QUANTITIES FOR FEASIBILITY STUDY AND REVIEW STAGE STUDY

A tentative comparison has been done for quantities of the Project components from Feasibility stage selected layout “Alternate-I A” and Review stage layout “Modified Alternate-I A”. Details of Feasibility stage layout and Review stage layout are described in chapter 7 of this report. Quantities comparison is given in Table 14.2 through Table 14.7.



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**Table 14.2 Comparison of Quantities for Rigid Weir and Flexible Overflow Structure**

| Sr. No. | Description | Units | Quantity | | Remarks |
|---|---|---|---|---|---|
| | | | Feasibility Stage | Feasibility Review Stage | |
| 1 | Excavation for weir upto design depth in Medium Hard Soil i/c removing of material from outside of the structure area | $m^3$ | 828,000 | 7,595 | Drastic reduction in quantities is due to the replacement of the concrete weir structure with the proposed flexible/rigid overflow structure (Gabion mattress) at the feasibility review stage. |
| 2 | Excavation for Main Weir upto design depth in Rock Material requiring blasting i/c from outside of the structure area | $m^3$ | 180,000 | 0 | |
| 3 | Free Draining Backfill | $m^3$ | 8,280 | 0 | |
| 4 | Lean Concrete 1:4:8 | $m^3$ | 990 | 226 | |
| 5 | Grout Curtain as per design alignment and depth in drawing, size (0.10m x 10m) Approx. | Lm | 0 | 2,000 | |
| 6 | RCC 1:1.5:3 for core using crushed stone aggregate (screening & ashing) and coarse sand i/c cost of all labor and material and all kinds of form works, molds, shuttering lifting/pumping, curing, rendering and finishing the exposed surface excluding steel reinforcement | $m^3$ | 10,920 | 365 | |
| 7 | Reinforcement Grade 60 in Lining | Ton | 655.2 | 0 | |
| 8 | Gabion Complete in all respects | $m^3$ | 0 | 7,024 | Quantity of gabions added as proposed at the feasibility review stage. |
| 9 | Dewatering | LS | 1 | 1 | |
| 10 | Riprap Protection | $m^3$ | 2,160 | 0 | Items will not be utilized for the proposed Alternative 1A. |
| 11 | Protection with Gabions | $m^3$ | 1,000 | 0 | |
| 12 | Miscellaneous 5% for joints of all types, Drainage, Architectural details, finishes etc. | LS | 1 | 1 | |



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**Table 14.3 Comparison of Quantities for Under sluices and Flushing Tunnel**

| Sr. No | Description | Units | Quantity | | Remarks |
|---|---|---|---|---|---|
| | | | Feasibility Stage | Feasibility Review Stage | |
| 1 | Clearing and Grubbing of area 300m upstream of the weir | $m^2$ | 10,875 | 0 | Flushing Tunnel was not part of the feasibility stage, added later in review feasibility stage. |
| 2 | Excavation for Flushing Tunnel/Under sluices upto design depth in Medium Hard Rock requiring blasting i/c removing of material from outside of the structure area | $m^3$ | 280,000 | 25,423 | |
| 3 | Compacted Concrete | $m^3$ | 413 | 0 | |
| 4 | Riprap face protection u/s | $m^3$ | 500 | 0 | |
| 5 | PCC in overbreak section including placing, compacting, finishing & curing (Ratio 1:2:4) | $m^3$ | 0 | 1,518 | |
| 6 | Lean Concrete 1:4:8 | $m^3$ | 645 | 226 | |
| 7 | Shotcrete excluding wire mesh reinforcement | $m^3$ | 0 | 1,477 | |
| 8 | Providing and fixing wire mesh as per drawing (6mm dia., 15x15 cm) | $m^2$ | 0 | 11,416 | |
| 9 | Providing and fixing wire mesh as per drawing (8mm dia., 10x10 cm) | $m^2$ | 0 | 8,585 | |
| 10 | RCC 1:1.5:3 for Lining / Under sluices using crushed stone aggregate (screening & ashing) and coarse sand i/c cost of all labor and material and all kinds of form works, molds, shuttering lifting/pumping, curing, rendering, and finishing the exposed surface excluding steel reinforcement | $m^3$ | 9,970 | 13,111 | |
| 11 | Reinforcement Grade 60 in Lining / Under sluices | Ton | 499 | 524 | |
| 12 | Rock Bolts 3m long and 26mm dia. including grouting complete in all respects | No. | 0 | 6,829 | |
| 13 | Advance early strength rock bolt 4 m long complete in all respects as per drawing | No. | 0 | 448 | |
| 14 | Steel Rib NPI 180 | Lm | 0 | 4,821 | |



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| Sr. No | Description | Units | Quantity | | Remarks |
|---|---|---|---|---|---|
| | | | Feasibility Stage | Feasibility Review Stage | |
| 15 | Excavation for upto design depth in Medium Hard Soil removing of material from outside of the structure area | $m^3$ | 1,120,000 | 3,018,903 | |
| 16 | Back Filling | $m^3$ | 0 | 204,000 | |
| 17 | Adits (Access Tunnel) | LS | 0 | 1 | |
| 18 | Grout Curtain | LS | 1 | 0 | |
| 19 | Dewatering | LS | 1 | 1 | |
| 20 | Consolidation Grouting | LS | 1 | 0 | |
| 21 | Miscellaneous 5% for joints of all types, Drainage, Architectural details, finishes etc. | LS | 1 | 1 | |

**Table 14.4 Comparison of Quantities for Power Tunnel**

| Sr. No | Description | Units | Quantity | | Remarks |
|---|---|---|---|---|---|
| | | | Feasibility Stage | Feasibility Review Stage | |
| 1 | Excavation for Headrace Tunnel upto design depth in Medium Hard Rock requiring blasting i/c removing of material from outside of the structure area | $m^3$ | 60,737 | 71,085 | |
| 2 | PCC in overbreak section including placing, compacting, finishing & curing (Ratio 1:2:4) | $m^3$ | 4,191 | 0 | |
| 3 | Lean Concrete 1:4:8 | $m^3$ | 1,030 | 1,074 | |
| 4 | Shotcrete 35mm thick-fiber reinforced | $m^3$ | 1,012 | 0 | 35mm thick-fiber reinforced shotcrete in the feasibility stage is replaced with shotcrete excluding wire mesh and wire mesh (6mm dia., 15x15 cm) and (8mm dia., 10x10 cm) at the |



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| Sr. No | Description | Units | Quantity | | Remarks |
|---|---|---|---|---|---|
| | | | Feasibility Stage | Feasibility Review Stage | |
| | | | | | feasibility review stage. |
| 5 | Shotcrete excluding wire mesh reinforced | $m^3$ | 0 | 4,430 | Added at Feasibility review stage as tentative design of tunnel support system. |
| 6 | Providing and fixing wire mesh as per drawing (6mm dia, 15x15 cm) | $m^2$ | 0 | 24,755 | |
| 7 | Providing and fixing wire mesh as per drawing (8mm dia, 10x10 cm) | $m^2$ | 0 | 32,270 | |
| 8 | RCC 1:1.5:3 for Lining using crushed stone aggregate (screening & ashing) and coarse sand i/c cost of all labor and material and all kinds of form works, molds, shuttering lifting/pumping, curing, rendering and finishing the exposed surface excluding steel reinforcement | $m^3$ | 9,935 | 10,602 | |
| 9 | Reinforcement Grade 60 in Lining | Ton | 397 | 424 | |
| 10 | Rock Bolts 4m long with 4m spacing | Ton | 1,728 | 0 | 4m long rock bolts in the feasibility stage are replaced with Advanced early strength 4m long bolts and 2.6m long rock bolts with 26m diameter in the feasibility review stage. |
| 11 | Rock Bolts 2.6 m long and 26mm dia. including grouting complete in all respects | No. | 0 | 1,686 | Added at Feasibility review stage as tentative design of tunnel support system. |
| 12 | Advance early strength rock bolt 4 m long complete in all respects as per drawing | No. | 0 | 196 | |
| 13 | Steel Rib NPI 180 | Lm | 0 | 17,662 | |
| 14 | Adits (Access Tunnel) | LS | 1 | 1 | |



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| Sr. No | Description | Units | Quantity | | Remarks |
|---|---|---|---|---|---|
| | | | Feasibility Stage | Feasibility Review Stage | |
| 15 | Dewatering | LS | 1 | 1 | |
| 16 | Miscellaneous 5% for joints of all types, Drainage, Architectural details, finishes etc. | LS | 1 | 1 | |

**Table 14.5 Comparison of Quantities for Penstock**

| Sr. No | Description | Units | Quantity | | Remarks |
|---|---|---|---|---|---|
| | | | Feasibility Stage | Feasibility Review Stage | |
| 1 | Excavation for Penstock upto design depth in Medium Hard Rock requiring blasting i/c removing of material from outside of the structure area | $m^3$ | 1,382 | 2,928 | Due to the relocation of the powerhouse at the feasibility review stage, the length of the penstock has decreased. However, the cut volumes have increased due to the adjustment of the penstock longitudinal profile according to the new powerhouse location. |
| 2 | Excavation for Penstock upto design depth in Medium Hard Soil removing of material from outside of the structure area | $m^3$ | 15,600 | 26,349 | |
| 3 | PCC in overbreak section including placing, compacting, finishing & curing (Ratio 1:2:4) | $m^3$ | 110 | 110 | No Change |
| 4 | Shotcrete 35mm thick-fiber reinforced | $m^3$ | 51 | 51 | No Change |
| 5 | Filter Material | $m^3$ | 1,400 | 933 | Due to the relocation of the powerhouse at the feasibility review stage, the length of the penstock has decreased. Hence, the quantities have decreased. |
| 6 | RCC 1:1.5:3 for Lining using crushed stone aggregate (screening & ashing) and coarse sand i/c cost of all labour and material and all kinds of form works, moulds, shuttering lifting / pumping, curing, rendering and finishing the exposed | $m^3$ | 1,354 | 948 | |



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| Sr. No | Description | Units | Quantity | | Remarks |
|---|---|---|---|---|---|
| | | | Feasibility Stage | Feasibility Review Stage | |
| | surface excluding steel reinforcement | | | | |
| 7 | Reinforcement Grade 60 in Lining | Ton | 81 | 54 | |
| 8 | Rock Bolts 3m long with 2m spacing | No | 123 | 123 | No Change |
| 9 | Dewatering | LS | 1 | 1 | |
| 10 | Miscellaneous 10% for joints of all types, Drainage, Grouting, finishes etc. | LS | 1 | 1 | |
| 11 | Penstock | Ton | 802 | 535 | Due to the relocation of the powerhouse at the feasibility review stage, the length of the penstock has decreased. Hence, the quantity has decreased. |



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**Table 14.6 Comparison of Quantities for Powerhouse**

| Sr. No | Description | Units | Quantity | | Remarks |
|---|---|---|---|---|---|
| | | | Feasibility Stage | Feasibility Review Stage | |
| 1 | Excavation for Powerhouse upto design depth in Medium Hard Soil removing of material from outside of the structure area | $m^3$ | 74,451 | 138,318 | The power has been relocated to a more suitable location at the feasibility review stage, resulting in change of excavation and backfill volumes. |
| 2 | Backfilling | $m^3$ | 74,451 | 52,000 | |
| 3 | Lean Concrete 1:4:8 | $m^3$ | 635 | 635 | No Change |
| 4 | RCC for Sub structures and around Draft Tubes using crushed stone aggregate (screening & ashing) and coarse sand i/c cost of all labor and material and all kinds of form works, molds, shuttering lifting/pumping, curing, rendering and finishing the exposed surface excluding steel reinforcement | $m^3$ | 7,774 | 7,774 | |
| 5 | RCC 1:1.5:3 for walls, columns, slabs and floors using crushed stone aggregate (screening & ashing) and coarse sand i/c cost of all labor and material and all kinds of form works, molds, shuttering lifting/pumping, curing, rendering and finishing the exposed surface excluding steel reinforcement | $m^3$ | 3,426 | 3,426 | |
| 6 | Reinforcement Grade 60 | Ton | 715.45 | 715 | |
| 7 | Dewatering | LS | 1 | 1 | |
| 8 | Miscellaneous 15% for joints of all types, Drainage, Architectural details, and finishes, etc. | LS | 1 | 1 | |



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**Table 14.7 Comparison of Quantities for Tailrace Channel**

| Sr. No | Description | Units | Quantity | | Remarks |
|---|---|---|---|---|---|
| | | | Feasibility Stage | Feasibility Review Stage | |
| 1 | Excavation for Tailrace Channel upto design depth in Medium Hard Soil removing of material from outside of the structure area | $m^3$ | 12,593 | 75,558 | Due to the relocation of the powerhouse at the feasibility review stage, the length of the tailrace channel has increased. Hence, quantities have increased correspondingly. |
| 2 | RCC 1:1.5:3 for Lining using crushed stone aggregate (screening & ashing) and coarse sand i/c cost of all labour and material and all kinds of form works, moulds, shuttering lifting / pumping, curing, rendering and finishing the exposed surface excluding steel reinforcement | $m^3$ | 1,750 | 10,500 | |
| 3 | Reinforcement Grade 60 | $m^3$ | 105 | 630 | |
| 4 | Backfill | $m^3$ | 1,440 | 8,640 | |
| 5 | Dewatering | LS | 1 | 1 | No Change |
| 6 | Miscellaneous 10% for joints of all types, Drainage, Grouting, finishes etc. | LS | 1 | 1 | |



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# 15 REVIEW OF CONSTRUCTION PLANNING AND COST ESTIMATES

## 15.1 FACTORS AFFECTING PROGRESS OF CONSTRUCTION WORKS

The EPC Contractor shall plan the construction schedule keeping in view the non-productive periods of project especially two months severe winter season when the ambient temperature is below freezing point at site and the construction materials storage shall also be ensured properly protected from severe cold weather.

## 15.2 PROCUREMENT AND STORAGE OF MATERIALS

### 15.2.1 Cement

The EPC shall consider the provision of weather proof Cement silos for feeding of concrete batching plants round the year without the intrusion of moisture and will also consider the shelf life of Cement. The source approval for Cement will be subjected to the compliance of relevant standards of ASTM C-150. For mass concrete in project, use of pozzolonic material with the cementious material will also be subjected to the results of Aggregates having ASR value (Alkali Silica Resistance) or having heat of hydration more than specified limits.

### 15.2.2 Coarse Aggregate

Coarse Aggregates sources of Passu and Powerhouse area will be used for concrete production. The marble present in Passu area and Rounded Boulder Gravel Silt (RBGM) at Powerhouse Area can be used as coarse aggregate by certain amount of processing, i.e. crushing, washing, screening and blending. The suitability of coarse aggregate will be subjected to the complying the requirements of relevant ASTM Standards.

### 15.2.3 Fine Aggregate (Sand)

Huge quantity of shiskat sand deposits downstream of Attabad Lake can be checked by the EPC for the production of concrete for the project. The suitability of fine aggregate will be finalized on complying of the sand with the relevant standards of ASTM.

### 15.2.4 Reinforcing Steel

The reinforcing steel G-60 or reinforcing steel G-40 will be approved on the source selection and the complying of reinforcing steel with relevant standards of ASTM. Proper reinforcing Steel yard is required to be developed by EPC Contractor with sufficient stock of material to match with the pace of site work.

### 15.2.5 Explosive Materials

Sufficient Explosive Material will be required at site for drilling & blasting of hard rock strata and shall be utilized within its expiry date.

### 15.2.6 Steel Plates and Steel Formwork

The steel plates and steel formwork to be used for embedment and for concrete works shall be of good quality complying with the requirements of their relevant international standard.

### 15.2.7 Water and Stone for Riprap and Fill Material

The water to be used for construction and drinking purpose shall be potable and fit for drinking along with the complying of relevant health standards. Rip Rap stone to be used for protection works of structure shall be complying with the requirements of hydraulic design and relevant



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test standards. The fill materials to be used for different structures shall be selected as per the requirement and complying with the relevant standards.

## 15.3 REVIEW OF CONSTRUCTION PLANNING AND METHODOLOGY

The key for the timely completion of the Project is the construction of low-pressure Headrace Tunnel whose length is 2.3 km and this activity is on critical path which EPC contractor has to consider during preparation of Project Execution Schedule and arrange the resources accordingly

### 15.3.1 Care and Handling of Water

The two temporary coffer dams were proposed to be constructed as per Feasibility Report. First coffer dam on upstream of sediment flushing channel / under sluice and second on upstream of overflow weir. The alternative proposal by MC mentioned in Chapter 7 for construction of sediment flushing tunnel underneath the Power Intake in lieu of sediment flushing channel / under sluice will be carried out together through adit from downstream and the rock ridge on upstream will act as coffer dam for their construction and this rock ridge will be drill and blast after completion of construction whereas the placement of stepped flexible Gabion Mattress on existing weir crest will be carried out during low flow season.

EPC Contractor needs to submit the Method Statement for Care and Handling of Water for finally selected layout during detail design studies along with the detail design of coffer dam (if any) and dewatering scheme for a safe working area.

### 15.3.2 Sediment Flushing Tunnel / Channel (Under sluice)

The excavated material of sediment flushing tunnel / Channel (under sluice) will be disposed-off at spoil areas planned near the Powerhouse site as the spoil area designated shall have sufficient area to accommodate the surplus excavated material. The construction of sediment flushing Tunnel / channel (Under Sluice) is envisaged to be completed in 8 months period depending upon the available resources at site.

Upon the completion of sediment flushing tunnel underneath the Power Intake, lake water will be diverted through this structure, to commence construction activities on power intake and overflow weir section and will act as diversion tunnel.

### 15.3.3 Power Intake

The excavation and concreting activities at power intake structure are envisaged to be completed in 12 months period. After the completion of power intake structure, a trash rack cleaning machine (TRCM) will be installed for removal of debris in front of trash racks. A gantry crane will be installed for placement and removal of the stoplogs designed on the basis of their weights.

### 15.3.4 Overflow Weir / Ungated Spillway

The stone apron will be provided at the upstream and downstream side for overflow weir having stepped flexible Gabion Mattress on top of existing crest level for weir. Before placing stone apron and Gabion Mattress, the ground will be properly adjusted and compacted and if required covered by a filter fabric. The overflow weir is envisaged to be completed in 6-month period. Upon completion of overflow weir, the working area will be re-flooded to match the lake water level.



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### 15.3.5 Access Tunnels / Adits for Headrace Tunnel

The excavation of these two access tunnels for headrace tunnel one on the Power Intake side and the other is on the surge tank side will be done using the drill and blast technique which will also be used for the low-pressure headrace tunnel.

### 15.3.6 Low Pressure Headrace Tunnel

After the completion of construction activities of low-Pressure headrace tunnel, the access tunnels / adits will be plugged on both sides with the concrete mix of special type. Total time of construction around 25 months has been estimated for the excavation, rock support measures and concrete lining of low-pressure headrace tunnel

### 15.3.7 Surge Tank

After completion of excavation, the concrete lining in this structure will be taken up immediately by starting from its bottom to top with slip forms moving in an upward direction towards the tank collar. A total of 12 months has been allocated for completion of the underground excavation and concrete works of the surge tank.

### 15.3.8 Penstock

The total time for construction of Penstock (Steel lined portion & concrete Portion) starting from surge shaft to Powerhouse is estimated to be 10 months depends upon the availability of steel plate complying with the relevant standard used for fabrication of steel liner.

### 15.3.9 Powerhouse Civil Works

All these activities related to powerhouse construction will be completed in 15.5 months. The Powerhouse architectural works will be completed parallel to testing and commissioning of units as the architectural finishes items to be used for Powerhouse shall comply with the relevant standards.

### 15.3.10 Unit Erection

A proper coordination will be required between Civil & Mechanical EPC Contractor's site teams for unit erection works in Powerhouse which will ensure timely completion of the Project.

### 15.3.11 Mechanical & Electrical Installations

The total time for excavation, concreting of foundations in Powerhouse and installation of vertical Francis turbines, generators, transformers and auxiliary systems is estimated to be 21 months which require timely placement of order for manufacturing to the approved vendors, custom clearance from Port and uninterrupted transportation of Equipment to site.

### 15.3.12 Tailrace Channel

The detail design of tailrace channel shall be carried out in such a manner that the flow will smoothly discharge into Hunza river from turbine draft tubes of turbines keeping all the hydraulic parameters within the permissible limits.

### 15.3.13 Switchyard

The construction of control building is also required along with the construction of 132 kV Switchyard where Power and Control Panels for switching of different bays will be carried out. All the Power and Control cables through cable trenches will terminate in these panels.



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### 15.3.14 Transmission Lines

Two transmission lines, one from Attabad switchyard to Aliabad grid station (double circuit approx. 27km) and other from Attabad switchyard to Sost grid station (single circuit approx. 70km) shall be constructed. The total construction period for both transmission lines of 23 months will be achieved subjected to the approval of detail design, route survey and availability of construction materials.

### 15.3.15 Assembly of Electro-Mechanical Equipment

The transportation of heavy Electro-Mechanical Equipment shall be planned by EPC in such a way that the equipment shall arrive at site with the foundation ready to receive the equipment directly on it to avoid protection from wear and tear.

### 15.3.16 Testing and Commissioning

The two months duration for the final testing and commissioning shall be planned by EPC in such a manner that the design flow required to guarantee the full installed generation capacity of the Project.

## 15.4 REVIEW OF PROJECT IMPLEMENTATION SCHEDULE

During detailed design and execution of actual works, EPC Contractor may develop his own construction schedule in such a way that most of the works can be taken up simultaneously as per the resource allocation on various project components in order to complete the project in the shortest possible time. The requirement of coffer dam construction can be assessed by EPC on the basis of methodology used for the construction of sediment flushing tunnel underneath the Power Intake and placement of stepped Gabion Mattress on existing weir crest.

## 15.5 CONSTRUCTION MANAGEMENT

### 15.5.1 Project Executing Agency

WAPDA as Project Execution Agency will also coordinate with Gilgit Baltistan's authorities and departments for any issues arising about the project execution, which require resolution by inter-departmental interaction for smooth Project execution.

### 15.5.2 Consultants

During the Construction Phase of the Project, the Consultants will in general review & monitor the detailed design, construction procedures, Inspection & Testing Plans, Quality assurance & Quality Control Manual, manufacturing, procurement, installation, commissioning & testing of works by the EPC Contractor. The Consultant's services will be in close coordination with the Project Executing Agency WAPDA.



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# 16 REVIEW OF ENVIRONMENTAL IMPACT STUDY

## 16.1 GENERAL

The Volume 6 of Feasibility study 2021 represents the Environmental and Socioeconomic Impact Assessment (ESIA) Report. WAPDA has submitted the ESIA Report to Gilgit Baltistan Environmental Protection Agency (GBEPA) in August 31, 2022 to initiate the process of No Objection Certificate (NOC) / Environmental Approval. The title of document should be Environmental Impact Assessment (EIA) or Initial Environmental Examination (IEE) as per regulations being followed by Gilgit Baltistan Environmental Protection Agency (GBEPA), not an Environmental and Socioeconomic Impact Assessment (ESIA). Moreover, an executive summary should be included in the document.

Following are the section/chapter wise review findings and comments for Volume 6 of the Feasibility report.

## 16.2 CHAPTER 1: INTRODUCTION

1. Please refer to ***Section 1.3: Environmental and Social Impact Assessment (ESIA)***

- After the 18th Amendment protection of the environment became a provincial subject, so it is better to use Gilgit Baltistan Environmental Protection Act, 2014, instead of Pakistan Environmental Protection Act, 1997.
- Screening had been carried out for EIA while the title of document is ESIA, needs correction.
- Either the proposed project is being funded by World Bank or not, as it referred the World Bank guidelines (OP 4.0).

2. Please refer to ***Section 1.4 Project Categorization***

- Since the proposed project falls under the schedule II requiring an EIA, while the name of document is ESIA, there is no provision of ESIA under IEE/EIA Regulations 2000.
- If the project is not being funded by donor agencies, then there is no need to mention the WB, ADB and JICA, their requirements are more stringent than national/provincial laws in specific aspects.
- As it is mentioned that the proposed project involve installation of 132kV transmission line as well, so the consent of GB EPA was obtained that either a consolidated document/EIA or separate documents/EIAs for hydropower and transmission line will be submitted to GBEPA? Both Hydropower and 132kV Transmission Line may have adverse environmental and social impacts.

3. List of EIA team is not provided. Project Location map showing the location and area of influence needs to be provided to assess/have an idea of environmental and social impacts of the area.

## 16.3 CHAPTER 2: PROJECT DESCRIPTION

1. Project Alternatives are not provided/discussed, including no project option, based on cost, design, location and other technical aspects considered while designing different components of hydropower and associated transmission lines.
2. Project layout plans are not provided.



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3. Limited design details are provided for 132kV Transmission Line, it needs to be elaborated to properly encounter the possible environmental and social risks and impacts.
4. Safety consideration during operation are not provided.
5. Construction planning aspect is also not provided including but not limited to: details of construction camps, work force required during construction and operation phase, water requirements, power requirements, material requirements and source, construction schedule, project cost etc.

## 16.4 CHAPTER 3: REGULATORY LAWS AND THE INSTITUTIONAL FRAMEWORK

1. GB Environmental Protection Act 2014 is the core act in Gilgit Baltistan dealing with environment related issues, which has not been discussed in the main report.
2. Following, but not limited to, Acts are not considered in the report:

- Prohibition of Employment of Children.
- Gilgit-Baltistan Forest.
- Fisheries
- GB Disaster Management.
- Protection against Harassment of Women at the Workplace.

3. Pakistan is a member/signatory of several international organizations; the report is silent regarding International Treaties and Conventions.
4. Please refer to ***Section 3.4.1 Land Acquisition Act (LAA), 1894***, in addition to LAA, 1894, it is mentioned that the proposed project fulfil the requirements of World Bank, again if the project is not being funded the WB then no need to follow its guidelines, as these are more stringent than LAA, 1894 and may face difficulties while complying.
5. The relevancy of each act may be provided that either it is applicable to the proposed project or not.
6. Guidelines for the preparation of EIA report are not provided such as Guidelines for Public Consultations, Guidelines for Sensitive and Critical Areas and Guidelines for the preparation and review of Environmental reports.

## 16.5 CHAPTER 4: BASELINE CONDITIONS

1. Overall, the baseline information (physical, biological and socio-economic environment) provided in the report is generic and representing almost whole province (Gilgit Baltistan). The baseline information needs to be revised and should be project specific.
2. Sources of secondary information are not provided, supporting maps of the project area may also be provided.
3. Time period of climatic data is not provided.
4. Either the Environmental Monitoring was carried by EPA certified Laboratory or not?
5. Number of Monitoring points along with location is not discussed, only results of one (01) point of ambient air and noise is provided. Moreover, comparison with NEQS is also not provided.
6. Separate noise values are not provided for daytime and nighttime intervals as per NEQS.
7. Detail regarding the sensitive receptors of the project area are not provided. It may help in actual impact assessment and their mitigation measures.
8. Please refer to ***Section 4.1.10: Land Use***, The land use of project area needs to be provided where the project interventions are proposed instead of whole province (Gilgit Baltistan).
9. Please refer ***Section 4.1.18: Surface Water,*** Environmental Monitoring, Sampling and Testing of water quality is not provided as per NEQS.



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10. Please refer to ***Section: 4.2.6 Endangered, Threatened or Vulnerable Species of Fauna***, *the endangered, threatened and vulnerable species in the project area are Markhor (Capra flconeri) Snow leopard (Unica unical) Ladakh urial (Ovis vignei) Woolly flying squirrel (Eupegaurus cinereus.).* It needs to be rechecked, the relevant expert carried the ecological survey or not?
11. Please refer to ***Section 4.3: Social and Economic Environment***, either the socio-economic survey was carried out with the project affected persons or not, as no information about no. of respondents interviewed, their socio-economic conditions, sample size, project acceptability etc. is provided.

**Stakeholder Consultations**

1. Stakeholder Consultation is an important part of the environmental studies, this chapter is missing in this report.

## 16.6 CHAPTER 5: ESIA AND MITIGATION MEASURES

1. Please refer to ***Section 5.1: General***, multiple funding agencies have been mentioned in this report, if the proposed project is not being funded by the ADB, then no need to mention that impact assessment has been carried out using checklist developed by ADB.
2. Please refer to ***Section 5.2: Impact Assessment Procedure***, Impact evaluation matrix is not provided.
3. Please refer to ***Section 5.3: Impacts During Construction***, Impacts may be categorized into different phases of project like pre-construction, construction and operation phase for better assessment.
4. Land acquisition is a critical issue, while this impact is not covered in this chapter. Hoverer, in ***Section 6.8: Land Requirements for The Project (Chapter 6)***, it is mentioned that land (government and private) will be acquired for the proposed project.
5. Overall, the impact assessment (physical, ecological and socio-economic environment) is generic keeping in view the extent of project, it needs to be revised based on project activities and quantified. In addition, following impacts but not limited to, are also anticipated due to the proposed interventions which are not addressed: wastewater generation, solid waste management, siting of construction camps, emergency response, land acquisition, labour influx, child and forced labor, COVID-19, gender issues, community health and safety etc.
6. Since the proposed project involves the installation of 132kV Transmission Lines, the present impact assessment is not covering this aspect.
7. In baseline conditions, it is mentioned that in project area there are endangered, threatened and vulnerable species, the impact assessment is silent in lieu of these species.
8. Impact assessment is based on the project specific baseline for the physical, biological and social profile, since the existing Baseline Conditions (***refer chapter 5***) presented for the whole province instead of project specific area. Keeping in view the above, the impact assessment needs substantial improvement.

## 16.7 CHAPTER 6: ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN

1. Please refer to ***Section 6.2: Mitigation Management Matrix (MMM)***, under this section, a table needs to be provided including impacts, mitigation measures, responsibilities, monitoring frequency, and monitoring indicators etc.
2. Institutional Arrangement for Implementation of EMMP during construction and O&M phases is not provided. Further, roles and responsibilities of implementing agencies is also not provided.



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3. Following guidelines, but not limited to (as per advice of Environmental Specialist), need to be provided for the preparation of site specific environmental and health & safety management plans: *Tree Plantation / Reforestation Plan, Health, Safety and Environment (HSE) Management Plan, Emergency Preparedness and Response Plan, Restoration and Rehabilitation Plan, Waste Management Plan, Disaster Management Plan, Drinking Water Supply and Sanitation Plan, Traffic Management Plan, Change Management Plan, Resource Conservation Plan etc.*
4. Please refer to ***Section 6.6: Impact Monitoring Program***, detailed monitoring plan needs to be provided including monitoring parameters, location, monitoring mechanism, frequency, duration etc.
5. Please refer to ***Section 6.9: Environmental Mitigation and Land Acquisition Cost***, Costs related to Land Acquisition, HSE, Environmental Monitoring, Tree Plantation, Environmental, Social & Health and Safety Experts are not provided.
6. This ESIA including EMMP should be made a part of bidding document to ensure the compliance, there a separate section / a paragraph needs to be provided showing the inclusion of ESIA including EMMP into the contract documents.
7. Reporting and Documentation section is also not provided.
8. Trainings and Awareness Plan including type of training, staff/participants, schedule, responsibility etc. also not provided.
9. Appropriate Grievance Redress Mechanism (GRM) is not provided to resolve the complaints.

## 16.8 CONCLUSIONS AND RECOMMENDATIONS

This chapter is missing in the Feasibility Report.



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# 17 REVIEW OF ECONOMIC AND FINANCIAL ANALYSIS

## 17.1 GENERAL

The Attabad Hydropower Project will be located on Hunza River. The project is 20 km from Karimabad, 120 km from Gilgit and 735 km from Islamabad. Initial Feasibility of Attabad Lake Hydropower Project (ALHPP) was conducted by Govt. of Gilgit-Baltistan in 2016-17, with the estimated installed capacity of 32.5 MW. In 2019, WAPDA updated the project feasibility study with proposed installed capacity to 54 MW with a 2320 m long headrace low pressure tunnel on the left side of Hunza River. According to Feasibility Report 2019, It will have an installed capacity of 54MW, capable of producing 374 GWh of average annual energy per year. According to the construction schedule provided in the Consultant's Report, the total construction time for ALHPP is about thirty-six (36) months.

This review report briefly discusses the economic and financial analysis of the feasibility report, as prepared by WAPDA in 2019. The financial and economic parameters associated with project benefits and costs were studied and compared with reference to Economic and Financial Analysis (Chapter 17 of Feasibility Study Report) along with the judgment from other similar nature projects.

The objectives of the review were to verify the main parameters, analysis and results of economic and financial analysis of ALHPP and provide review comments, suggestions and recommendations, if any.

Following are the key aspects covered during the study.

i) Review of assumptions and calculation of economic parameters, conversion factors, prices etc.
ii) Review of methodology and parameters adopted for estimation of economic benefits of hydropower.
iii) Review of Economic Internal Rate of Return (EIRR) and sensitivity tests.
iv) Review of assumptions and parameters used for financial analysis.
v) Review of estimation of energy revenues.
vi) Review of composition of total investment cost of the project, including price escalation, interest during construction and cost of project financing.
vii) Review of financial profitability, financial internal rate of return (FIRR) etc.
viii) Review of unit generation cost.
ix) Indication of shortcomings (if any) and suggestions for improvement.

To ascertain the financial and economic viability of the said project, the analysis has been reviewed on the basis of efficiency criterion of public investment using "discounted cash flow" technique. The parameters like "Net Present Worth", "Benefit Cost Ratio", and "Internal Rate of Return" have been reviewed in detail by rechecking calculations.

Following are the main comments/observation on economic and financial analysis of the project.

## 17.2 REVIEW OF ECONOMIC ANALYSIS

- Opportunity cost of capital/cut-off discount rate has been taken as 12% for deciding the economic viability of the project.
- Standard Conversion Factor (SCF) has been calculated as 0.91 on the basis of data from 214-15 to 2018-19. In some places, the figure of 0.90 was used. The data on total exports, import duty and sales tax on imports (Table-17-6) was not found correct. Once



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substantiated with updated data of import/export and tax/subsidies statistics, SCF has been recalculated as 0.871.

- Shadow wage rate for labour has been used as 0.75 in the Feasibility report.
- Economic cost has been estimated as Rs. 18410 Million, using the base cost of Rs. 20028 Million.
- While converting the financial investment cost of ALHPP to economic cost, the taxes have not been deducted from the base cost. Taxes are transfer payments and usually excluded in economic cost.
- Economic appraisal has been undertaken mainly on the basis of conventional avoided costs of equivalent thermal plant. The LNG based thermal power plant (OCGT) was indicated as alternate equivalent thermal power source. The investment cots of alternate thermal power plant has been assumed as USD 1.0 Million (at the given exchange rate of 1USD=157 Pak Rupee), which seems on a higher side. This investment cost has been phased in two years (50% each).
- The installed capacity of equivalent thermal power plant is not mentioned in the document.
- Annual O & M cost of OCGT plant has been assumed as 3% (USD 0.004/kWh), which seems reasonable.
- LNG price (fob) has been taken as USD 7.48 MMBtu. The fuel cost has been calculated as Rs. 8.42 per Kwh. The fuel cost need to be updated as per latest prevailing prices.
- Saving of fuel and O & M cost of alternate thermal power plant has been taken as major economic benefits of ALHPP.
- Emission reduction benefits of ALHPP in economic analysis were calculated on the basis of CDM financial price of USD 1.5 per Ton of CO2, which is not correct. The economic benefits of CO2 emission reduction are based on “Global Social Cost of Carbon” rather than on financial price of CDM.
- The operating cost of hydel station is mentioned as 1% of base cost. The difference of civil and electro-mechanical items has not been adopted.
- EIRR of ALHPP was calculated as 22.54% and 22.36% for with and without emission scenario. Sensitivity analysis showed that EIRR calculated was robust and remained above opportunity cost of capital (12%) even under worst assumption of simultaneous increase in project cost and decease in project benefits.

## 17.3 REVIEW OF FINANCIAL ANALYSIS

- Project cost has been worked out at price level of 2021, with an exchange rate of 1USD=157 Pak Rs.
- Project base cost has been calculated as Rs. 20028.920 Million, phased in three years.
- Price escalation (during construction) has been estimated as Rs. 1000.537 Million, using annual inflation rate of 6.5% for local cost and 2% for foreign cost.
- Keeping in view the historic increase in US CPI, foreign escalation rate need to be reconsidered.
- Source of financing is not mentioned in the Feasibility study.
- Interest During Construction (IDC) was not calculated, shown as zero.
- Total financial cost (without IDC) was calculated as Rs. 21246 Million.
- While doing the amortization of financial investment cost for calculating the Unit Generation Cost, the interest rates for local and foreign cost financing have been kept same (12.20%), which may be different if there is different sources of financing.
- Unit generation cost has been estimated as Rs. 5.67 per kWh, which seems attractive.



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- The energy sale price has been assumed as Rs. 13.40 per kWh for estimating energy sales revenues. If the energy is intended to be sold in GB, this seems higher sale price as the existing tariff rate in GB is lower (under Rs. 10 per kWh).
- Annual energy revenues have been estimated as Rs. 5007 Million while CDM revenues (@ USD 1.5 per Ton) were found as Rs. 29.92 Million.
- FIRR has been estimated as 19.27% and 19.17% for with and without CDM benefits.
- Sensitivity analysis of FIRR has not been performed.
- Payback of investment cost has been estimated as 5 years, however backup calculation is not given.

## 17.4 RECOMMENDATIONS FOR FURTHER IMPROVEMENT OF STUDIES

Following are the important recommendations for improving the robustness of economic and financial analysis of the said project:

- For economic analysis, taxes and duties need to be exempted from economic cost.
- Energy sale price need to be reconsidered, keeping in view existing tariff in GB.
- A detailed sensitivity study to check the robustness of financial model is required which would ultimately impact the financial viability of the project.
- The financial analysis needs to be updated on the basis of careful and through project cost reviews.



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# 18 CONCLUSIONS AND RECOMMENDATIONS OF REVIEW STUDY

The Dam due to landslide created a Lake behind it at Attabad not only possess a threat but at the same time an opportunity for making use of the head due to this Earthen Dam. Due to lake formation, there is potential drop of more than 100 m in 2.5 km river reach. The mean annual flow of Hunza River at Attabad Lake is 204 $m^3/s$. The Project Layout is to be configured considering the power demand and demand pattern of regional grid. Attabad Lake storage can be used for daily peaking. A design discharge with peaking storage facility is to be selected to generate the installed capacity 95% time of the year in peak hours. From the available flow data and estimated flow series at Project Area, a discharge of 60 $m^3/s$ has been taken as design discharge for power generation.

A modification in Feasibility stage Alternative- IA layout is proposed by MC based on Feasibility Report review findings and site visit observations. The modifications, as summarized hereunder, are to be checked for technical and economic viability during Detail design stage by EPC Contractor.

If a flushing tunnel is added underneath the intake area at distance of 7m away in the plan and its outlet after the most disturbed area, it will increase the life of Power house for many years. A tentative discharge of about 72 $m^3/s$ for flushing tunnel will be required which is available plenty of time throughout the year. Only risk involved in this concept will be outlet portion of the flushing tunnel which will lie in overburden area. Cut and cover conduit or even open channel can be provided in this overburden area. In worst conditions, if some damage occurs to outlet structure, it can easily be repaired any time because flushing will not be done throughout the year.

Another aspect if in case all past slided mound at Weir site is washed away at weir site, then a temporary coffer dam can be constructed for constructing new/ fresh weir / dam in this area.

In case we move intake structure to weir location and in case all slide material washed away then in this scenario to restore electricity from Power house we have to wait for restoration of weir / dam first then Power house will be in operation condition.

To strengthen the present weir / dam area MC propose a gabion mattress overlay in all area of weir site to avoid long term damages during flood season.

The reduction in the total project excavation by avoiding excavation for abutments and foundation of overflow weir will considerably reduce the overall cost of the project due to presence of slided mass on right and left banks both.

Based on verification study and calculations, the solution finalized in the Feasibility study with installed capacity of 54MW and 79% plant factor is most optimized solution. However, as per recommendations from Mechanical expert, efficiency of turbine can be taken as 93%. MC endorse the selection of turbine with 93% efficiency which may result in little higher installed capacity of about 57 MW.

Based on review of Feasibility Report, MC validate the data and importance to construct the Attabad Lake Project as early as possible.

ALHPP is found to be technically feasible, economically viable and environmentally acceptable and will fulfill electricity needs particularly for Hunza City and in general for Hunza, Gilgit and Ghizar Regions. Therefore, recommended for implementation at the earliest.



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WATER AND POWER DEVELOPMENT AUTHORITY
PAKISTAN

# ENGINEERING, PROCUREMENT AND CONSTRUCTION (EPC) OF ATTABAD LAKE HYDROPOWER PROJECT (54 MW)
# PACKAGE-III: ELECTRO-MECHANICAL WORKS

## VOLUME-III: ADDITIONAL INFORMATION

### PART-III: TOPOGRAPHIC SURVEY MAP BOOK

ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

NESPAK DOLSAR

MARCH 2026

BOOK 7

DOCUMENT NO: BD-ALHPP-03 (V3-TSMB)

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# ENGINEERING, PROCUREMENT AND CONSTRUCTION (EPC) OF ATTABAD LAKE HYDROPOWER PROJECT (54 MW) PACKAGE-III: ELECTRO-MECHANICAL WORKS

## INDEX TO BIDDING DOCUMENTS


VOLUME-I: BIDDING PROCEDURES AND CONDITIONS OF CONTRACT

Part-I: Bidding Procedures

Part-II: Conditions of Contract and Standard Forms

VOLUME-II: EMPLOYER'S REQUIREMENTS

Part-I: Special Provisions

Part-II: Technical Provisions

Part-III: Conceptual Drawings

**VOLUME-III: ADDITIONAL INFORMATION**

Part-I: Feasibility Study Report (2021)

Part-II: Feasibility Review Report (2022)

**Part-III: Topographic Survey Map Book (2025)**

Part-IV: Updated Environmental Impact Assessment (EIA) Report





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# GEODETIC SURVEY CONTROL REPORT

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ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

# ATTABAD LAKE HYDROPOWER PROJECT (54MW)

## GEODETIC SURVEY CONTROL REPORT

### TABLE OF CONTENTS


| | | Page No. |
|---|---|---|
| TABLE OF CONTENTS | | I |
| LIST OF TABLES | | II |
| LIST OF FIGURES | | II |
| LIST OF ABBREVIATIONS | | III |
| 1 | GEODETIC SURVEY CONTROL | 1 |
| 1.1 | REFERENCE SURVEY BENCHMARK | 1 |
| 1.2 | ESTABLISHMENT OF CONTROL NETWORK | 3 |
| 1.3 | LOCATION OF MONUMENTS AND SURVEY MARKERS | 6 |
| 1.4 | DESIGNATING SURVEY CONTROL MONUMENTS | 6 |
| 1.5 | DATUM AND COORDINATE SYSTEM | 6 |
| 1.6 | TOOLS AND SOFTWARE | 7 |
| 1.7 | PRECISION AND ACCURACY STANDARDS | 7 |
| 2 | PREPARATION OF TOPOGRAPHIC SURVEY PLAN | 8 |


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## LIST OF TABLES

Table 1.1: List of R Geodetic Survey Control Points (CPs) ..... 1
Table 1.2: List of Established Geodetic Survey Control Points (CPs) ..... 3

## LIST OF FIGURES

Figure 1.1: Permanent Benchmarks in Project Area ..... 1
Figure 1.2: Location Map of Reference Survey Control in the Project Area ..... 2
Figure 1.3: Location Map of Established Control Map ..... 4
Figure 1.4: Onsite Views of Control Points (CPs) ..... 5

**Annexure:**

**Annexure A** Topographic Survey Plan – Map Book



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## LIST OF ABBREVIATIONS

| | |
|---|---|
| AOI | Area of Interest |
| BM | Benchmark |
| CAD | Computer Aided Design |
| CP | Control Point |
| DEM | Digital Elevation Model |
| DGPS | Differential Global Positioning System |
| DSM | Digital Surface Model |
| DTM | Digital Terrain Model |
| DWG | Drawing |
| EDM | Electromagnetic Distance Measurement |
| EGM | Earth Gravitational Model |
| GCP | Ground Control Point |
| GeoTIFF | Geographic Tag Image File Format |
| GIS | Geographic Information System |
| GOP | Government of Pakistan |
| GNSS | Global Navigation Satellite System |
| GPS | Global Positioning System |
| NFZ | No Fly Zone |
| NESPAK | National Engineering Services Pakistan Private Limited |
| PC | Personal Computer |
| RTK | Real Time Kinematic |
| SD Card | Secure Digital Card |
| TBC | Trimble Business Center |
| TOR | Terms of Reference |
| UAV | Unmanned Aerial Vehicle |
| UTM | Universal Transverse Mercator |
| WGS | World Geodetic System |

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# 1 GEODETIC SURVEY CONTROL

A geodetic control lays the foundation for the creation of an accurate topographic survey. The system permits the spatial referencing of all identifiable land features using permanent structures and control points.

## 1.1 REFERENCE SURVEY BENCHMARK

During the topographic survey, two permanent benchmarks named BM-01 and BM-02 were found that were established during the feasibility study. These benchmarks were found stay able and intact. Figures are shown below.

Figure 1.1: Permanent Benchmarks in Project Area

These benchmarks were used as reference control points for the extension of survey control network and to conduct the aerial topographic survey.

The details of coordinates of benchmarks are listed below.

Table 1.1: List of R Geodetic Survey Control Points (CPs)

| REFERENCE SURVEY CONTROL POINTS | | | |
|---|---|---|---|
| **Name** | **Easting (m)** | **Northing (m)** | **Elevation (m)** |
| BM-1 | 481492.111 | 4017731.973 | 2384.005 |
| BM-2 | 482044.978 | 4017941.760 | 2360.841 |

The location map of the reference benchmarks is given in Figure 1.2.



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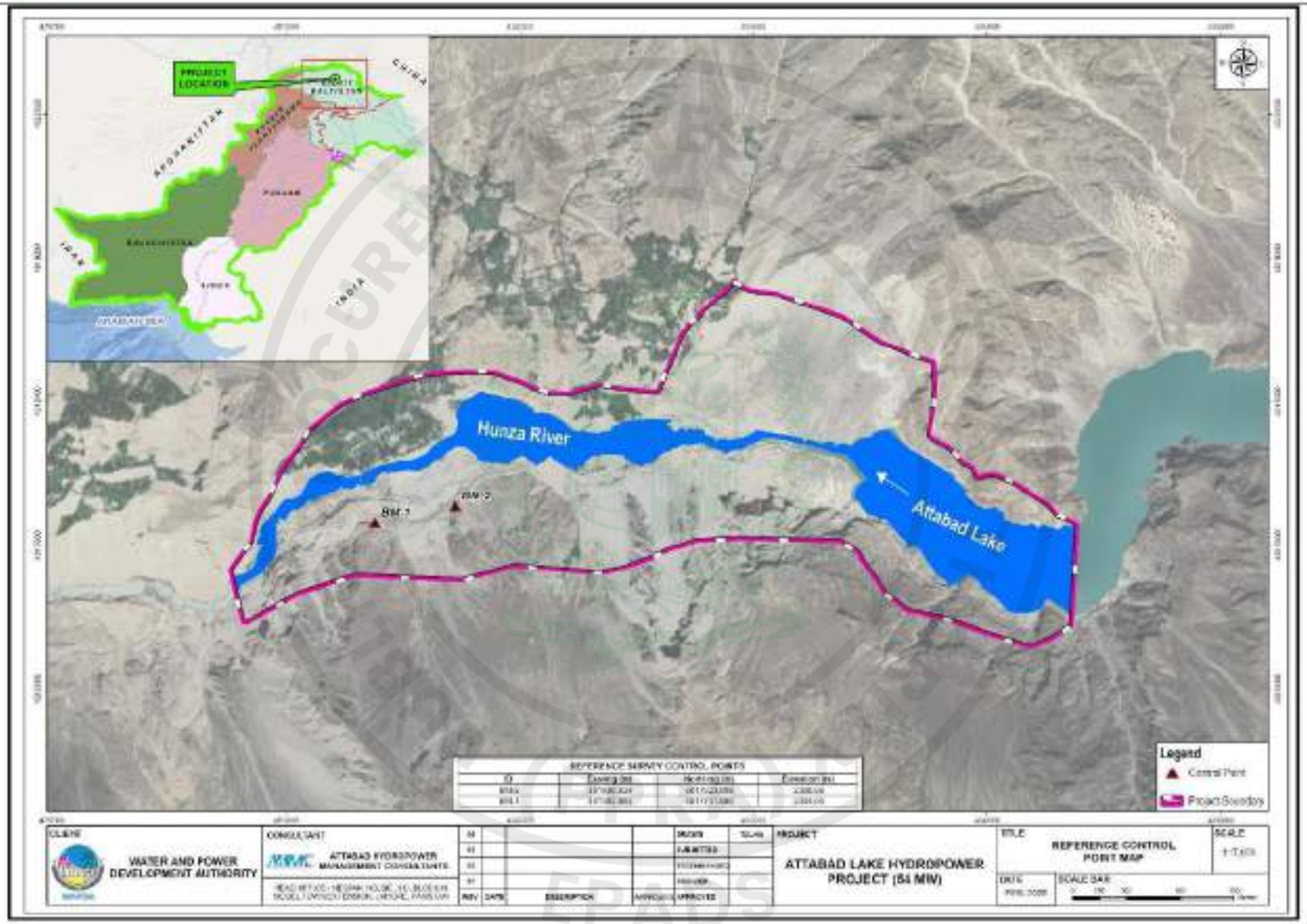


Figure 1.2: Location Map of Reference Survey Control in the Project Area



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## 1.2 ESTABLISHMENT OF CONTROL NETWORK

A wide variety of GPS satellite networks were available and processed to establish reliable baselines in static mode and hence were used to densify the project control network through static survey technique. Unlike terrestrial triangulation, trilateration, and EDM traverse surveying, the shape or geometry of the GPS/GNSS network design is usually not as significant. Care was taken to avoid including trivial baselines in the final network adjustment. No previous benchmark/control was found in the project site. Therefore, a new control network was established using Trimble Dual-frequency DGPS.

Table 1.2: List of Established Geodetic Survey Control Points (CPs)

| Serial No. | Control Point Name | Easting | Northing | Elevation |
|---|---|---|---|---|
| | | (Meter) | (Meter) | (Meter) |
| 1 | ALD2B | 481298.784 | 4017715.022 | 2396.44 |
| 2 | APH-5 | 483642.674 | 4018013.34 | 2490.69 |
| 3 | ALD-6 | 484047.319 | 4017955.711 | 2478.97 |
| 4 | ALD-7 | 485705.464 | 4017439.092 | 2457.45 |

The listed above coordinates are computed in ground coordinates with UTM (Universal Transverse Mercator) projection system in zone 43 N.

The location map of the Control Points (CPs) is given in Figure 1.3.



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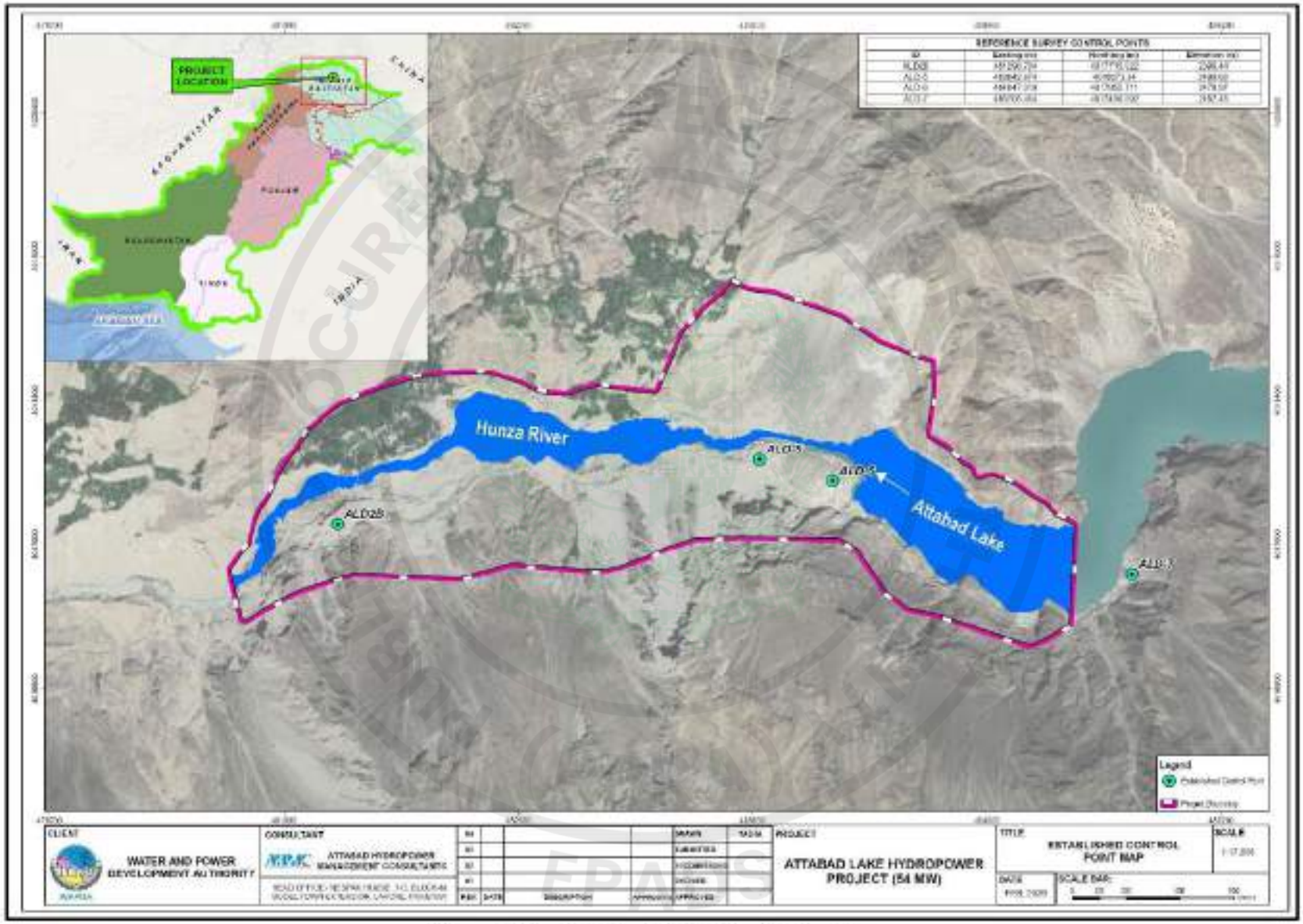


Figure 1.3: Location Map of Established Control Map



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The on site views during the establishment of the control network as shown in Figure 1.4:

Figure 1.4: Onsite Views of Control Points (CPs)



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## 1.3 LOCATION OF MONUMENTS AND SURVEY MARKERS

The most effective precaution taken to ensure marker's stability and survival is to choose an appropriate location. Therefore, good judgment has been exercised.

The survey team selected the locations of the monuments based on the following aspects:

- **SECURITY:** The security of a survey monument is the foremost in the list of evaluation considerations. To avoid the susceptibility to damage or destruction by local people, animals, etc., the selected location should be safe and secure.
- **AVOIDANCE OF FLOODPLAIN:** Markers located in floodplains may be buried in sediment or washed out due to erosion. To avoid such damages, the floodplains were avoided during site selection for monuments.
- **ACCESSIBILITY:** Accessibility of the markers is a vital criterion in the selection of the location for survey markers. These yields are time-saving for observation and workability.
- **STABILITY:** The markers are subject to the effects of geologic and soil activity. The consistency of the soil, soil type, vegetation, and its roots, surface geology, and corrosion were considered for the selection of the location of the control monuments.
- **SATELLITE VISIBILITY:** Since all the markers are being observed and established using the GNSS system, hence the satellite visibility was also considered for the selection of the location of the marker. Sites that provide maximum visibility above the horizon, plus 15 degrees were selected.
- **INTER-VISIBILITY:** The locations were precisely refined in such a way that all the markers should be inter-visible to adjacent markers. This ensured the usability of terrestrial survey equipment such as the Total Station for survey works during construction.

## 1.4 DESIGNATING SURVEY CONTROL MONUMENTS

It is a standard practice to assign understandable names to the control monuments for identification. In this case, Control Points were named "PH" while Ground Control Points were shown with the "GCP" acronym.

## 1.5 DATUM AND COORDINATE SYSTEM

The survey was conducted in the WGS-84 datum, UTM (Universal Transverse Mercator) zone 43 N (Northern Hemisphere) using geodetic parameters as listed below.

All of the quoted coordinates in this report are referred to the following parameters:

- Spheroid: WGS-84
- Semi-major axis (a): 6378137 m
- Semi-minor axis (b): 6356752.314 m
- Inverse Flattening (f): 298.25722



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The project area lies in the UTM 43 Northern Zone. The parameters for Universal Transverse Mercator (UTM) Zone 43 N are as under:

- Latitude of Origin: 0.000000° equator
- Central meridian: 63.000000° E
- False easting: 500000.00000 m
- False northing: 0.000000 m
- Scale factor: 0.999600
- Linear Unit: Meter (m)

### 1.6 TOOLS AND SOFTWARE

A Trimble® R9 GNSS system and Trimble R2 GNSS system were used for the establishment of horizontal and vertical control networks within the periphery of the project boundary.

The data collected by GNSS was processed by using the licensed software Trimble® Business Centre (TBC) v5.4. It comes with the dedicated Geoid Model for Pakistan based on EGM (Earth Gravitational Model) 2008 Geoid Model. This model was used to derive orthometric heights (elevations) of the control network during the processing of GNSS data.

### 1.7 PRECISION AND ACCURACY STANDARDS

The Geodetic Survey Control Network was established by following the international standards and protocols. Special care was taken in setup of equipment in filed like measuring the antenna height and centering. The specifications of GNSS equipment are shown below.

| Positioning | Mode | Horizontal Accuracy (RMS) | Vertical Accuracy (RMS) |
|---|---|---|---|
| RTK (OTF) | Synchronized | 1 cm + 1 ppm (× baseline length) | 2 cm + 1 ppm (× baseline length) |
| | Low Latency | 2 cm + 2 ppm (× baseline length)[3] | 3 cm + 2 ppm (× baseline length)[3] |
| L1 C/A Code Phase | Synchronized/ Low Latency | 25 m + 1 ppm RMS | 50 m + 1 ppm RMS |
| Static/ FastStatic | N/A | 5 mm + 0.5 ppm (× baseline length) | 5 mm + 1 ppm (× baseline length) |
| WAAS | N/A | Less than 5 m[3] | Less than 5 m[3] |

Special protocols were adopted in post-processing and the accuracy was achieved according to the standards.



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## 2 PREPARATION OF TOPOGRAPHIC SURVEY PLAN

As stated, all the data was processed with reference to the geodetic control network. The topographic survey data and aerial mapping were executed in the metric system.

The final Ortho-rectified very high-resolution image of 4 cm pixel size, was used for visual interpretation. Spatial features were digitized on the ortho-rectified image that included:

- Road
- Tracks
- Orchid
- Lake
- River
- Built-up
- Structures
- Road Debris
- Transmission Pole
- Trees
- Transmission Line
- Agriculture Boundary
- Drain

These vector features were incorporated into the map to develop topographic survey drawing.
The contours were extracted from Digital Terrain Model (DTM) at 0.5m interval.

Furthermore, GIS based map book was generated at a 1:1000 scale for the Topographic Survey Plan in the metric System having fifty-six (56) sheets of A3 page size (**"Annexure –A"**).



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# ANNEXURE-A
# TOPOGRAPHIC SURVEY PLAN
# MAP BOOK

ATTABAD HYDROPOWER
MANAGEMENT CONSULTANTS

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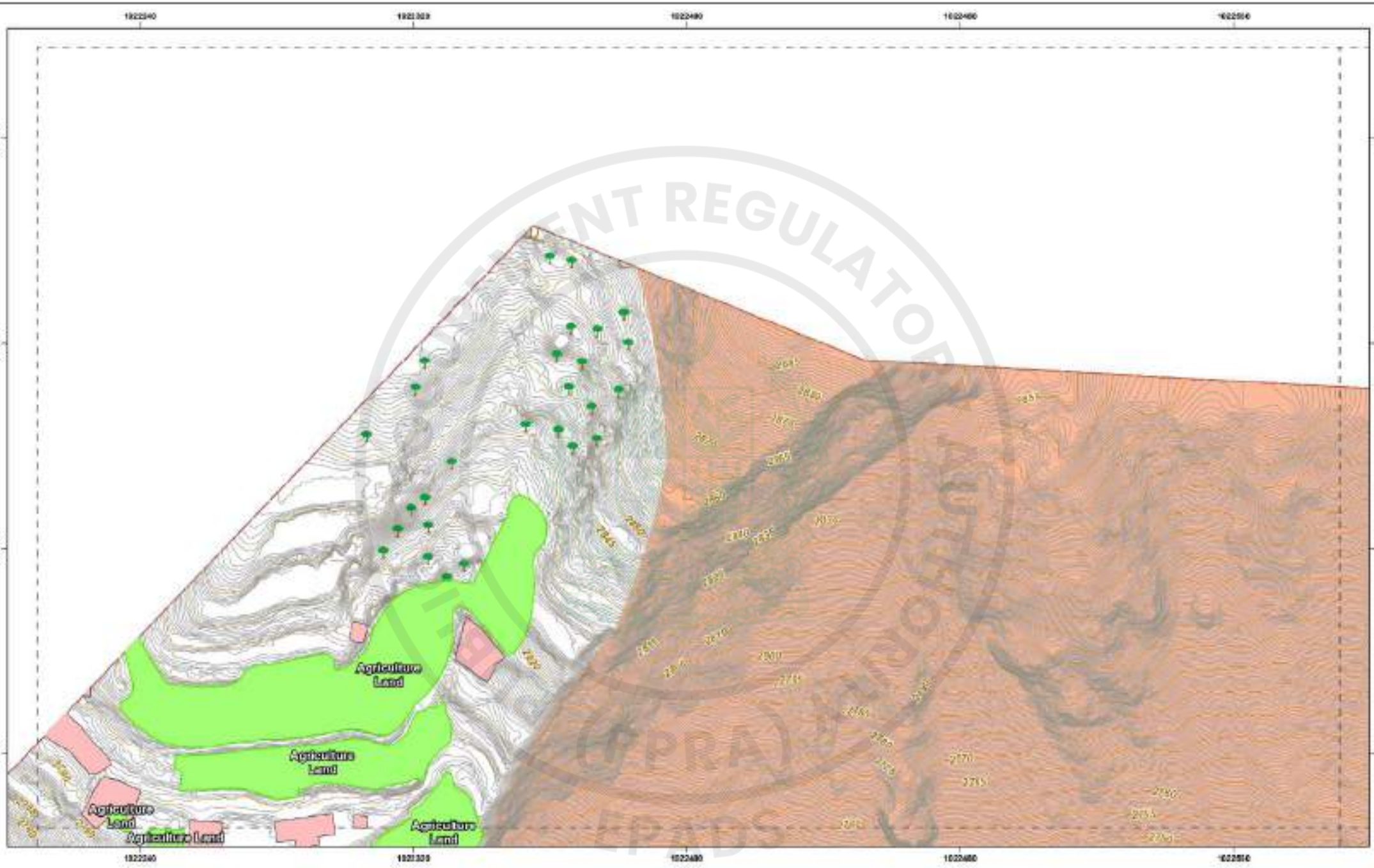


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|---|---|---|---|---|---|---|---|
| CLIENT<br>WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | CONSULTANT<br>APK ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: 15 FARAK HOUSE, 1-E, BLOCK-R, MODEL TOWN EXTENSION, LAHORE, PAKISTAN | LEGEND | INDEX MAP | DISCLAIMER<br>1. This Map has been prepared by National Engineering Services Pakistan (PVT) Ltd exclusively for the Technical Inquiry Purposes in connection with Study and Detailed Design for Construction of Attabad Lake Hydropower Project (54 MW).<br>2. The Topographic Survey has been prepared by Aerial Photogrammetric Survey carried out in October 2021.<br>3. This information can solely for the use of the authorized recipient.<br>4. In no case, will be a third party replies of this Report and response on an exclusive basis made based on it, are the responsibility of the such party, and NESPAK accepts no responsibility for damages, if any, suffered by any third party as a result of such decisions or actions. | PROJECT<br>ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TITLE<br>TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM | SCALE<br>1:1000<br>DATE<br>FEB 2026<br>SHEET NO.<br>Page 1 of 01<br>SCALE BAR: |

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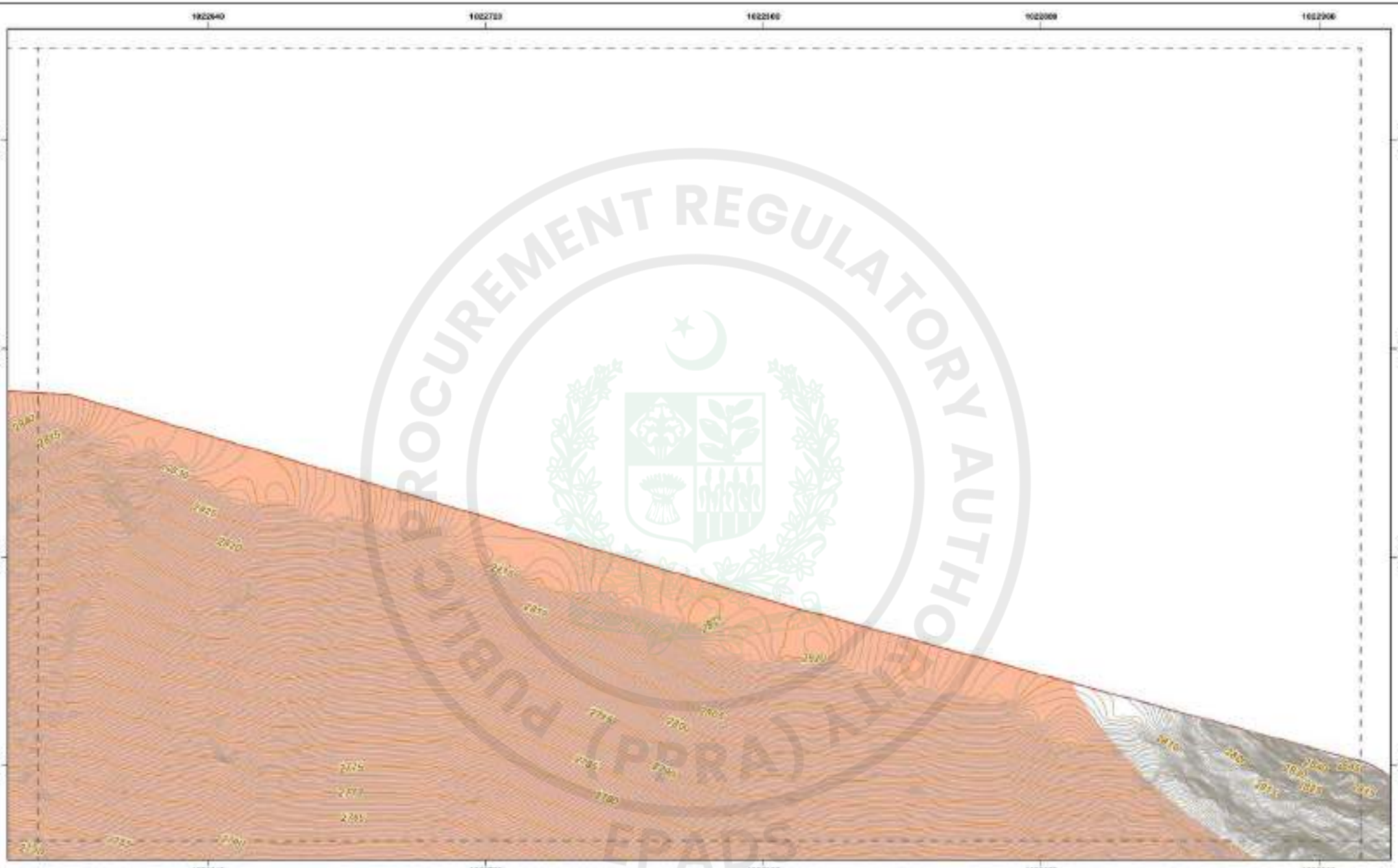


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| CLIENT<br>WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | CONSULTANT<br>APK ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE : 5 FARAK HOUSE, 1-E, BLOCK-R MODEL TOWN EXTENSION, LAHORE, PAKISTAN | LEGEND | INDEX MAP | DISCLAIMER<br>1. This Map has been prepared by National Engineering Services Pakistan (PVT) Ltd exclusively for the Technical Inquiry Purposes in Year 2020 for Study and Detailed Design for Construction of Attabad Lake Hydropower Project (54 MW).<br>2. The Topographic Survey was done physical characteristics of the terrain and details of the main roads have been from the project platform obtained through aerial mapping executed in October 2020.<br>3. The information on survey for this sum of the authorized request.<br>4. In no case, will the client party replace of this Report any responsible on an expression to be made based on it, are the responsibility of the such party, and NESPAK accepts no responsibility for damages, if any, suffered by any third party as a result of such decisions or actions. | PROJECT<br>ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TITLE<br>TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM | SCALE<br>1:1000 |
| | | | | | | DATE<br>FEB 2026 | SHEET NO.<br>Page 2 of 73 | SCALE BAR: |

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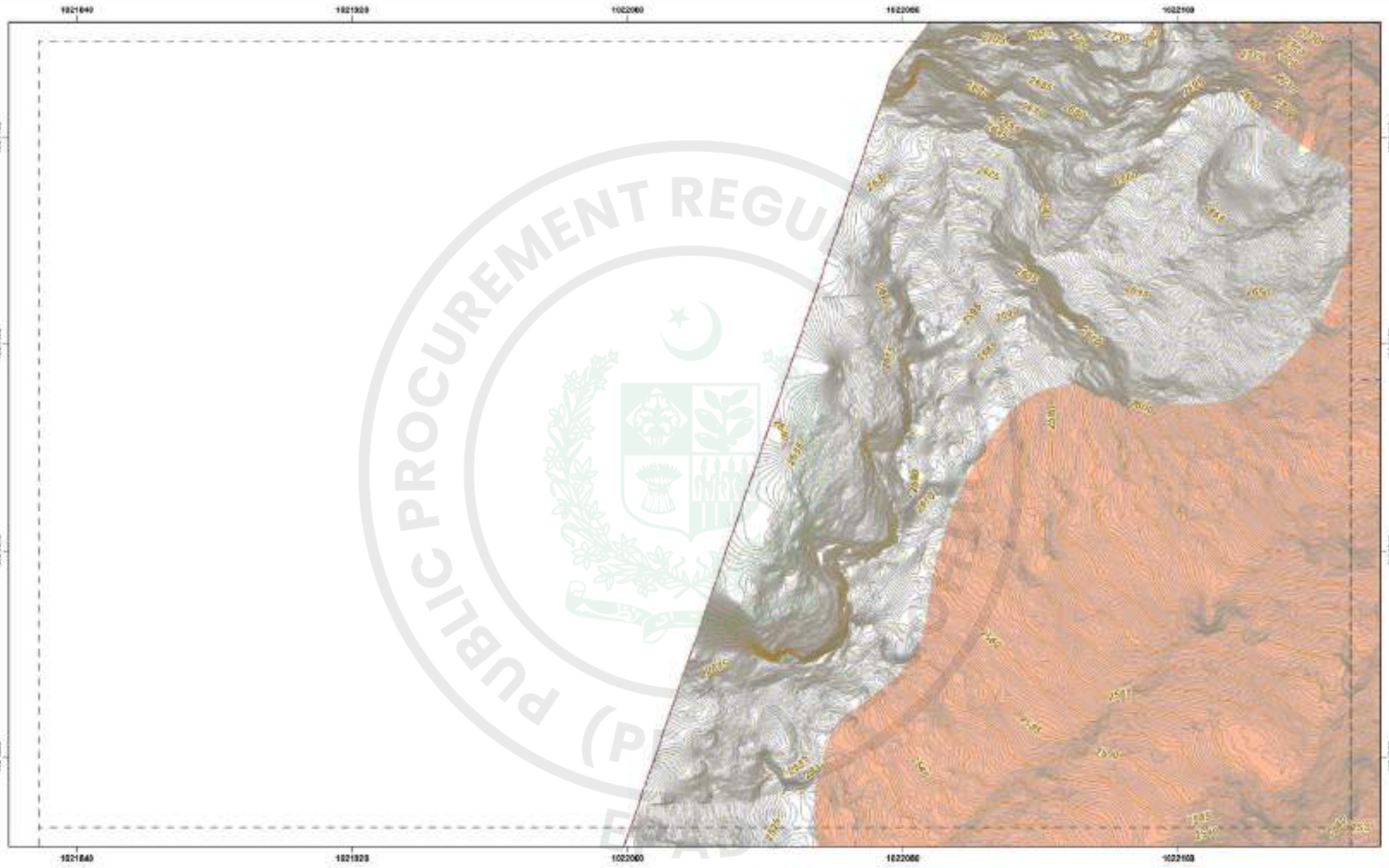


| CLIENT | CONSULTANT | LEGEND | INDEX MAP | DISCLAIMER | PROJECT | TITLE | SCALE |
|---|---|---|---|---|---|---|---|
| WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: 15 FARAK HOUSE, 1-E, BLOCK-R, GODEL TOWN EXTENSION, LAHORE, PAKISTAN | Control Point, Tree, Transmission Pole, Tunnel, 33 KV Line, Transmission Line, Intervention Contour, Water Contour, Roads, Dry Land, Agriculture Land, Rooftop, TESA, Electricity, Landslide Zone, Peoples Hut, HRMA, Dam, Culvert, Bridge, Shed, 11 KV Line | | 1. This Map has been prepared by National Engineering Services Pakistan (PVT) Ltd exclusively for the Technical Inquiry purposes in the ROAD ENTRY SHEAR AND DIVERSION DRIVERS FOR CONSTRUCTION OF ATTABAD LAKE HYDROPOWER PROJECT (54 MW).<br>2. The Topographic Survey has been physical measurements of the levels and details of the main roads have been from the project particulars obtained through aerial mapping executed in October 2021.<br>3. The information on survey for the use of the authorized request.<br>4. Any use, which a third party makes of this Report or any reliance on or decisions to be made based on it, are the responsibility of the such party, and NESPAK accepts no responsibility for damages, if any, suffered by any third party as a result of such decisions or actions. | ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TOPOGRAPHIC SURVEY PLAN ATTABAD LAKE DAM | 1:1000 |

| DATE | SHEET NO. | SCALE BAR: |
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| FEB 2026 | Page 3 of 73 | |

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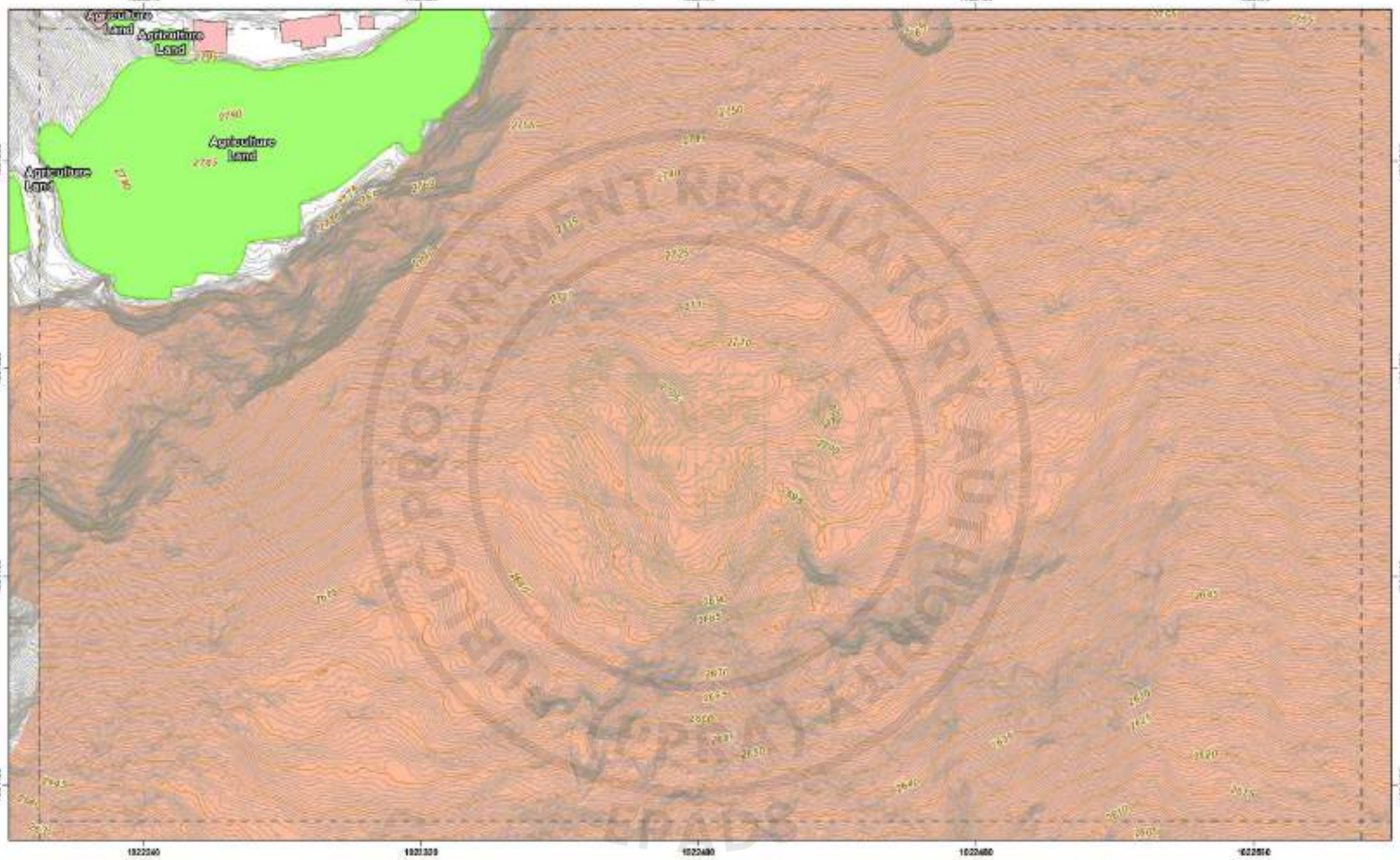


| CLIENT | CONSULTANT | LEGEND | INDEX MAP | DISCLAIMER | PROJECT | TITLE | SCALE |
|---|---|---|---|---|---|---|---|
| WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: ELEPHANT HOUSE, 1-E, BLOCK-B, GODEL TOWN EXTENSION, LAHORE, PAKISTAN | Control Point, Tree, Tel Telecom Pole, Tunnel, Oil Line, Tel Telecom Line, Intervention Contour, Water Course, Farm, Dry Land, Agriculture Land, Building, Track, Electric Line, Landslide Zone, Peoples Hut, Hotels, Dam, Culvert, Bridge, Shed, 11 KV Line | 1. This Map has been prepared by National Engineering Services Pakistan (PVT) Ltd exclusively for the individual / industry mentioned in the Feasibility Study and Detailed Design for Construction of Attabad Lake Hydropower Project (54 MW).<br>2. The Topographic Survey has been prepared by using Total Station and details of the main roads have been taken from the project authority obtained through aerial mapping executed in October 2020.<br>3. This information can solely for the use of the authorized recipient.<br>4. Any use, which a third party makes of this Report or any reliance on or decisions to be made based on it, are the responsibility of the such party and NESPAK accepts no responsibility for damages, if any, suffered by any third party as a result of such decisions or actions. | ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM | 1:1000 |

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| FEB 2026 | Page 6 of 73 | |

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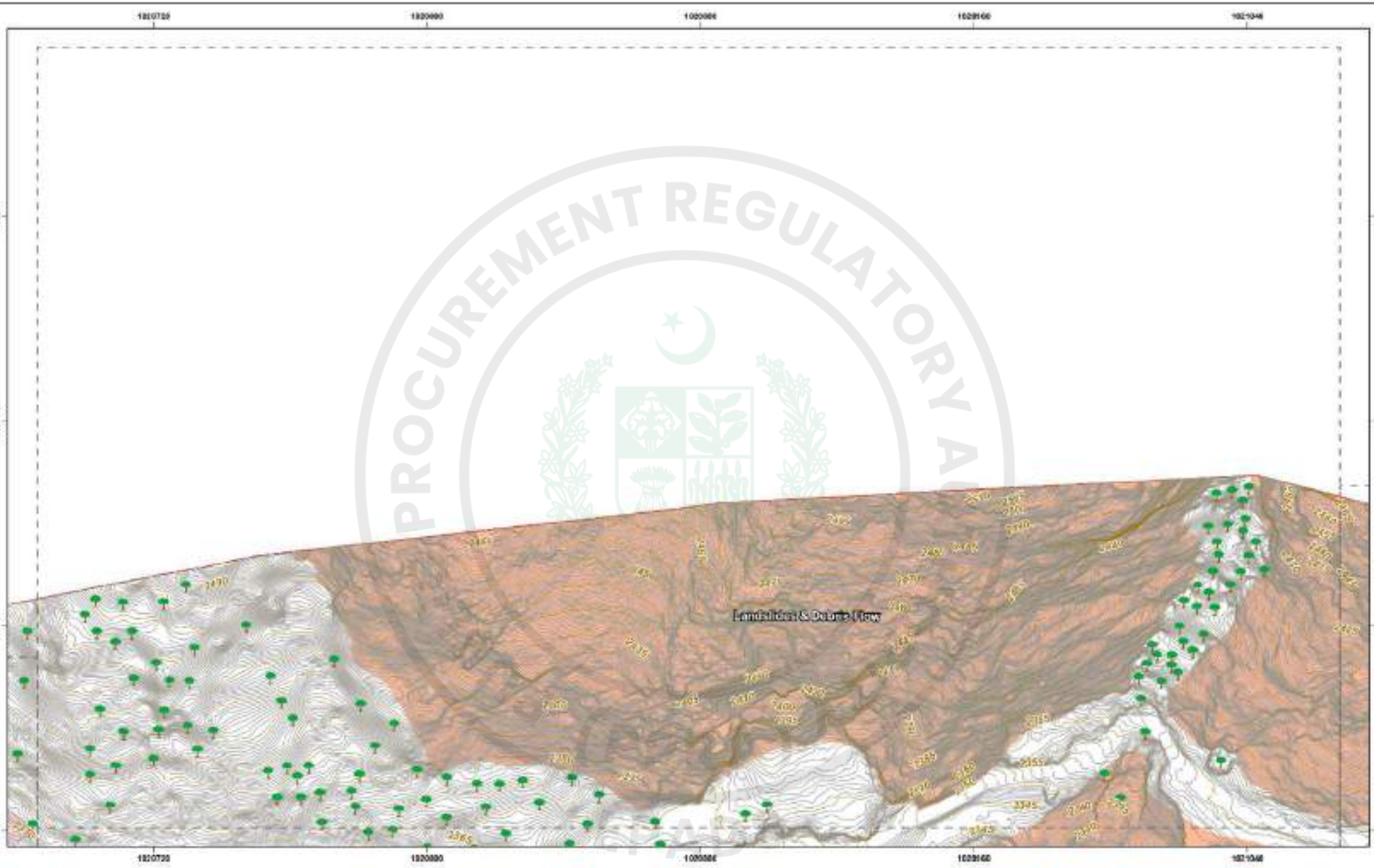


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| CLIENT: WAPDA — WATER AND POWER DEVELOPMENT AUTHORITY | CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS — HEAD OFFICE: 5 FARAK HOUSE, 1-E, BLOCK-R, MODEL TOWN EXTENSION, LAHORE, PAKISTAN | LEGEND | INDEX MAP | DISCLAIMER | PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TITLE: TOPOGRAPHIC SURVEY PLAN ATTABAD LAKE DAM | SCALE: 1:1000 |
| | | | | | | DATE: FEB 2026 — SHEET NO: Page 6 of 73 — SCALE BAR: | |

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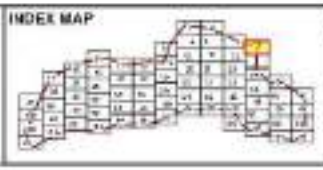
| CLIENT | CONSULTANT | LEGEND | INDEX MAP | DISCLAIMER | PROJECT | TITLE | SCALE |
|---|---|---|---|---|---|---|---|
| WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: 15 PARK HOUSE, 1-C, BLOCK-R, MODEL TOWN EXTENSION, LAHORE, PAKISTAN | Control Point, Tree, Tube Well/Hand Pump, Electric Pole, Spot Height, Water Course, River, Dry Land, Agriculture Land, Built-up, Trees, Electric Line, Boundary Wall, Project Site, Village, Road, Check, Culvert, Bridge, Shed, L.T. Electric Line |  | 1. This Map has been prepared by National Engineering Services Pakistan (PVT) Ltd exclusively for the Technical Viability Submission in Two Stage Bidding Process for DETAILED DESIGN FOR CONSTRUCTION OF ATTABAD LAKE HYDROPOWER PROJECT (54 MW).<br>2. The Topographic Survey has been physical characteristics of the terrain and details of the main roads have been from the project preliminary obtained through aerial mapping executed in October 2021.<br>3. This information can solely for the use of the authorized recipient.<br>4. Any use, which a third party makes of this Report or any reliance on or decisions to be made based on it, are the responsibility of the such party, and NESPAK accepts no responsibility for damages, if any, suffered by any third party as a result of such decisions or actions. | ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM | 1:1000 |

| DATE | SHEET NO. | SCALE BAR: |
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| FEB 2026 | Page 7 of 73 | |

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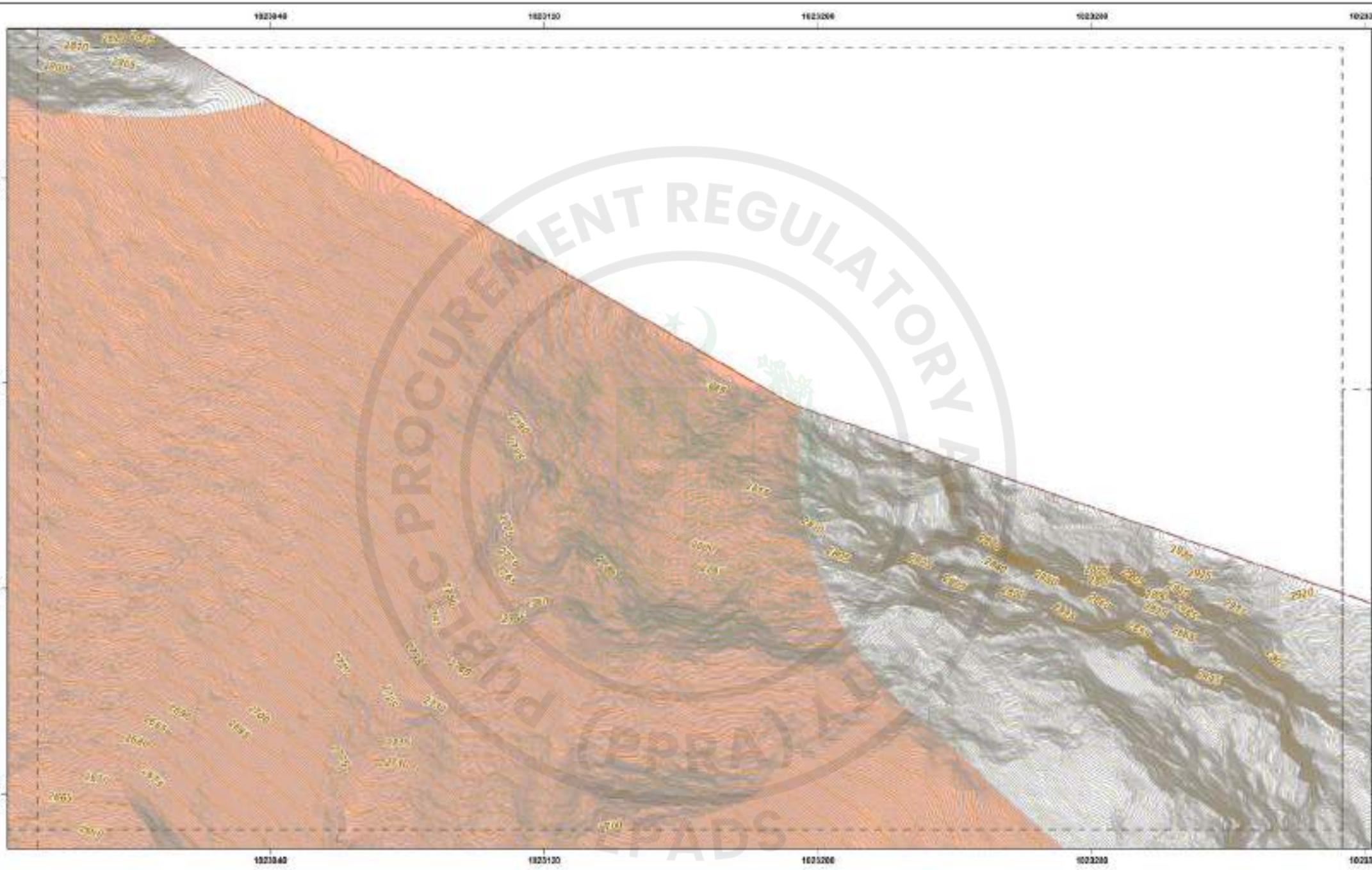


| CLIENT | CONSULTANT | LEGEND | INDEX MAP | DISCLAIMER | PROJECT | TITLE | SCALE |
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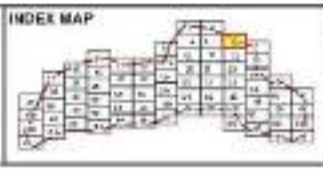
| WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: 5 FARAK HOUSE, 1-C, BLOCK R, MODEL TOWN EXTENSION, LAHORE, PAKISTAN | Control Point, Tree, Transmission Pole, Tunnel, Oil Line, Transmission Line, Intervention Contour, Water Contour, Roads, Dry Land, Agriculture Land, Rooftop, Trees, Structure, Landslide Dam, Perennial Nala, HRWA, Drain, Culvert, Bridge, Road, L.T. WIRE LINE |  | 1. This Map has been prepared by National Engineering Services Pakistan (PVT) Ltd exclusively for the Technical Inquiry purposes in connection with FEASIBILITY STUDY AND DETAILED DESIGN FOR CONSTRUCTION OF ATTABAD LAKE HYDROPOWER PROJECT (54 MW).<br>2. The Topographic Survey has been physical characteristics of the terrain and details of the main roads have been from the project platform obtained through aerial mapping executed in October 2025.<br>3. This information can solely for the use of the authorized recipient.<br>4. Any use, which a third party makes of this Report or any reliance on or decisions to be made based on it, are the responsibility of the such party, and NESPAK accepts no responsibility for damages, if any, suffered by any third party as a result of such decisions or actions. | ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM | 1:1000 |

| DATE | SHEET NO. | SCALE BAR: |
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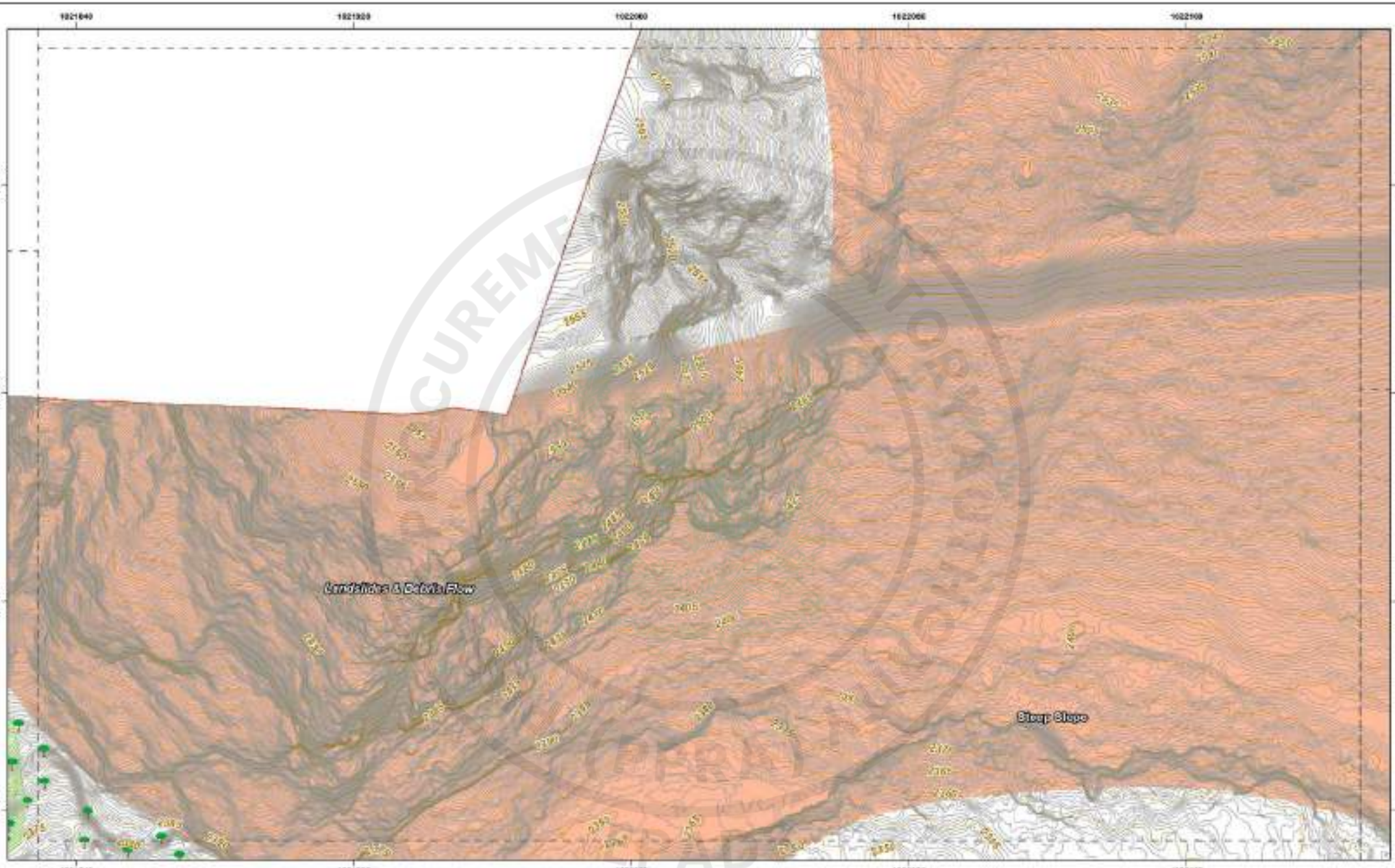
| FEB 2026 | Page 6 of 73 | |

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS




| CLIENT | CONSULTANT | LEGEND | INDEX MAP | DISCLAIMER | PROJECT | TITLE | SCALE |
|---|---|---|---|---|---|---|---|
| WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: 9 FARAK HOUSE, 1-E, BLOCK-R, MODEL TOWN EXTENSION, LAHORE, PAKISTAN | Control Point, Tree, Tube Well with Pump, Tube Well, Electric Line, Telephone Line, Intervention Contour, Water Contour, Rivers, Dry Land, Agriculture Land, Rooftop, Roads, Electric Pole, Landslide Zone, Peoples Hut, Houses, Check, Culvert, Bridge, Shed, L.T. Cable Line | | 1. This Map has been prepared by National Engineering Services Pakistan (PVT) Ltd exclusively for the Individual / Agency mentioned in the Head Quarter Letter and Drawing Order for Construction of Attabad Lake Hydropower Project (54 MW).<br>2. The Topographic Survey has been physically executed on the ground and details of the main roads have been taken with the help of Google earth image as it was in October 2021.<br>3. This information can solely be for the use of the authorized recipient.<br>4. In no case, will the above party, nor any of its officers or employees be liable to any person or entity whatsoever, for any loss or damage that may be caused to, or suffered by any third party as a result of, and all persons acting on behalf of each party shall have no responsibility or liability to any third party as a result of, such actions or inaction. | ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM | 1:1000 |

| DATE | SHEET NO. | SCALE BAR: |
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| FEB 2026 | Page 9 of 73 | |

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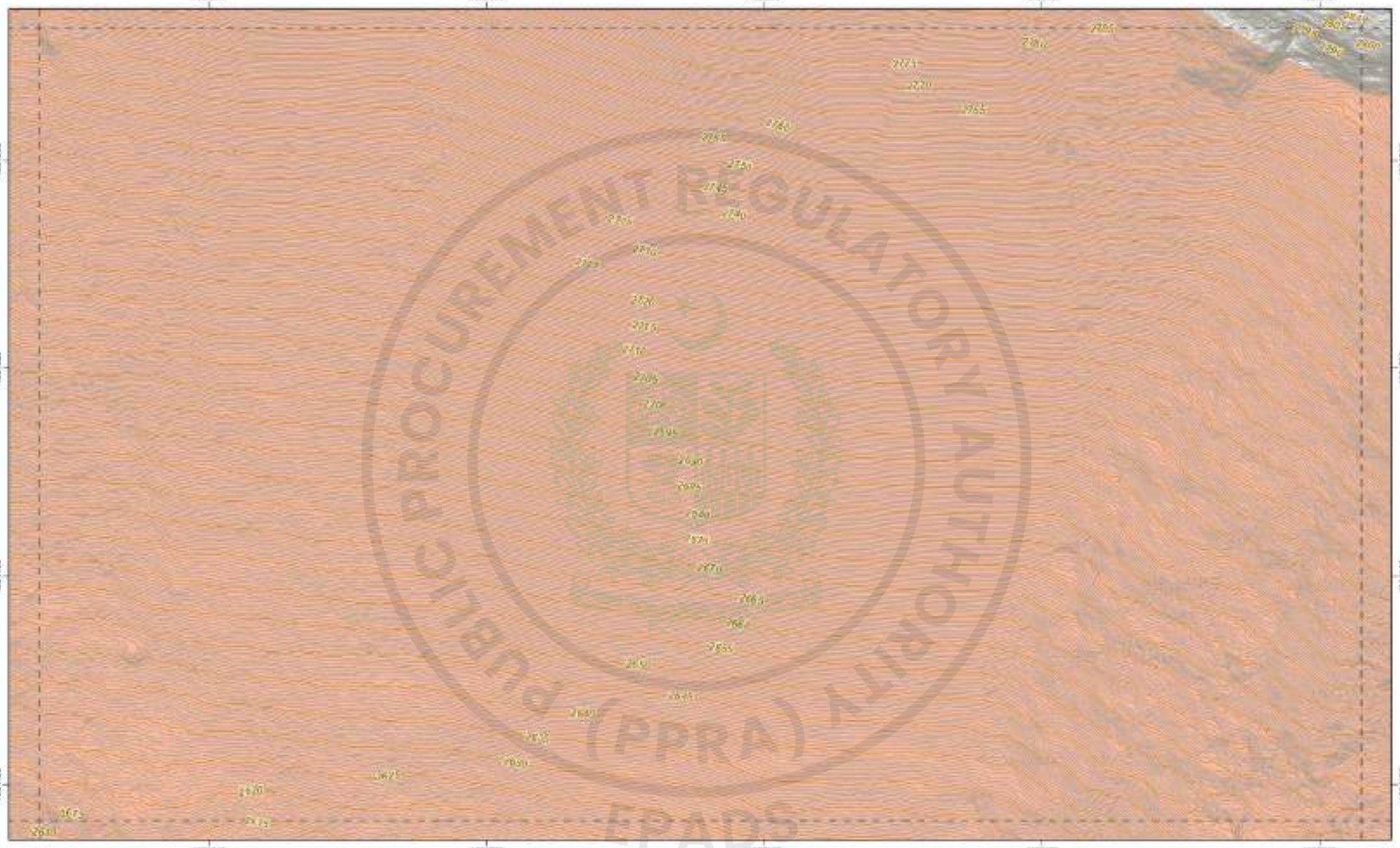


| CLIENT | CONSULTANT | LEGEND | INDEX MAP | DISCLAIMER | PROJECT | TITLE | SCALE |
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| WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: 15 SHAH HOUSE, 1-C, BLOCK R, MODEL TOWN EXTENSION, LAHORE, PAKISTAN | Control Point, Tree, Tube Well/Hand Pump, Tel./Electric Pole, Tunnel, Dry Land, Agriculture Land, Rooftop, Dry Stream, Water Course, River, Dry Land, Agriculture Land, Rooftop, Village, Dry Stream, Bridge, Road, Intervention Contour, Landslide Zone, Project Site, HRWM, Dam, Culvert, Bridge, Road, L.T. 11KV Line | | 1. This Map has been prepared by National Engineering Services Pakistan (PVT) Ltd exclusively for the Individual, Inquiry Purposes. Use, Reproduction or Distribution of this Map for Commercial Purposes is strictly prohibited.<br>2. The Topographic Survey information provided on this map and details of the main roads have been taken from the project partner obtained through aerial mapping executed in October 2021.<br>3. Site information and survey for the use of the authorized recipient.<br>4. In no case, will the above party, nor any of their officers or employees be liable for any loss or damage, whether direct, indirect, consequential or economic, or for any claim brought against the above party by any third party, even if the above party has been advised of the possibility of such loss or damage. | ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM | 1:1000 |

| DATE | SHEET NO. | SCALE BAR: |
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| FEB 2026 | Page 6 of 73 | |

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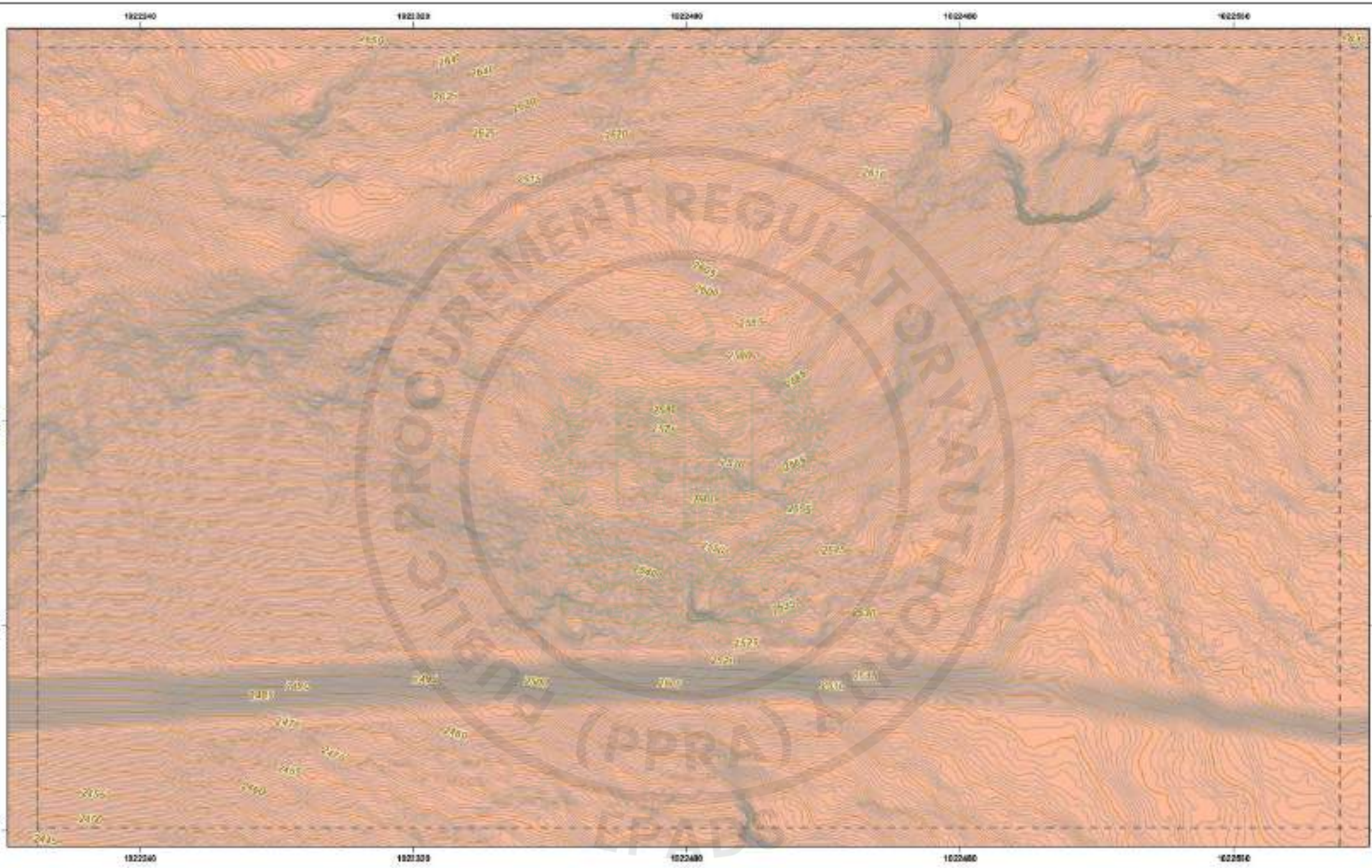


| CLIENT | CONSULTANT | LEGEND | INDEX MAP | DISCLAIMER | PROJECT | TITLE | SCALE |
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| DATE | SHEET NO. | SCALE BAR: |
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| FEB 2026 | Page 93 of 73 | |

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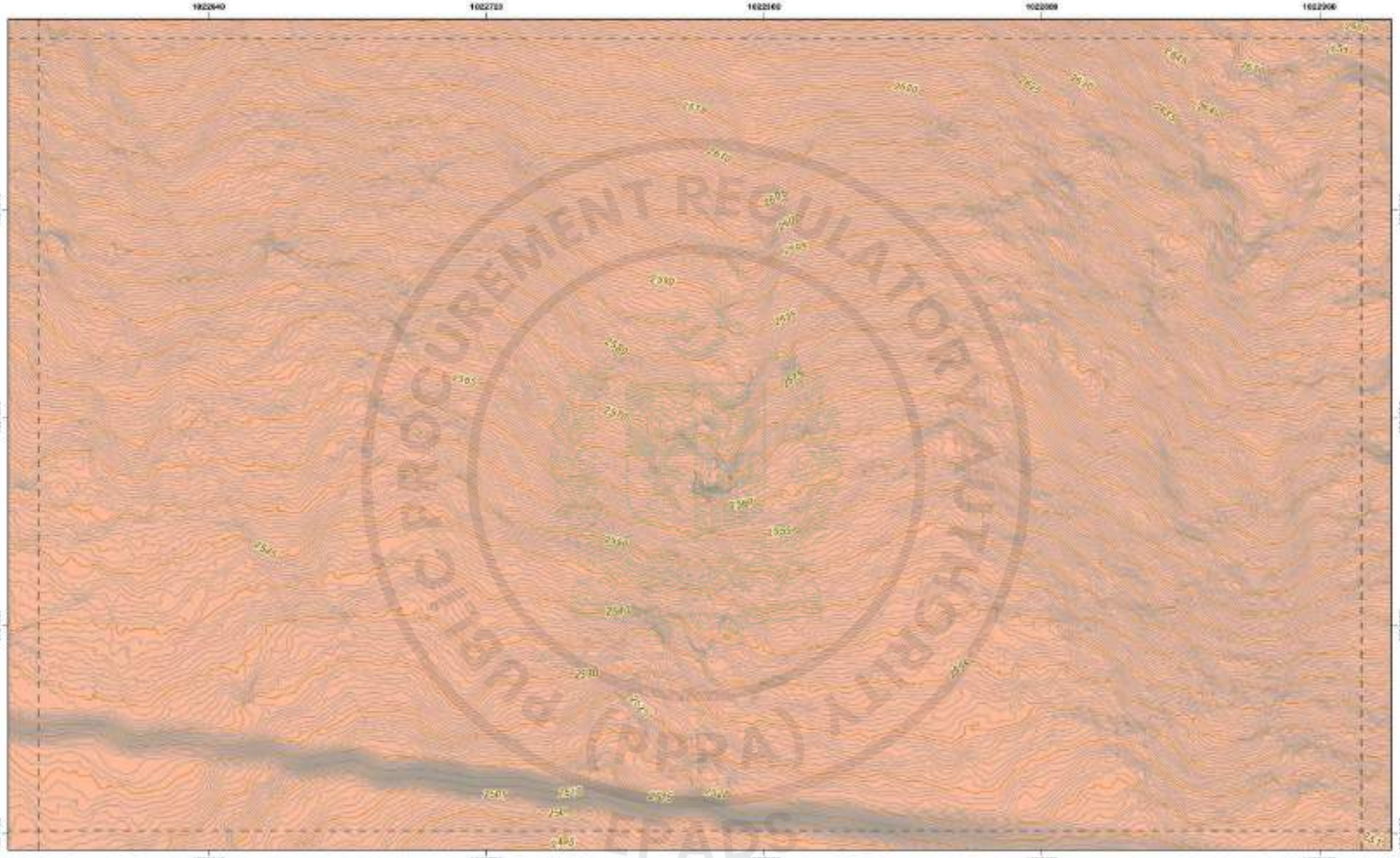


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| CLIENT<br>WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | CONSULTANT<br>ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: 5 FARAK HOUSE, 1-E, BLOCK-R, MODEL TOWN EXTENSION, LAHORE, PAKISTAN | LEGEND | INDEX MAP | DISCLAIMER<br>1. This Map has been prepared by National Engineering Services Pakistan (Pvt.) Ltd. (NESPAK) for the exclusive, sole use of WAPDA in connection with the ATTABAD LAKE HYDROPOWER PROJECT (54 MW).<br>2. The Topographic Survey was carried out in October 2020. Any changes in the topography of the area after the said survey will not be the responsibility of NESPAK.<br>3. This map is not to be used for any purpose other than mentioned above. NESPAK will not be responsible for any misuse of this map.<br>4. Any use, sale or distribution of this map to any third party without the written permission of NESPAK will be illegal and NESPAK will not be responsible for any damages. | PROJECT<br>ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TITLE<br>TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM<br>DATE: FEB 2026<br>SHEET NO: Page 11 of 73<br>SCALE BAR: | SCALE<br>1:1000 |

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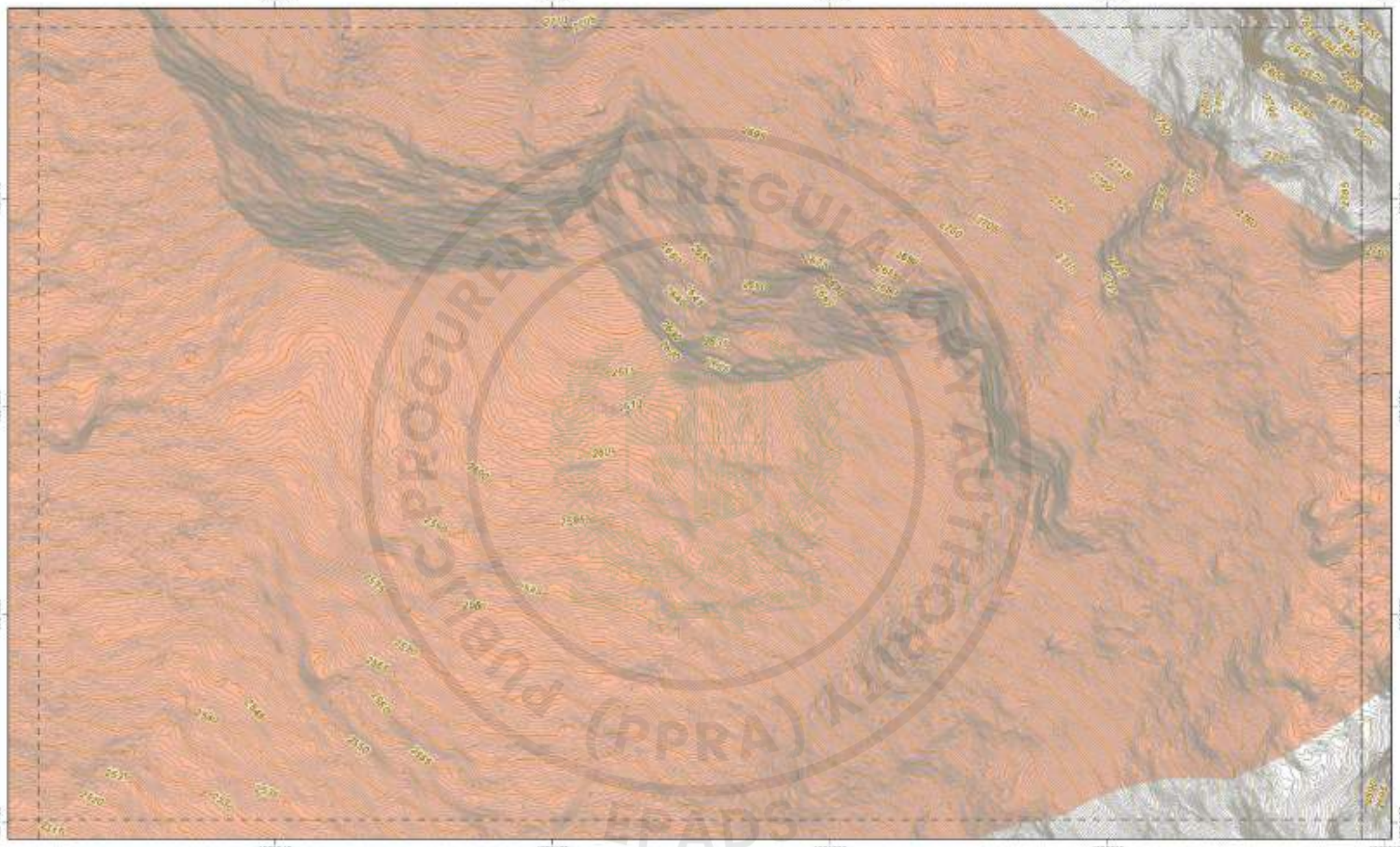


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| CLIENT<br>WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | CONSULTANT<br>ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: 5 FARAK HOUSE, 1-E, BLOCK-R, MODEL TOWN EXTENSION, LAHORE, PAKISTAN | LEGEND | INDEX MAP | DISCLAIMER<br>1. This Map has been prepared by National Engineering Services Pakistan (Pvt.) Ltd. exclusively for the Technical Tender Submission with Head Gravity Intake and Tailrace Options for Construction of Attabad Lake Hydropower Project (54 MW).<br>2. The Topographic Survey has been physically verified and details of the main roads, features within the project periphery obtained through aerial mapping executed in October 2021.<br>3. This information can solely be for the use of the authorized recipient.<br>4. In no case, will the client, party, copies of this Report or any reliance on or decisions to be made based on it, are the responsibility of the such party and NESPAK accepts no responsibility for damages, if any, suffered by any third party as a result of such decisions or actions. | PROJECT<br>ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TITLE<br>TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM<br>DATE: FEB 2026<br>SHEET NO: Page 12 of 13<br>SCALE BAR: | SCALE<br>1:1000 |

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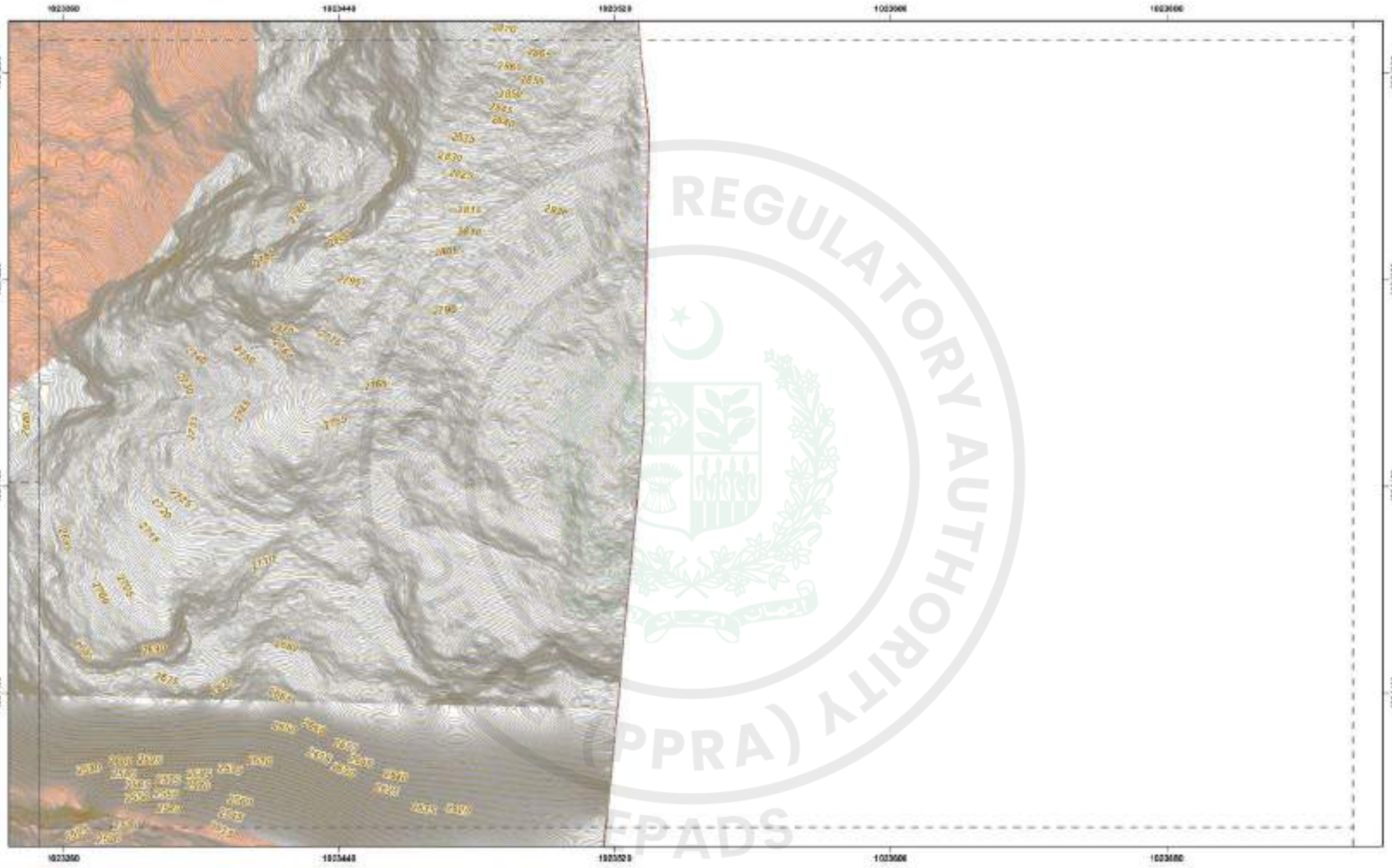
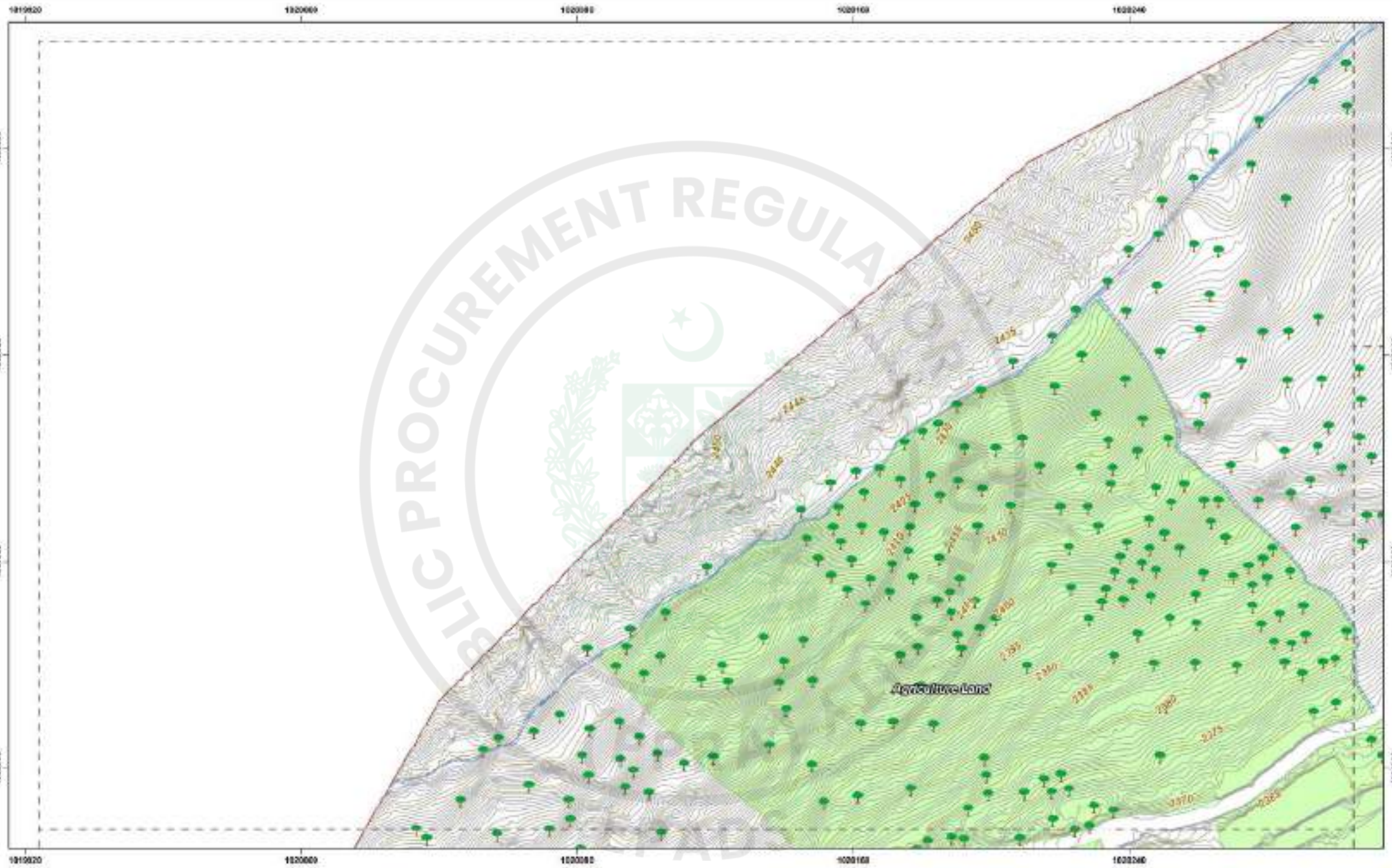



| CLIENT | CONSULTANT | LEGEND | INDEX MAP | DISCLAIMER | PROJECT | TITLE | SCALE |
|---|---|---|---|---|---|---|---|
| WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: FLEEMM HOUSE, 1-E, BLOCK-R, GOWAL TOWN EXTENSION, LAHORE, PAKISTAN | Control Point, Tree, Transmission Pole, Tunnel, 33 KV Line, Transmission Line, Intervention Contour, Water Contour, River, Tin Land, Agriculture Land, Rooftop, TSWA, Electricity, Landslide Zone, Project Site, PWMA, Check, Culvert, Bridge, Road, 11 KV Line | | 1. This Map has been prepared by National Engineering Services Pakistan (Pvt.) Ltd. exclusively for the Technical Viability Submission in PWMA Entity to carry out DETAILED DESIGN FOR CONSTRUCTION OF ATTABAD LAKE HYDROPOWER PROJECT (54 MW).<br>2. The Topographic Survey has been physical characteristics of the terrain and details of the main roads have been from the project platform obtained through aerial mapping executed in October 2021.<br>3. This information can solely for the use of the authorized recipient.<br>4. Any use, which a third party makes of this Report or any reliance on or decisions to be made based on it, are the responsibility of the such party, and NESPAK accepts no responsibility for damages, if any, suffered by any third party as a result of such decisions or actions. | ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TOPOGRAPHIC SURVEY PLAN ATTABAD LAKE DAM | 1:1000 |

| DATE | SHEET NO. | SCALE BAR: |
|---|---|---|
| FEB 2026 | Page 13 of 73 | |

REGULATORY AUTHORITY (PPRA) EPADS




| CLIENT | CONSULTANT | LEGEND | INDEX MAP | DISCLAIMER | PROJECT | TITLE | SCALE |
|---|---|---|---|---|---|---|---|
| WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: 11 FARAK HOUSE, 1-E, BLOCK-R MODEL TOWN EXTENSION, LAHORE, PAKISTAN | | | 1. This Map has been prepared by National Engineering Services Pakistan (PVT) Ltd exclusively for the Technical Tenders submitted to M/S PEAK ENTITY to carry out DETAILED DESIGN WORK FOR CONSTRUCTION OF ATTABAD LAKE HYDROPOWER PROJECT (54 MW).<br>2. The Topographic Survey has been physical characteristics of the terrain and details of the main roads have been with the project platform obtained through aerial mapping executed in October 2021.<br>3. This information are solely for the use of the authorized recipient.<br>4. Any use, which a third party makes of this Map or any reliance on or decisions to be made based on it, are the responsibility of the such party and NESPAK accepts no responsibility for damages, if any, suffered by any third party as a result of such decisions or actions. | ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM | 1:1000 |

| DATE | SHEET NO. | SCALE BAR: |
|---|---|---|
| FEB 2026 | Page 55 of 73 | |

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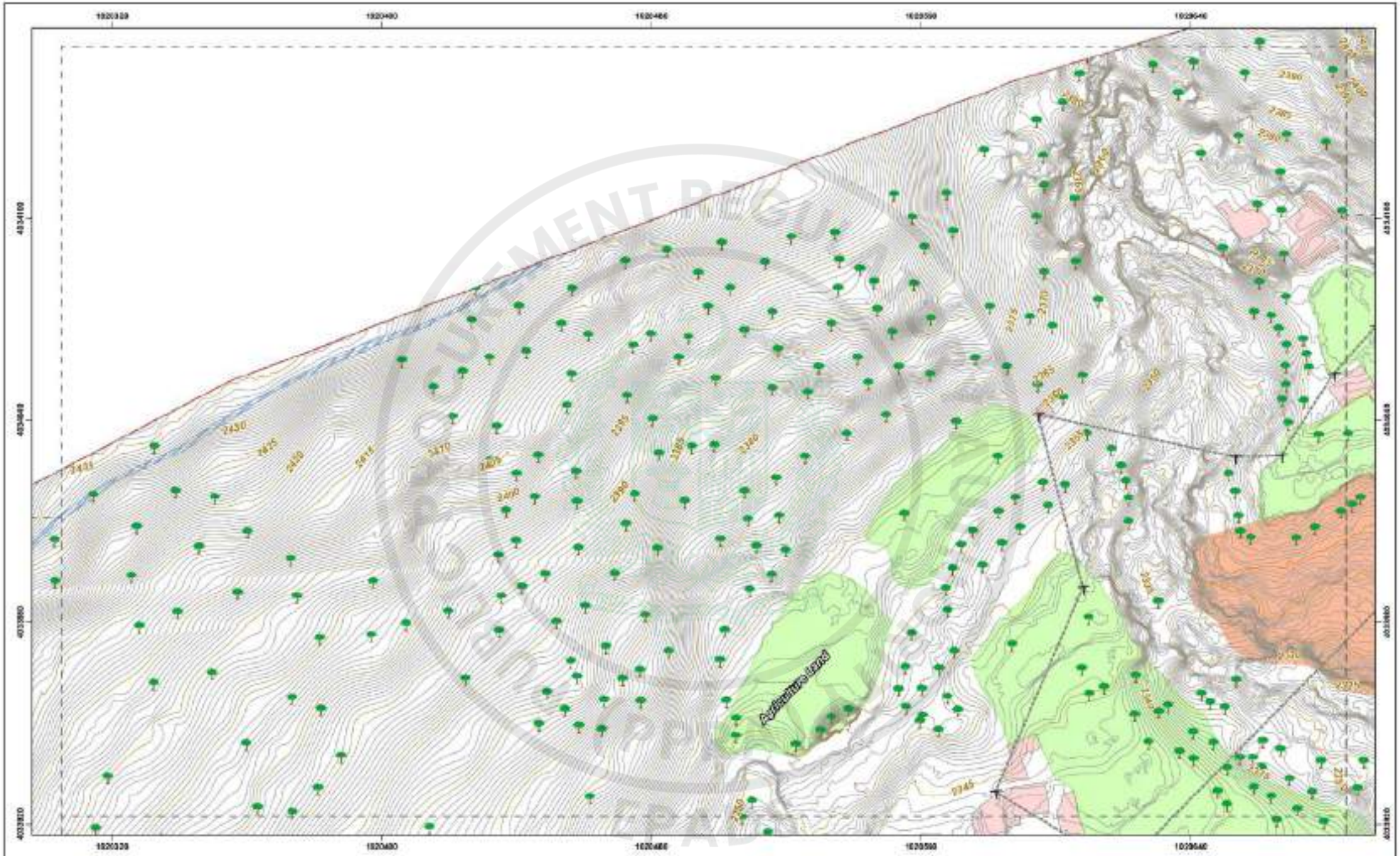


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| CLIENT<br>WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | CONSULTANT<br>ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: 9 FARAK HOUSE, 1-C, BLOCK R, MODEL TOWN EXTENSION, LAHORE, PAKISTAN | LEGEND | INDEX MAP | DISCLAIMER<br>1. This Map has been prepared by National Engineering Services Pakistan (Pvt.) Ltd. (NESPAK) for the exclusive use of WAPDA's ATTABAD HYDROPOWER PROJECT (54 MW).<br>2. The Topographic Survey has been carried out by NESPAK in October 2020.<br>3. This information is strictly for the use of the authorized recipient.<br>4. Any use, which a third party makes of this Map or any reliance on or decisions to be made based on it, is the responsibility of the such party, and NESPAK accepts no responsibility for damages, if any, suffered by any third party as a result of such decisions or actions. | PROJECT<br>ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TITLE<br>TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM | SCALE<br>1:1000 |
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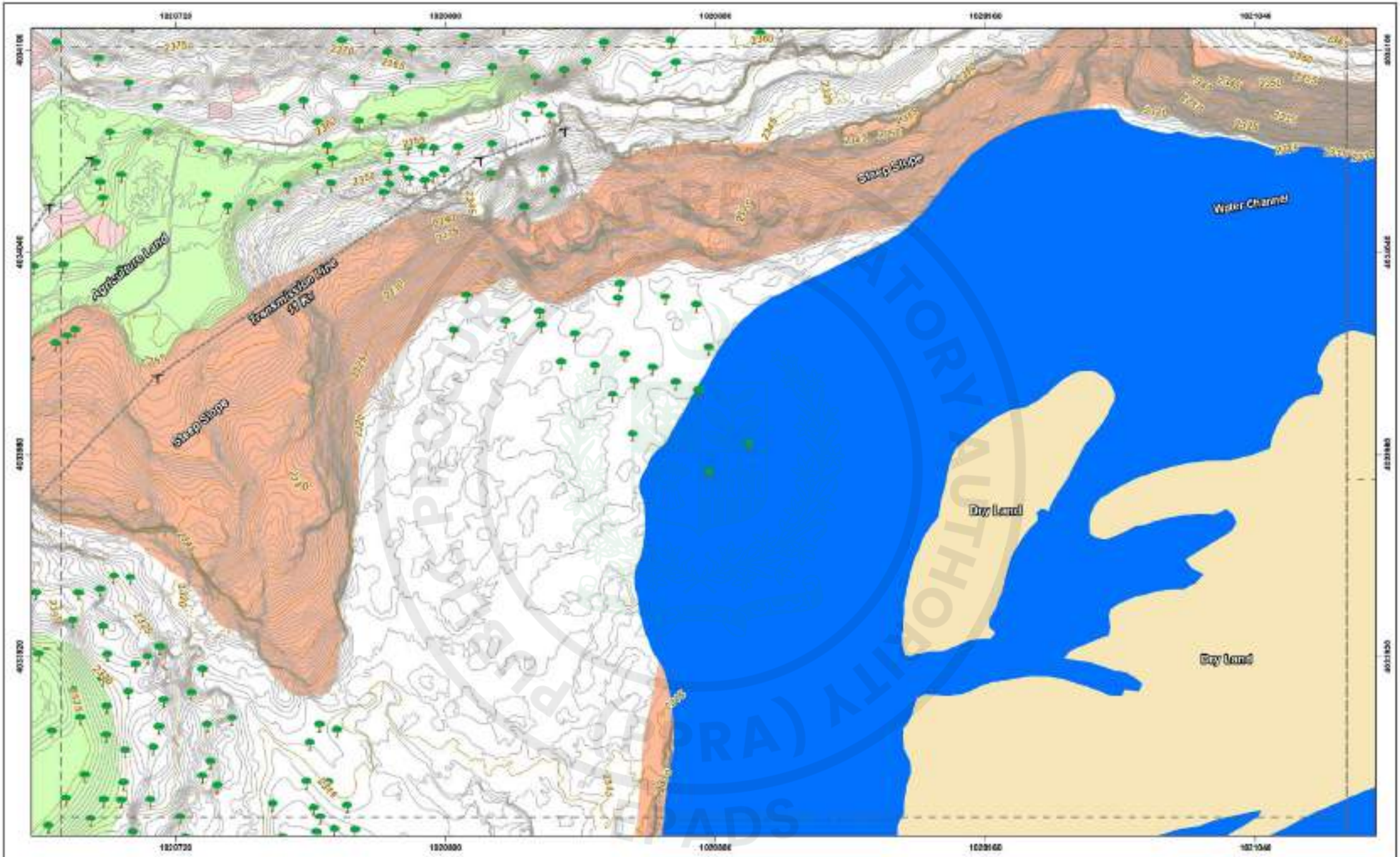


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| CLIENT<br>WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | CONSULTANT<br>ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: ELEPHANT HOUSE, 1-E, BLOCK-R, GOWAL TOWN EXTENSION, LAHORE, PAKISTAN | LEGEND | INDEX MAP | DISCLAIMER<br>1. This Map has been prepared by National Engineering Services Pakistan (Pvt.) Ltd. exclusively for the Individual / Military Settlements / Villages / Roads etc. only for DETAILED DESIGN FOR CONSTRUCTION OF ATTABAD LAKE HYDROPOWER PROJECT (54 MW).<br>2. The Topographic Survey has been physically executed on the ground and details of the main roads, Nallahs etc within the project platform obtained through aerial mapping executed in October 2021.<br>3. The information on survey for this sale of the authorized request.<br>4. In any case, where a third party replies of this Map or any response on an extension to be made based on it, are the responsibility of the such party, and NESPAK accepts no responsibility for damages, if any, suffered by any third party as a result of such decisions or actions. | PROJECT<br>ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TITLE<br>TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM | SCALE<br>1:1000 |
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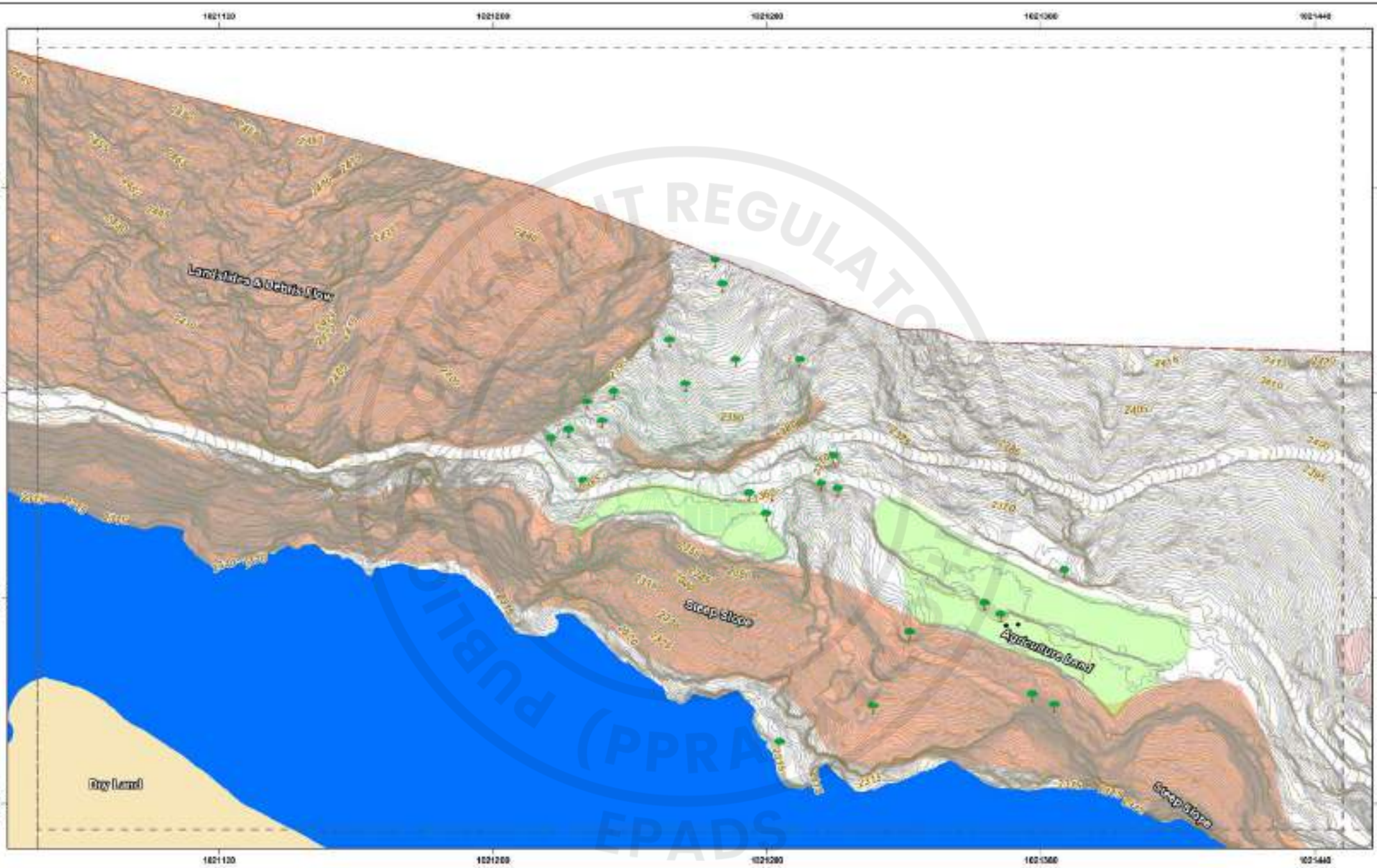


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| CLIENT: WAPDA — WATER AND POWER DEVELOPMENT AUTHORITY | CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS — HEAD OFFICE: 5 FARAH HOUSE, 1-C, BLOCK R, MODEL TOWN EXTENSION, LAHORE, PAKISTAN | LEGEND | INDEX MAP | DISCLAIMER | PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TITLE: TOPOGRAPHIC SURVEY PLAN ATTABAD LAKE DAM | SCALE: 1:1000 |
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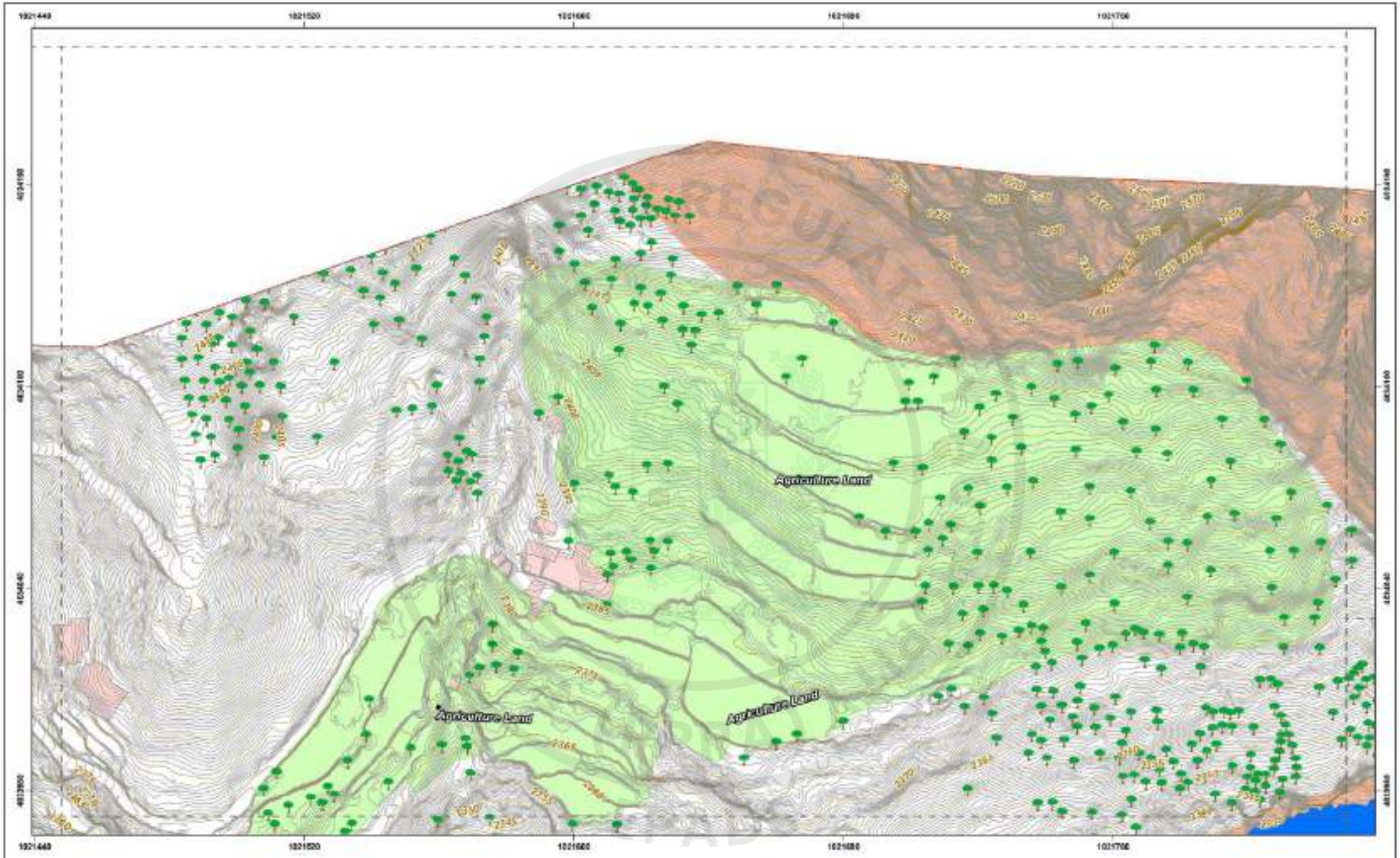


| CLIENT | CONSULTANT | LEGEND | INDEX MAP | DISCLAIMER | PROJECT | TITLE | SCALE |
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| WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: 9 FARAK HOUSE, 1-E, BLOCK-R, MODEL TOWN EXTENSION, LAHORE, PAKISTAN | Control Point<br>Tree<br>Transmission Pole<br>Tunnel<br>33 KV Line<br>Transmission Line<br>Intervention Contour<br>Water Contour<br>River<br>Tea Land<br>Agriculture Land<br>Built-up<br>Roads<br>Electricity<br>Landslide Zone<br>Project Site<br>Intake<br>Desilting Basin<br>Power House<br>Bridge<br>Shed<br>L.T. 11KV Line | | 1. This Map has been prepared by National Engineering Services Pakistan (PVT) Ltd exclusively for the purpose of feasibility of ATTABAD LAKE HYDROPOWER PROJECT (54 MW).<br>2. The Topographic Survey has been physically executed on the ground and details of the main roads have been taken from the project authority obtained through aerial mapping executed in October 2021.<br>3. This information on survey for the sole of the authorized request.<br>4. In no case, will the client party replies of this Report and Maps have an entitlement to be made based on it, and the responsibility of the such party, and NESPAK accepts no responsibility for damages, if any, suffered by any third party as a result of such decisions or actions. | ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM | 1:1000 |

| DATE | SHEET NO. | SCALE BAR: |
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| FEB 2026 | Page 18 of 73 | |

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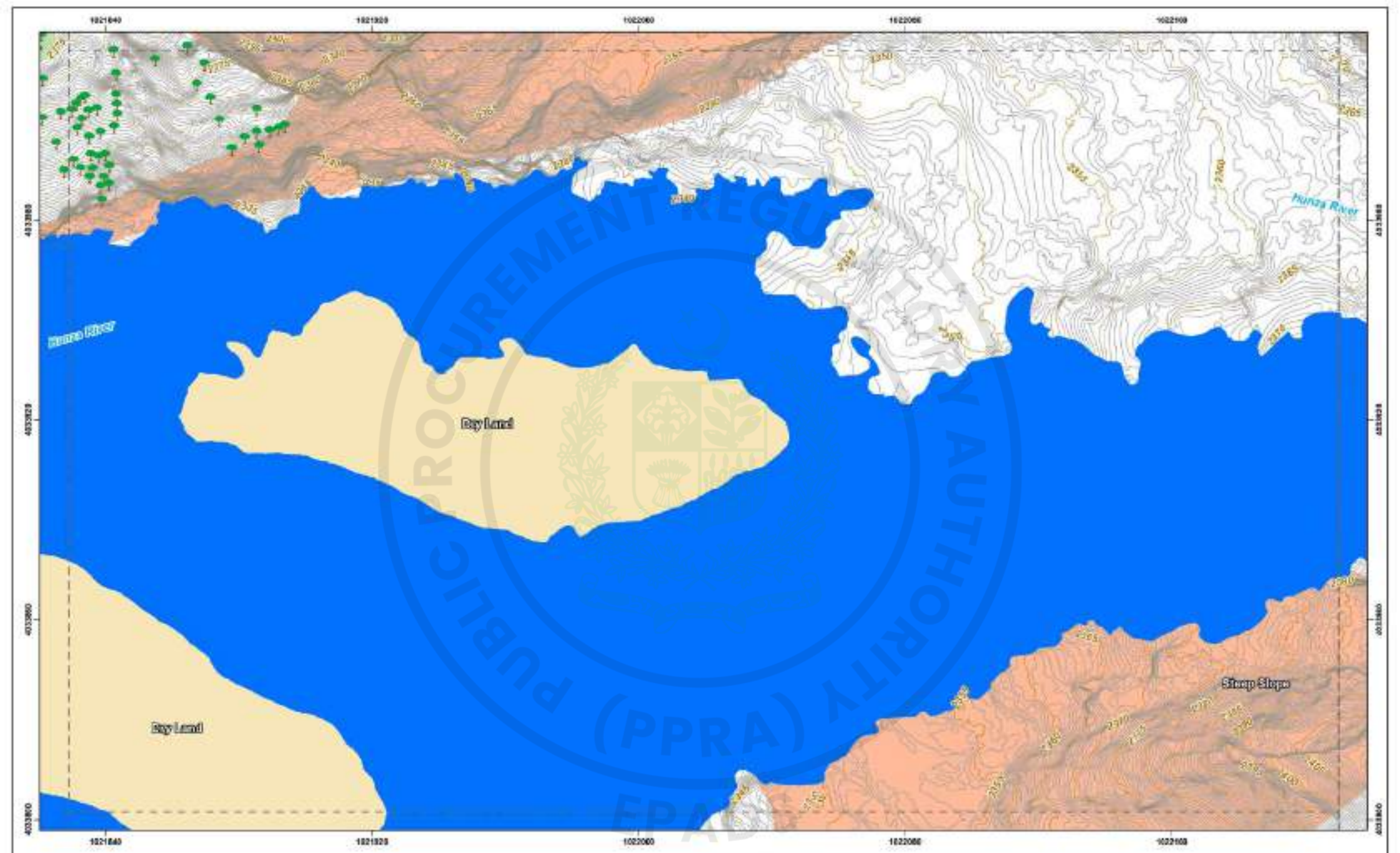


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| CLIENT: WAPDA — WATER AND POWER DEVELOPMENT AUTHORITY | CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS — HEAD OFFICE: 9 FARAK HOUSE, 1-C, BLOCK-R, MODEL TOWN EXTENSION, LAHORE, PAKISTAN | LEGEND | INDEX MAP | DISCLAIMER | PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TITLE: TOPOGRAPHIC SURVEY PLAN ATTABAD LAKE DAM | SCALE: 1:1000 |
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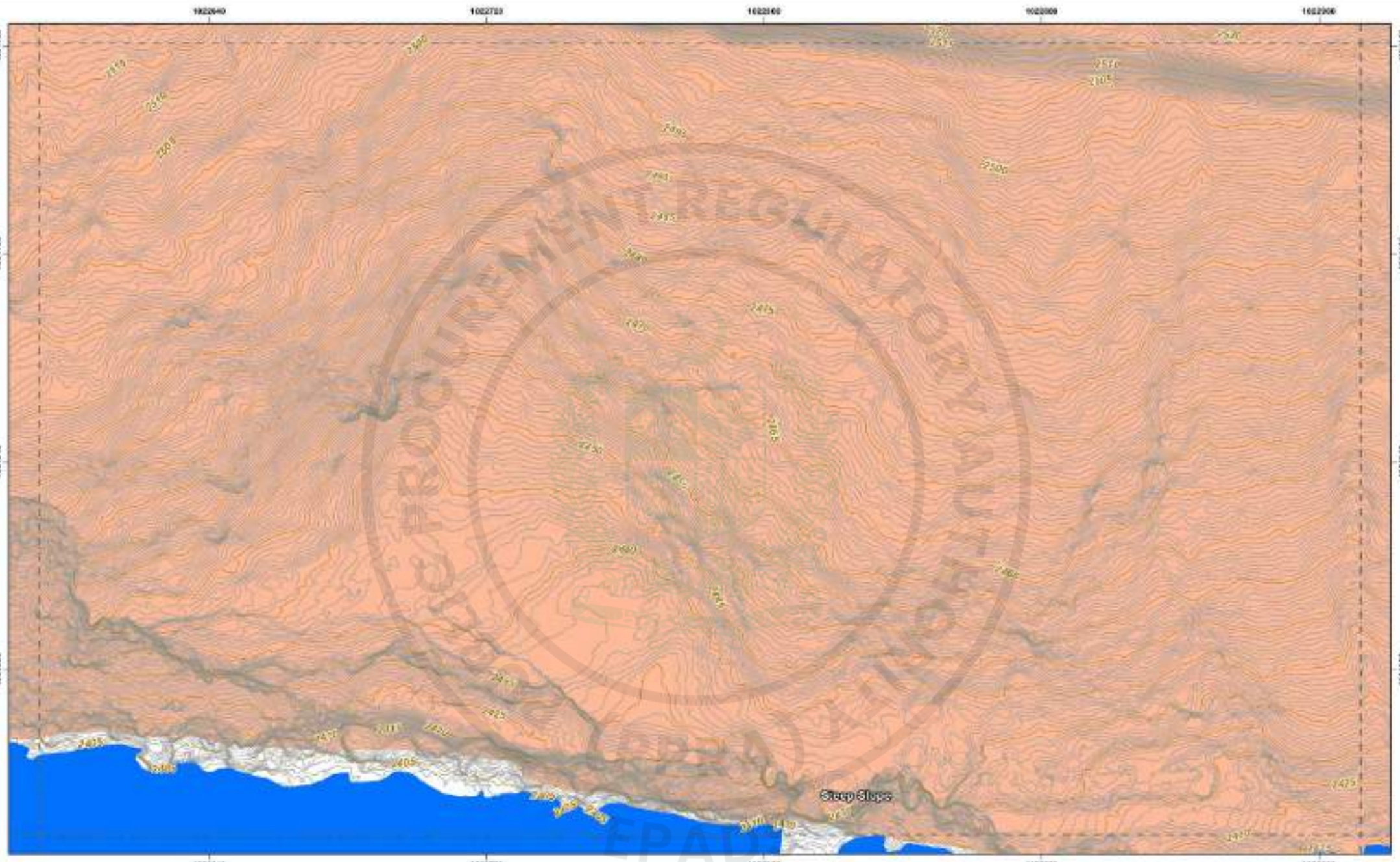
| CLIENT<br>WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | CONSULTANT<br>ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: 5 FARAK HOUSE, 1-E, BLOCK-R, MODEL TOWN EXTENSION, LAHORE, PAKISTAN | LEGEND | INDEX MAP | DISCLAIMER<br>1. This Map has been prepared by National Engineering Services Pakistan (PVT) Ltd exclusively for the purpose of "ENVIRONMENTAL AND SOCIAL IMPACT STUDY AND DETAILED DESIGN FOR CONSTRUCTION OF ATTABAD LAKE HYDROPOWER PROJECT (54 MW)".<br>2. The Topographic Survey has been physical characteristics of the terrain and details of the main roads have been from the project particulars obtained through aerial mapping executed in October 2025.<br>3. Title information not verified for this use of the authorized request.<br>4. Any use, which a third party makes of this Map or any reliance on or decisions to be made based on it, are the responsibility of the such party, and NESPAK accepts no responsibility for damages, if any, suffered by any third party as a result of such decisions or actions. | PROJECT<br>ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TITLE<br>TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM<br>DATE: FEB 2026<br>SHEET NO: Page 39 of 73<br>SCALE BAR: | SCALE<br>1:1000 |

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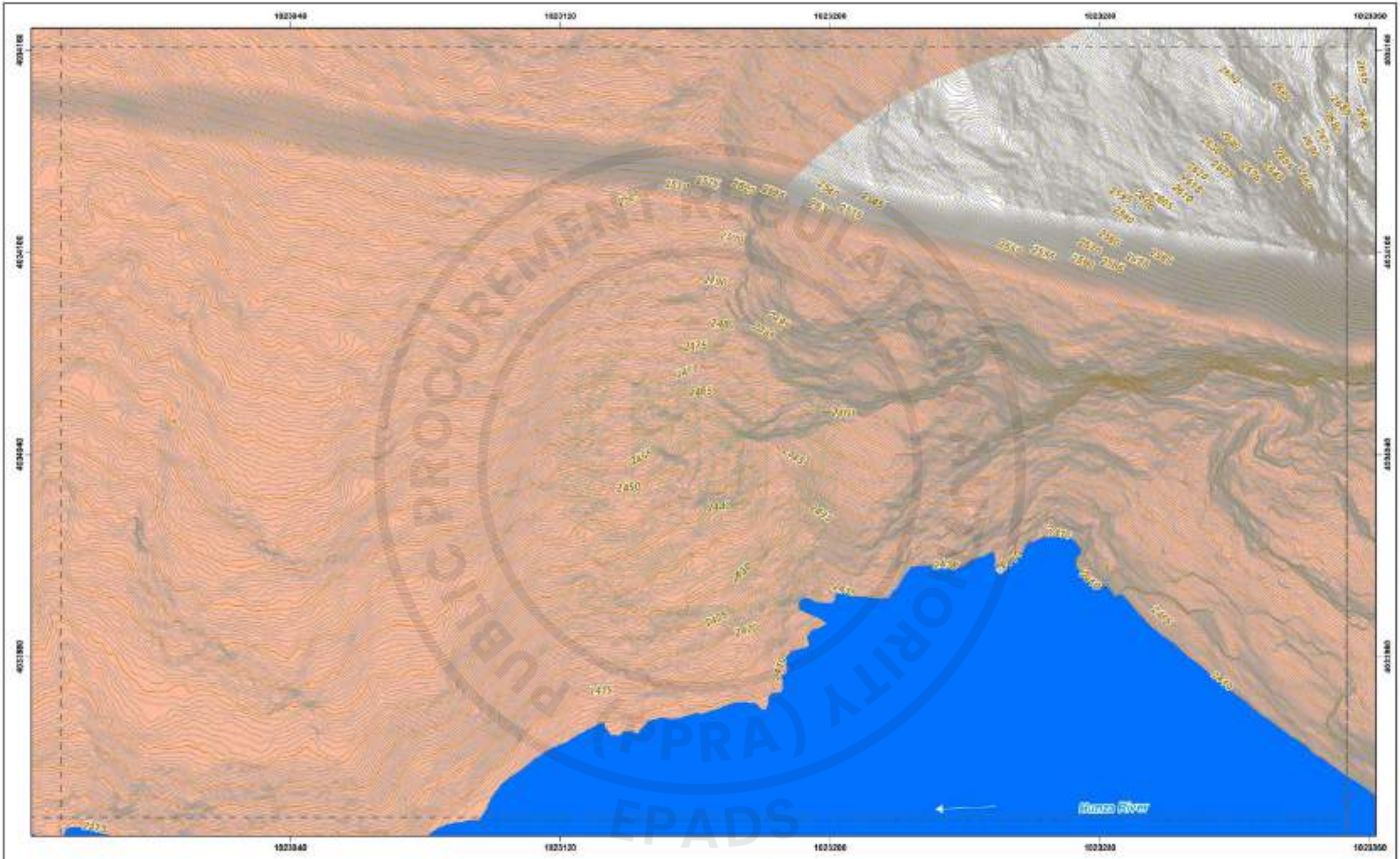


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| CLIENT<br>WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | CONSULTANT<br>ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: 9 FARAK HOUSE, 1-C, BLOCK R, MODEL TOWN EXTENSION, LAHORE, PAKISTAN | LEGEND | INDEX MAP | DISCLAIMER | PROJECT<br>ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TITLE<br>TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM | SCALE<br>1:1000 |
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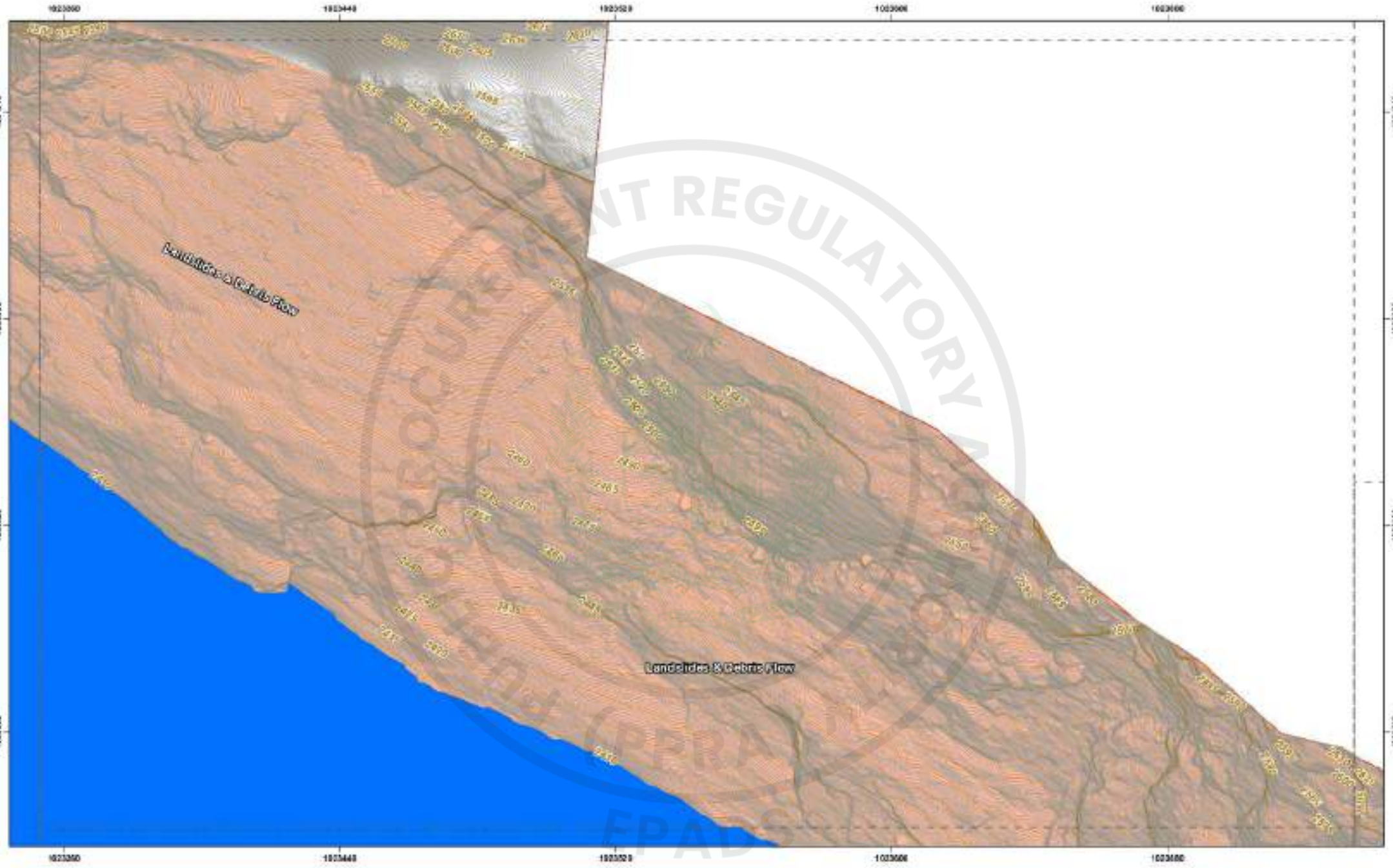


| CLIENT | CONSULTANT | LEGEND | INDEX MAP | DISCLAIMER | PROJECT | TITLE | SCALE |
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| WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: 5 FARAK HOUSE, 1-C, BLOCK-R, MODEL TOWN EXTENSION, LAHORE, PAKISTAN | | | 1. This Map has been prepared by National Engineering Services Pakistan (Pvt.) Ltd. (NESPAK) for the exclusive, sole and limited purpose of [illegible] ATTABAD LAKE HYDROPOWER PROJECT (54 MW).<br>2. The Topographic Survey was carried out in October 2025.<br>3. This information can solely be used for the said purpose.<br>4. In no case, will NESPAK be liable to any party or any third party for any loss, damage or expense which may be incurred or arise out of, or in connection with the use of this information by any party or any third party. | ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM | 1:1000 |

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| FEB 2026 | Page 33 of 73 | |

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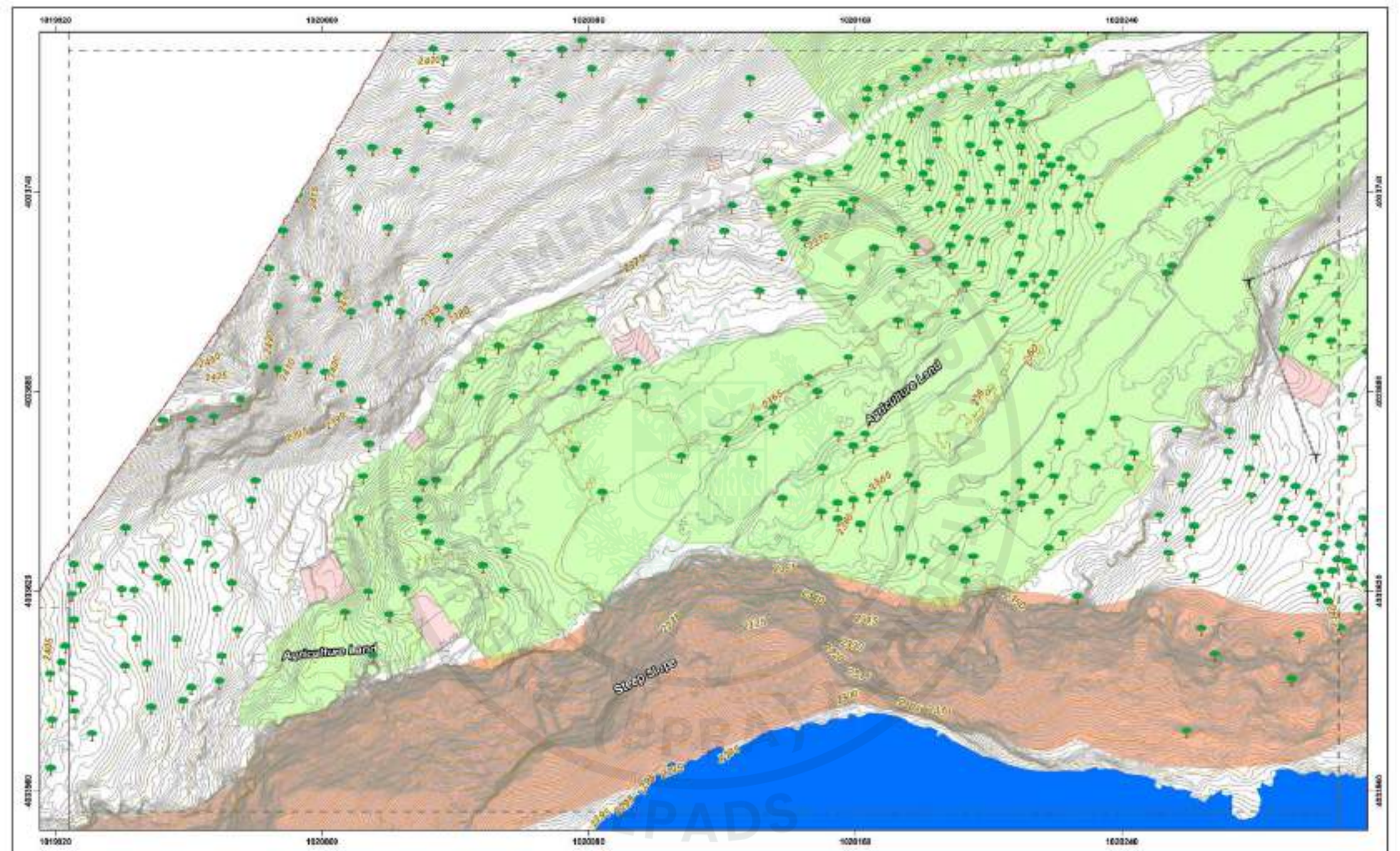


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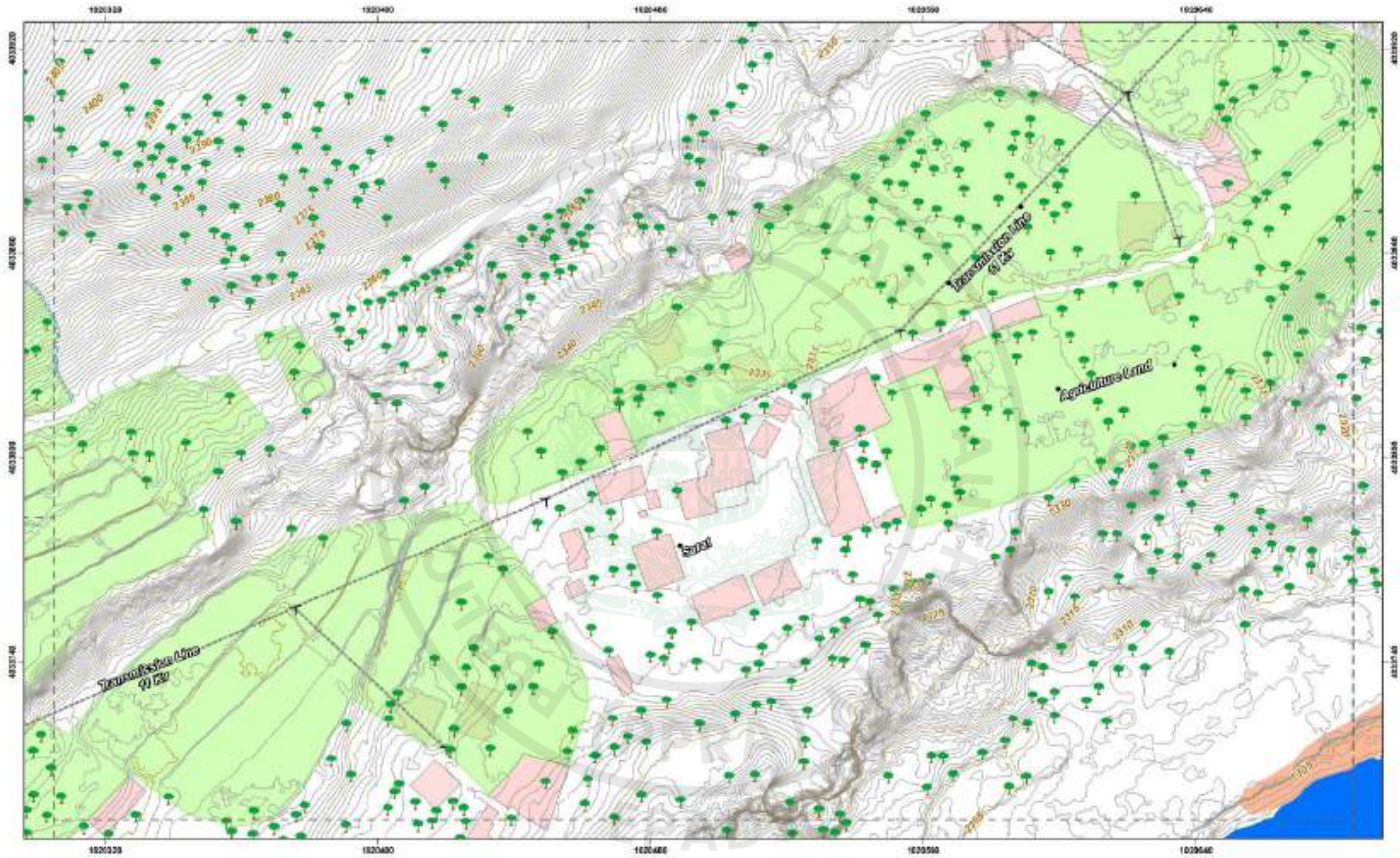


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| CLIENT: WAPDA — WATER AND POWER DEVELOPMENT AUTHORITY | CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS — HEAD OFFICE: 9 FARAH HOUSE, 1-C, BLOCK R, MODEL TOWN EXTENSION, LAHORE, PAKISTAN | LEGEND | INDEX MAP | DISCLAIMER | PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TITLE: TOPOGRAPHIC SURVEY PLAN ATTABAD LAKE DAM<br>DATE: FEB 2026<br>SHEET NO: Page 25 of 73<br>SCALE BAR: | SCALE: 1:1000 |

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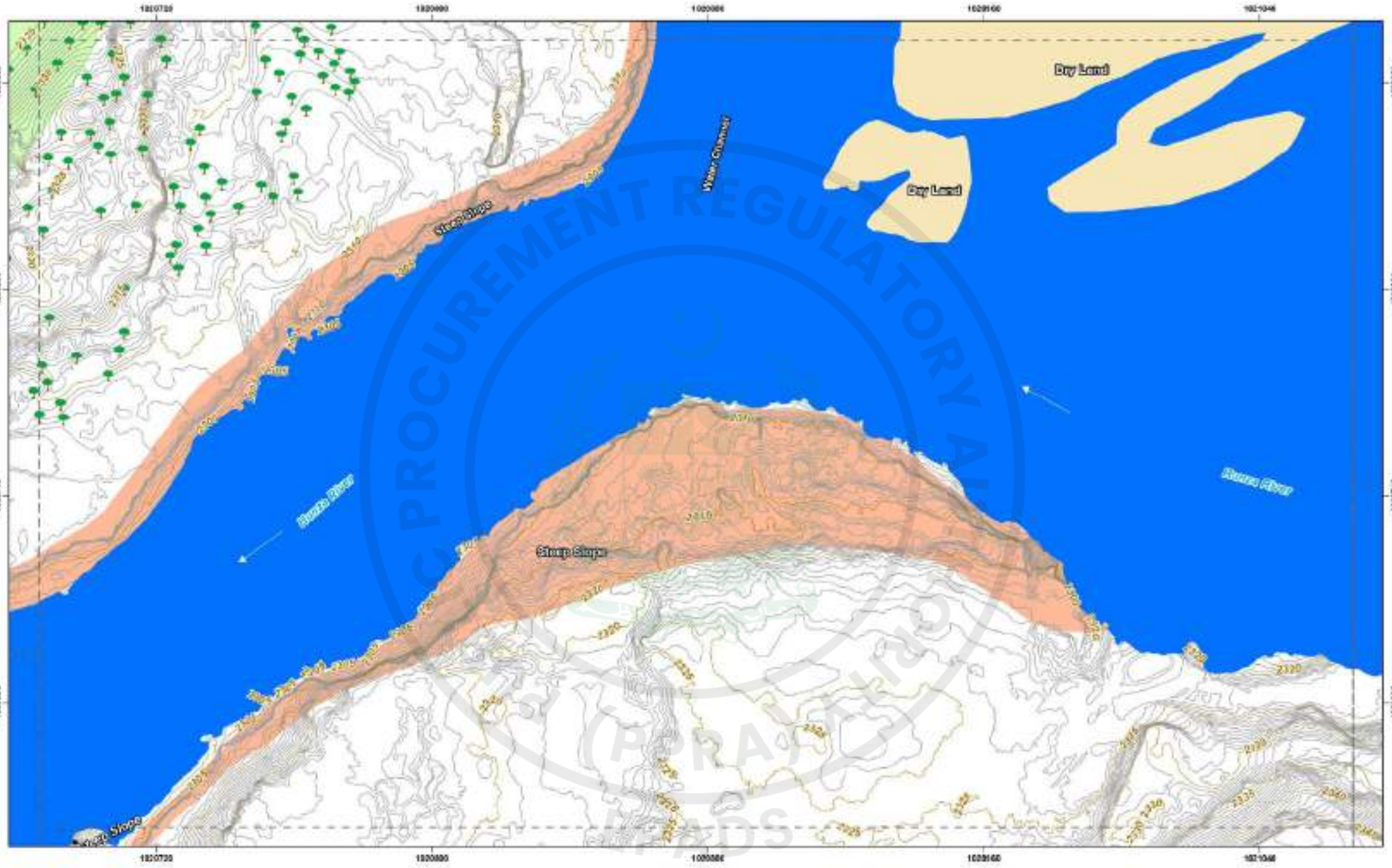
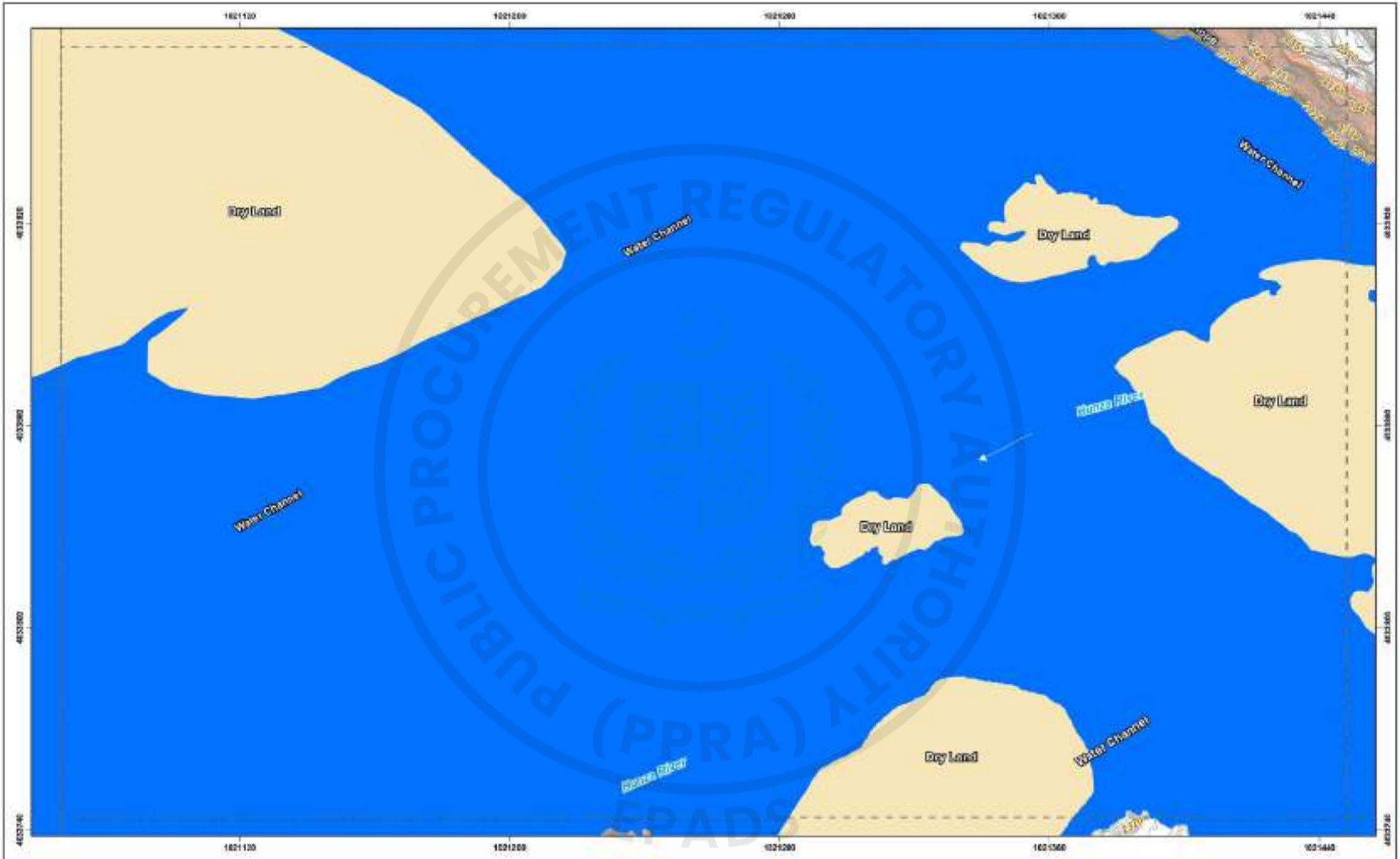

Dry Land
Dry Land
Water Channel
Steep Slope
Steep Slope
Steep Slope




| CLIENT | CONSULTANT | LEGEND | INDEX MAP | DISCLAIMER | PROJECT | TITLE | SCALE |
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| WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: 5 FARAH HOUSE, 1-C, BLOCK-R, MODEL TOWN EXTENSION, LAHORE, PAKISTAN | | | 1. This Map has been prepared by National Engineering Services Pakistan (PVT) Ltd exclusively for the individual, inhouse requirements under FEASIBILITY STUDY AND DETAILED DESIGN FOR CONSTRUCTION OF ATTABAD LAKE HYDROPOWER PROJECT (54 MW).<br>2. The Topographic Survey has been physical characteristics of the terrain and details of the main roads have been within the project pathway obtained through aerial mapping executed in October 2021.<br>3. This information can solely for the use of the authorized request.<br>4. In no case, will be a third party copies of this Map or any response on an extension to be made based on it, are the responsibility of the such party and NESPAK accepts no responsibility for damages, if any, suffered by any third party as a result of said decisions or actions. | ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TOPOGRAPHIC SURVEY PLAN ATTABAD LAKE DAM | 1:1000 |

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| FEB 2026 | Page 27 of 73 | |

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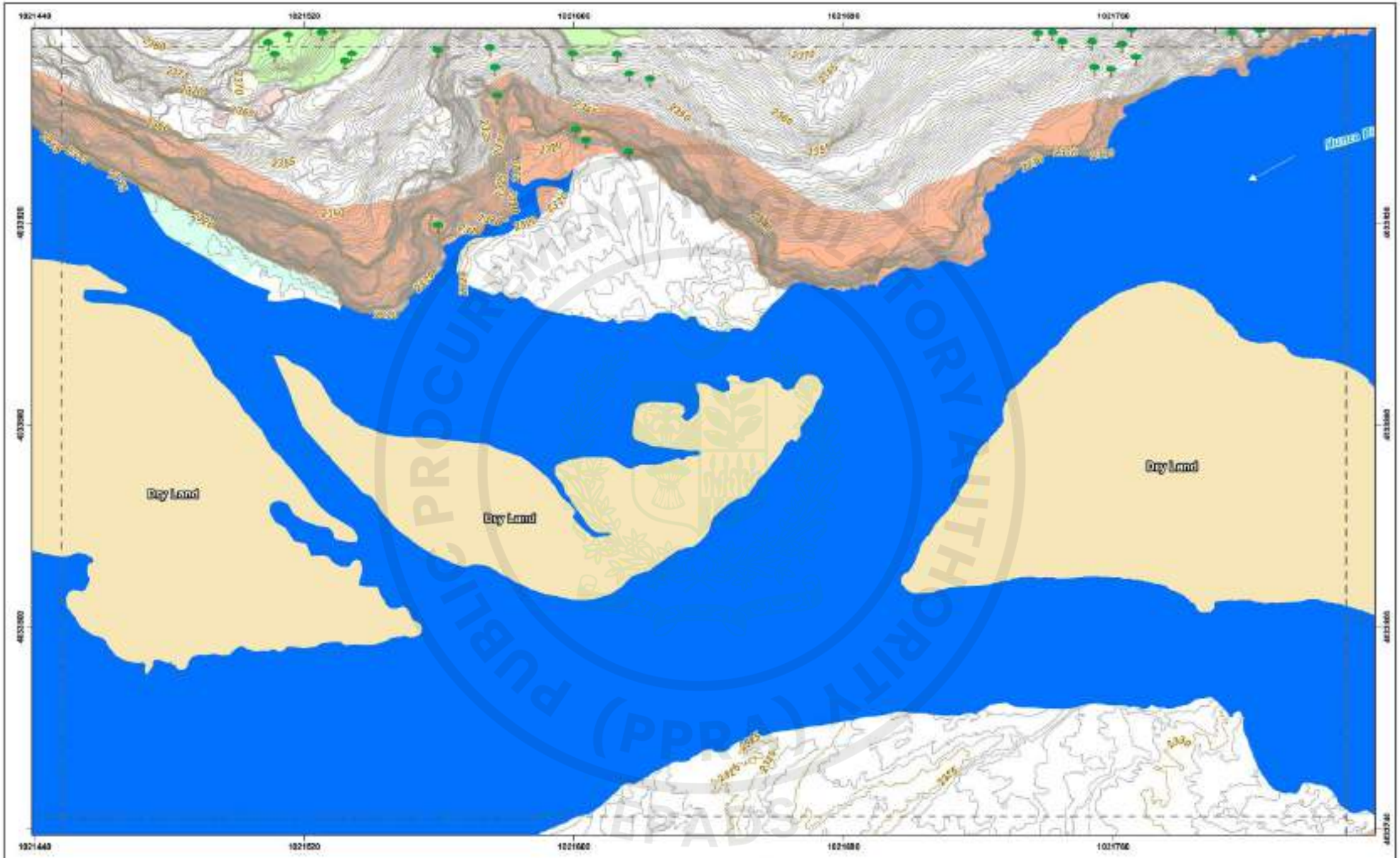


| CLIENT | CONSULTANT | LEGEND | INDEX MAP | DISCLAIMER | PROJECT | TITLE | SCALE |
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| WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: FLEEMM HOUSE, 1-C, BLOCK-B, GODEL TOWN EXTENSION, LAHORE, PAKISTAN | | | 1. This Map has been prepared by National Engineering Services Pakistan (Pvt.) Ltd. (NESPAK) for the exclusive, limited, confidential use of WAPDA and its employees for the purpose of DESIGN FOR CONSTRUCTION OF ATTABAD LAKE HYDROPOWER PROJECT (54 MW).<br>2. The Topographic Survey has been prepared by NESPAK and its sub-consultants. The details of the main roads have been taken from the project authority obtained through aerial mapping executed in October 2021.<br>3. This information can solely for the use of the authorized recipient.<br>4. In no case, will the above party replace of this Map or any responsible on an exclusive basis. In no case shall it, are the responsibility of the such party, and NESPAK accepts no responsibility for damages, if any, suffered by any third party as a result of such decisions or actions. | ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM | 1:1000 |

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| FEB 2026 | Page 28 of 73 | |

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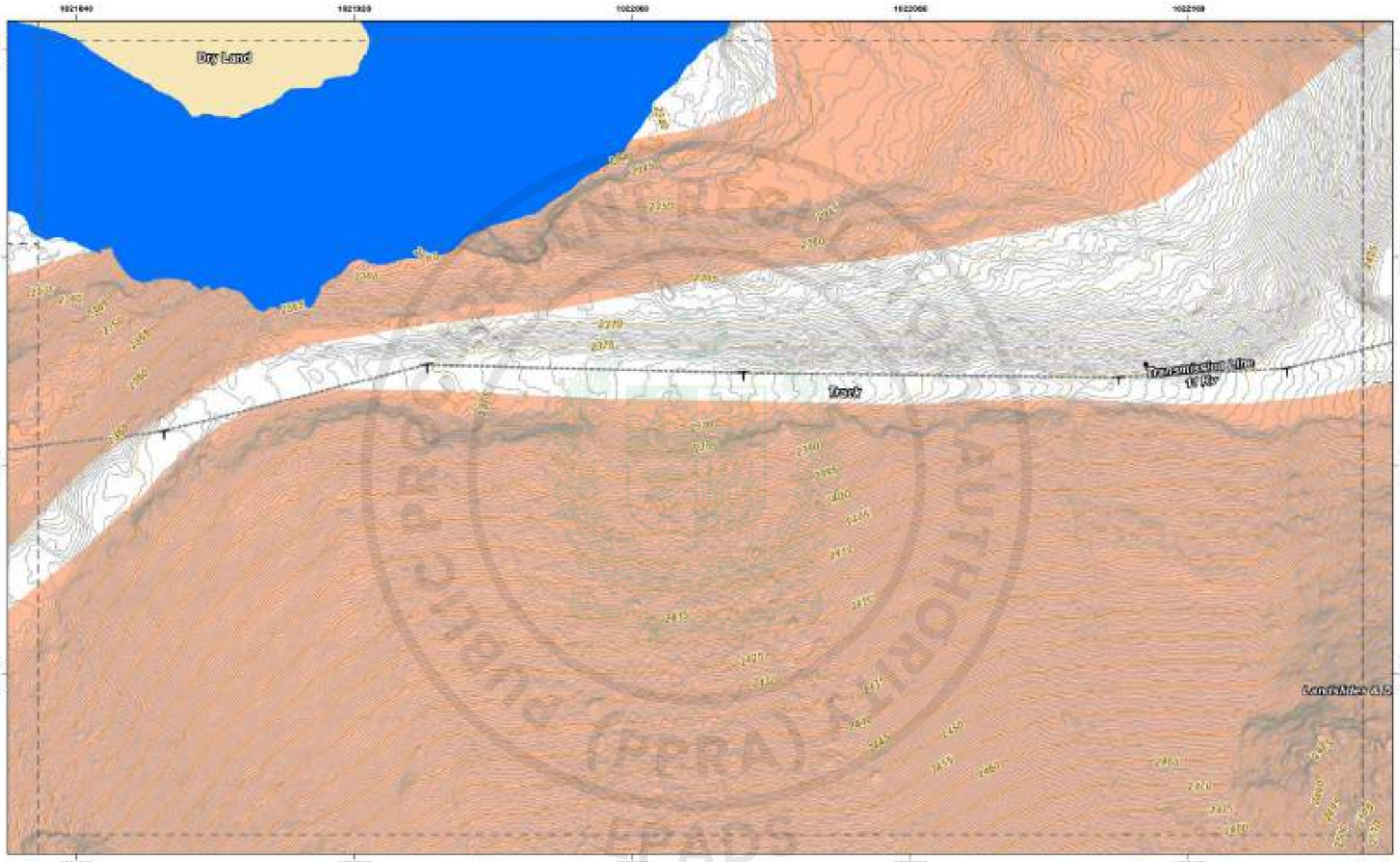


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| CLIENT: WAPDA — WATER AND POWER DEVELOPMENT AUTHORITY | CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS — HEAD OFFICE: ILEFANK HOUSE, 1-E, BLOCK-R, MODEL TOWN EXTENSION, LAHORE, PAKISTAN | LEGEND | INDEX MAP | DISCLAIMER | PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TITLE: TOPOGRAPHIC SURVEY PLAN ATTABAD LAKE DAM |
| | | | | | | DATE: FEB 2026 |
| | | | | | | SHEET NO: Page 39 of 73 |
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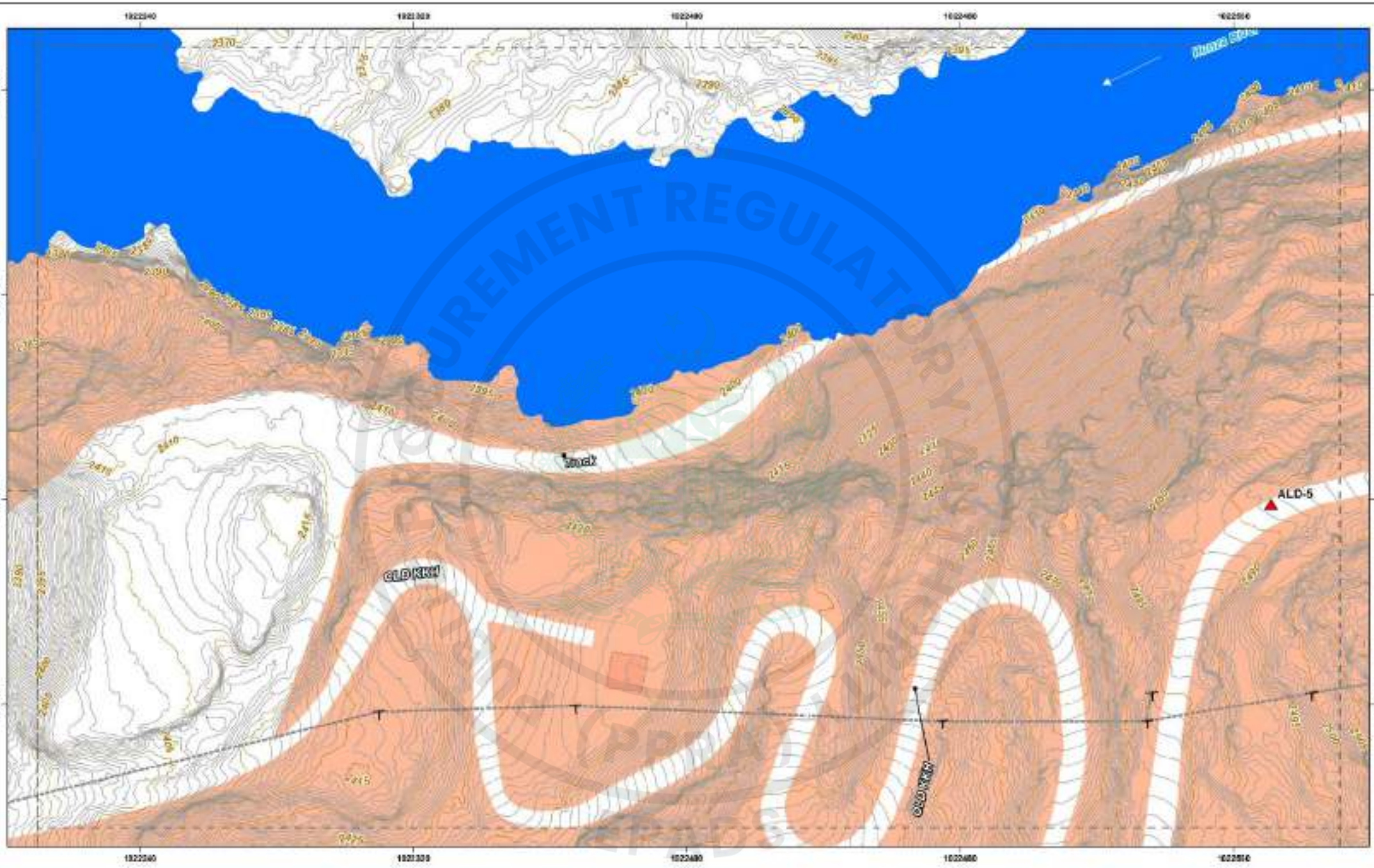


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| CLIENT<br>WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | CONSULTANT<br>ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: 9 FARAK HOUSE, 1-C, BLOCK R, GODEL TOWN EXTENSION, LAHORE, PAKISTAN | LEGEND | INDEX MAP | DISCLAIMER<br>1. This Map has been prepared by National Engineering Services Pakistan (Pvt.) Ltd. (NESPAK) for the exclusive use of WAPDA's HIGH HEAD HYDRO STUDY AND DETAILED DESIGN FOR CONSTRUCTION OF ATTABAD LAKE HYDROPOWER PROJECT (54 MW).<br>2. The Topographic Survey has been prepared using the data collected through aerial mapping executed in October 2021.<br>3. This information can solely be for the use of the authorized recipient.<br>4. In no case, will the above party replace of this Report and NESPAK or its employees be held liable in any way, and the responsibility of the such party, and NESPAK accepts no responsibility for damages, if any, suffered by any third party as a result of such decisions or actions. | PROJECT<br>ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TITLE<br>TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM | SCALE<br>1:1000<br>DATE<br>FEB 2026<br>SHEET NO.<br>Page 30 of 73<br>SCALE BAR: |

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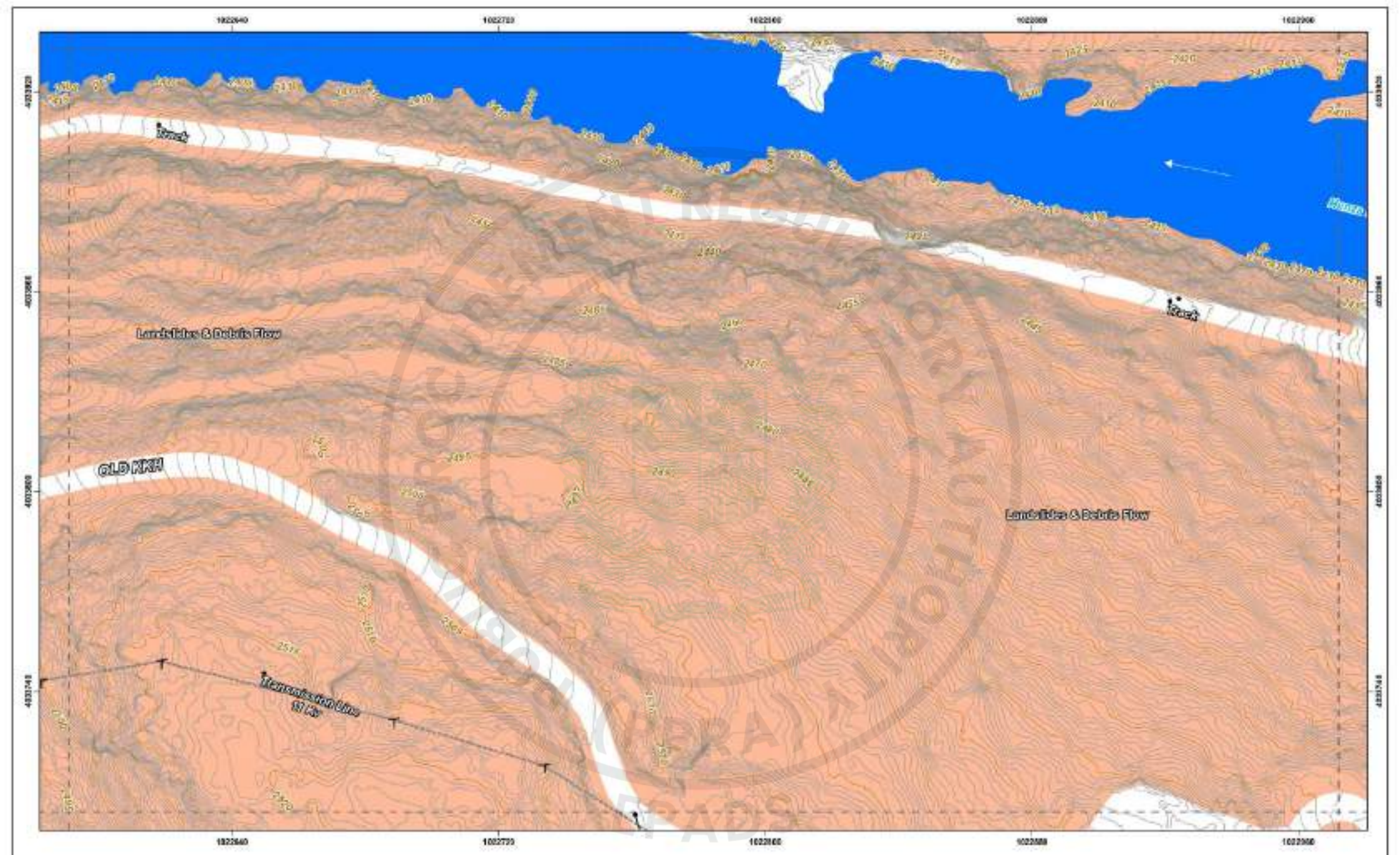


| CLIENT | CONSULTANT | LEGEND | INDEX MAP | DISCLAIMER | PROJECT | TITLE | SCALE |
|---|---|---|---|---|---|---|---|
| WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: 9 FARAK HOUSE, 1-E, BLOCK-R, MODEL TOWN EXTENSION, LAHORE, PAKISTAN | Control Point<br>Tree<br>Transmission Pole<br>Tunnel<br>Oil Line<br>Transmission Line<br>Intervention Contour<br>Water Contour<br>River<br>Dry Land<br>Agriculture Land<br>Rooftop<br>Track<br>Electricity<br>Landslide Dam<br>Peoples Hut<br>Hotels<br>Dam<br>Culvert<br>Bridge<br>Road<br>132 KV Line | | 1. This Map has been prepared by National Engineering Services Pakistan (Pvt.) Ltd. (NESPAK) for the Individual / Inquiry Purpose only. FOR FEASIBILITY STUDY AND DETAILED DESIGN FOR CONSTRUCTION OF ATTABAD LAKE HYDROPOWER PROJECT (54 MW).<br>2. The Topographic Survey has been physical observations of the terrain and details of the main roads have been from the project personnel obtained through aerial mapping executed in October 2025.<br>3. Title information on survey for this sum of the authorized request.<br>4. Any use, which a third party makes of this Report or any reliance on or decisions to be made based on it, are the responsibility of the such party, and NESPAK accepts no responsibility for damages, if any, suffered by any third party as a result of such decisions or actions. | ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM | 1:1000 |
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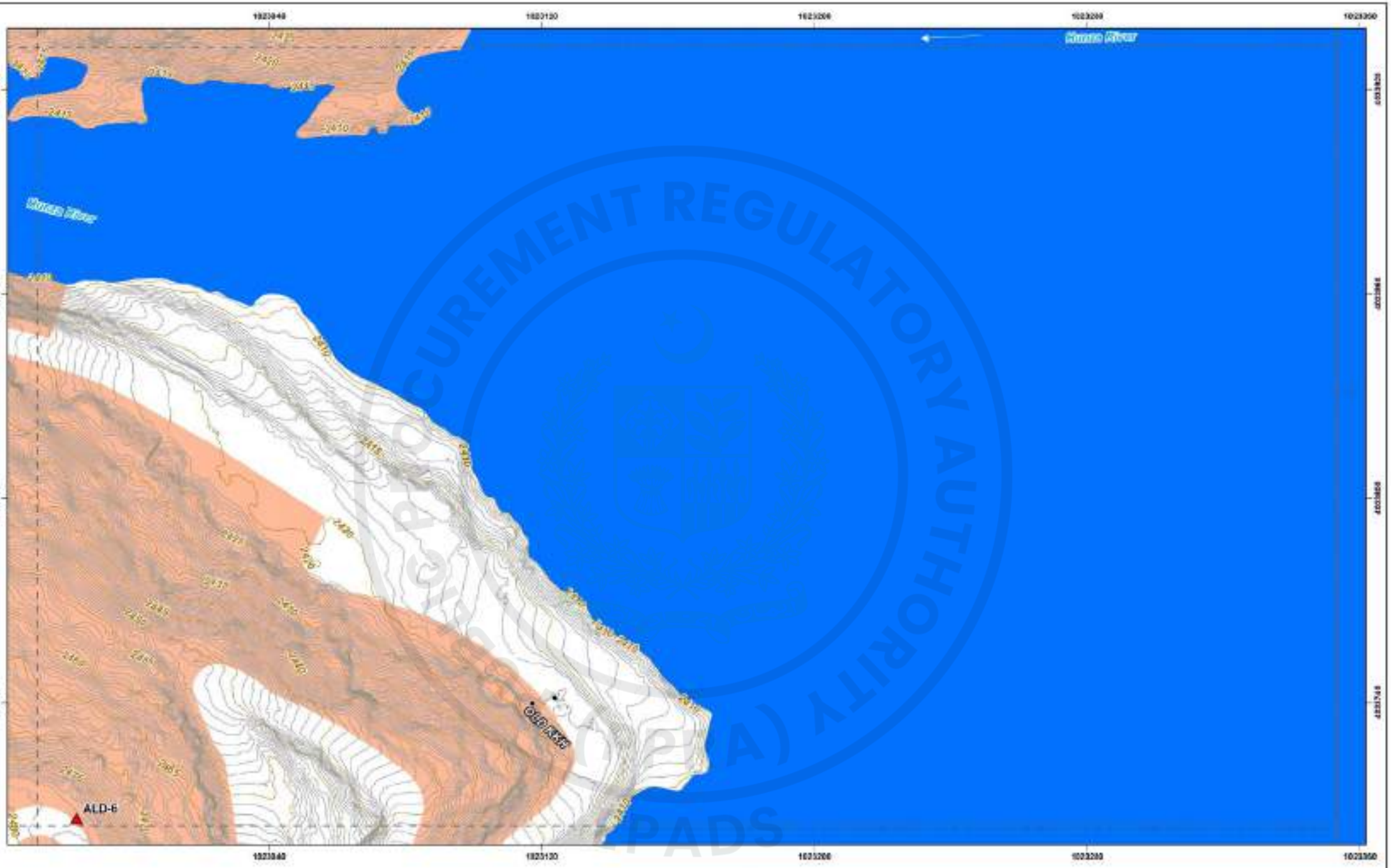


| CLIENT | CONSULTANT | LEGEND | INDEX MAP | DISCLAIMER | PROJECT | TITLE | SCALE |
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| WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: 9 FARAK HOUSE, 1-C, BLOCK-R, MODEL TOWN EXTENSION, LAHORE, PAKISTAN | Control Point, Tail, Tail Water Pipe, Tunnel, Transmission Line, Intervention Contour, Water Contour, River, Dry Land, Agriculture Land, Built-up, Forest, Mountain, Project Site, Powerhouse, Dam, Culvert, Bridge, Road, Landslide Dam | | 1. This Map has been prepared by National Engineering Services Pakistan (PVT) Ltd exclusively for the Individual / Military Settlements / Villages existing along DRIVE DESIGN FOR CONSTRUCTION OF ATTABAD LAKE HYDROPOWER PROJECT (54 MW).<br>2. The Topographic Survey has been physical characteristics of the terrain and details of the main roads have been within the project perimeter obtained through aerial mapping executed in October 2025.<br>3. The information on survey for this can of the authorized request.<br>4. In no case, will the client party replace of this Report any responsible on an expression be he made based on it, are the responsibility of the such party and NESPAK accepts no responsibility for damages, if any, suffered by any third party as a result of such decisions or actions. | ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM | 1:1000 |

| DATE | SHEET NO. | SCALE BAR: |
|---|---|---|
| FEB 2026 | Page 32 of 73 | |

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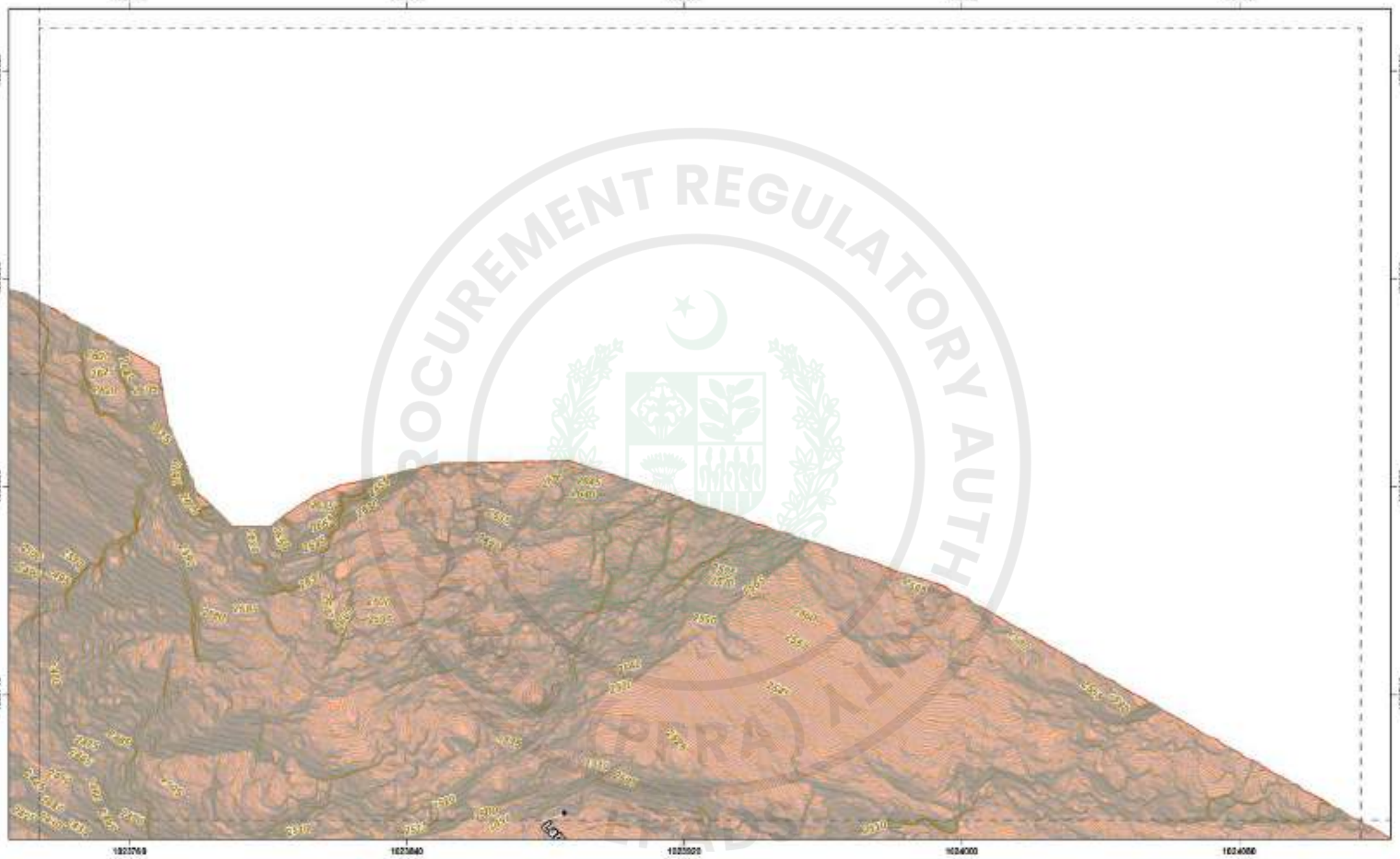
| CLIENT<br>WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | CONSULTANT<br>ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: 11 FARAK HOUSE, 1-C, BLOCK-R MODEL TOWN EXTENSION, LAHORE, PAKISTAN | LEGEND | INDEX MAP | DISCLAIMER<br>1. This Map has been prepared by National Engineering Services Pakistan (PVT) Ltd. (NESPAK) for the exclusive, limited purpose(s) of the PEAS entity for any and all PUBLIC DESIGN FOR CONSTRUCTION OF ATTABAD LAKE HYDROPOWER PROJECT (54 MW).<br>2. The Topographic Survey was carried physical characteristics of the terrain and details of the main roads have been from the project partners obtained through aerial mapping executed in October 2020.<br>3. The information on activity for this use of the authorized request.<br>4. Any use, which a third party makes of this Map or any reliance on or decisions to be made based on it, are the responsibility of the such party and NESPAK accepts no responsibility for damages, if any, suffered by any third party as a result of such decisions or actions. | PROJECT<br>ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TITLE<br>TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM<br>DATE: FEB 2026<br>SHEET NO: Page 33 of 73 | SCALE<br>1:1000<br>SCALE BAR: |

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS




| CLIENT | CONSULTANT | LEGEND | INDEX MAP | DISCLAIMER | PROJECT | TITLE | SCALE |
|---|---|---|---|---|---|---|---|
| WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: 15 SHAH HOUSE, 1-E, BLOCK R, MODEL TOWN EXTENSION, LAHORE, PAKISTAN | Control Point, Tree, Transmission Pole, Tunnel, 33 KV Line, Transmission Line, Intervention Contour, Water Contour, River, Dry Land, Agriculture Land, Rooftop, Track, Electricity, Landslide Zone, Peripheral Wall, Hillside, Drain, Culvert, Bridge, Road, 11 KV Line | | 1. This Map has been prepared by National Engineering Services Pakistan (PVT) Ltd exclusively for the Individual / Inquiry Purposes in Year 2025 for Study and Detailed Design for Construction of Attabad Lake Hydropower Project (54 MW).<br>2. The Topographic Survey has been physical characteristics of the terrain and details of the main roads have been within the project perimeter obtained through aerial mapping executed in October 2024.<br>3. The information on survey for the use of the authorized recipient.<br>4. Any use, which a third party makes of this Report or any reliance on or decisions to be made based on it, are the responsibility of the such party, and NESPAK accepts no responsibility for damages, if any, suffered by any third party as a result of such decisions or actions. | ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM | 1:1000 |

| DATE | SHEET NO. | SCALE BAR: |
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| FEB 2026 | Page 34 of 73 | |

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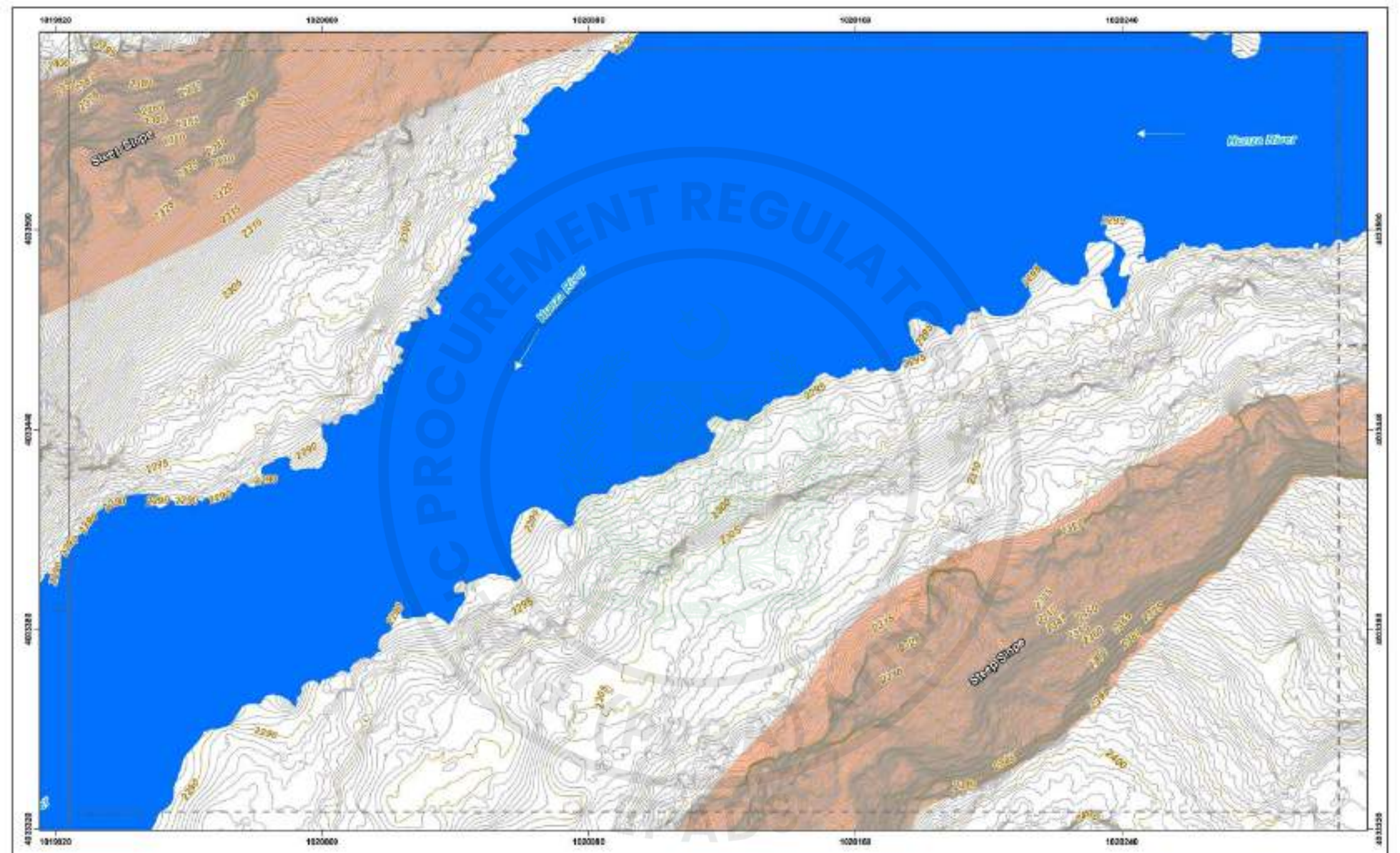


| CLIENT | CONSULTANT | LEGEND | INDEX MAP | DISCLAIMER | PROJECT | TITLE | SCALE |
|---|---|---|---|---|---|---|---|
| WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: FLEEMAK HOUSE, 1-C, BLOCK-N, GODEL TOWN EXTENSION, LAHORE, PAKISTAN | Control Point, Tree, Tax Division File, Survey, Grid Line, Tax Division Line, Intervention Contour, Water Contour, River, Dry Land, Agriculture Land, Built-up, Water, Project Site, Village, Road, Canal, Bridge, Shed, L.T. / HSE LIN, Landslide Zone | | 1. This Map has been prepared by National Engineering Services Pakistan (PVT.) Ltd. exclusively for the purpose of "PREPARATION OF PC-I FOR ENLISTMENT OF NEW DIVERSION DRIVEN HYDROPOWER PROJECT (54 MW)".<br>2. The Topographic Survey has been physically executed on the ground and details of the main roads have been added in the project platform obtained through aerial mapping executed in October 2021.<br>3. This information on survey for the sole of the authorized request.<br>4. Any use, which a third party makes of this Report or any reliance on or decisions to be made based on it, are the responsibility of the such party, and NESPAK accepts no responsibility for damages, if any, suffered by any third party as a result of such decisions or actions. | ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM | 1:1000 |

| DATE | SHEET NO. | SCALE BAR: |
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| FEB 2026 | Page 35 of 73 | |

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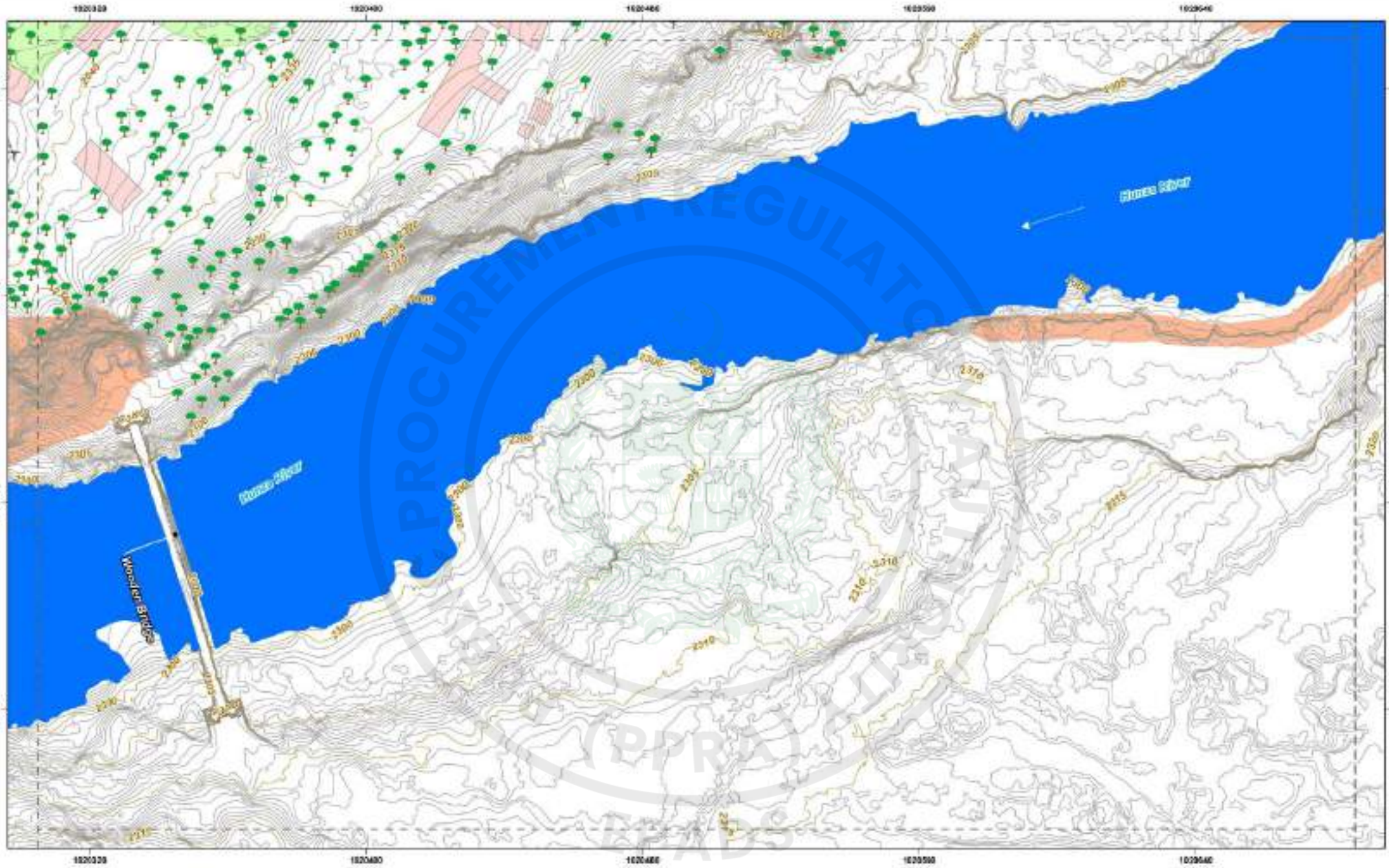


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| CLIENT<br>WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | CONSULTANT<br>ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: 5 FARAK HOUSE, 1-E, BLOCK-R, MODEL TOWN EXTENSION, LAHORE, PAKISTAN | LEGEND | INDEX MAP | DISCLAIMER<br>1. This Map has been prepared by National Engineering Services Pakistan (PVT) Ltd exclusively for the Technical Inquiry Purposes in Inter-Road Entity Survey and Detailed Design for Construction of Attabad Lake Hydropower Project (54 MW).<br>2. The Topographic Survey has been physical observations of the terrain and details of the main roads have been from the project particulars obtained through aerial mapping executed in October 2021.<br>3. This information on survey for the sole of the authorized request.<br>4. Any use, which a third party makes of this Report or any reliance on or decisions to be made based on it, are the responsibility of the such party, and NESPAK accepts no responsibility for damages, if any, suffered by any third party as a result of such decisions or actions. | PROJECT<br>ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TITLE<br>TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM<br>DATE: FEB 2026<br>SHEET NO.: Page 36 of 73<br>SCALE BAR: | SCALE<br>1:1000 |

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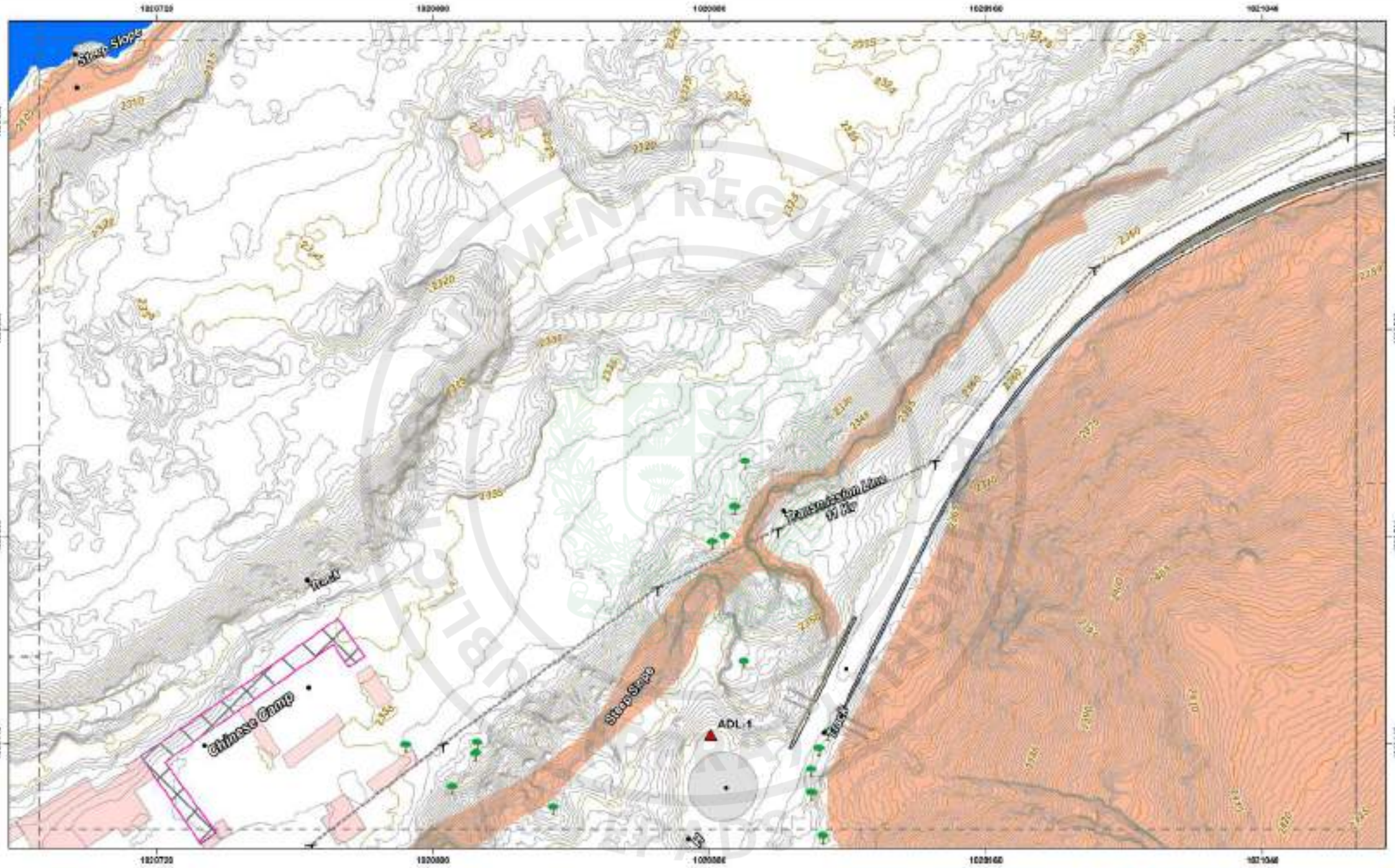


| CLIENT | CONSULTANT | LEGEND | INDEX MAP | DISCLAIMER | PROJECT | TITLE | SCALE |
|---|---|---|---|---|---|---|---|
| WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: FLEMING HOUSE, 1-E, BLOCK-R, GOWAL TOWN EXTENSION, LAHORE, PAKISTAN | Control Point, Tree, Spot Elevation Point, Contour, Dry Land, Agriculture Land, Building, Road, Transmission Line, Telephone Line, Irrigation Canal, Stream, Water Course, River, Dry Land, Cultivated, Built Up, Road, Bridge, Tunnel, Transmission Line, Telephone Line, Boundary, Project Site, Village, Chak, Nullah, Cemetery, Landslide Zone | | 1. This Map has been prepared by National Engineering Services Pakistan (PVT) Ltd exclusively for the Technical Inquiry purposes in connection with the ATTABAD HYDROPOWER PROJECT (54 MW).<br>2. The Topographic Survey has been physically verified on site in May 2021 and details of the main roads have been verified on site in October 2021.<br>3. This information is only for the use of the authorized recipient.<br>4. In no case, will the above party replace of this Map or any responsible or employee be held liable for it, and the responsibility of the such party, and NESPAK as well as no responsibility for damages, if any, suffered by any third party as a result of such actions or advice. | ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM | 1:1000 |

| DATE | SHEET NO. | SCALE BAR: |
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| FEB 2026 | Page 37 of 73 | |

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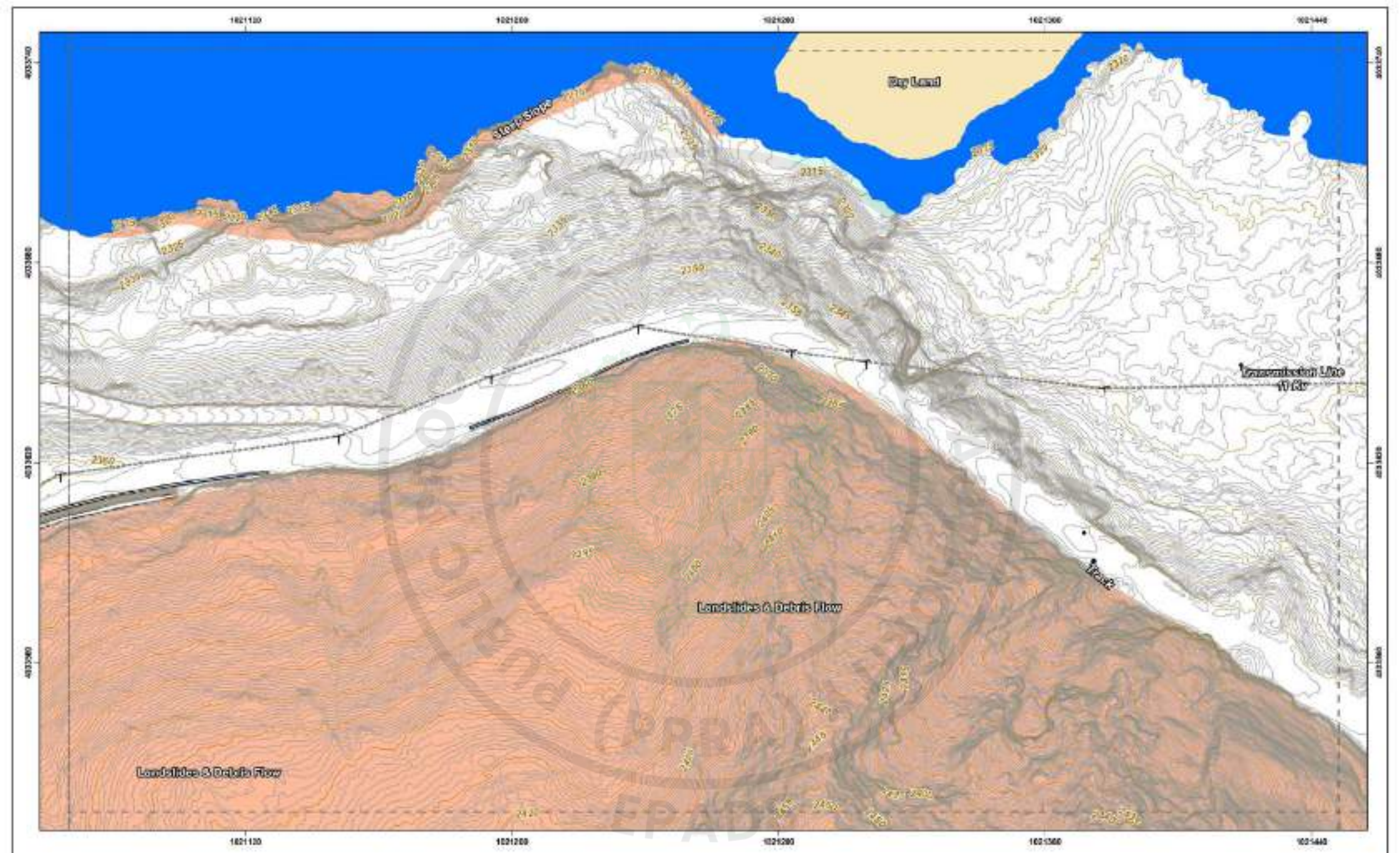


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| CLIENT: WAPDA — WATER AND POWER DEVELOPMENT AUTHORITY | CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS — HEAD OFFICE: 5 FARAK HOUSE, 1-E, BLOCK-R, MODEL TOWN EXTENSION, LAHORE, PAKISTAN | LEGEND | INDEX MAP | DISCLAIMER | PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TITLE: TOPOGRAPHIC SURVEY PLAN ATTABAD LAKE DAM | SCALE: 1:1000 |
| | | | | | | DATE: FEB 2026 — SHEET NO: Page 38 of 73 — SCALE BAR: | |

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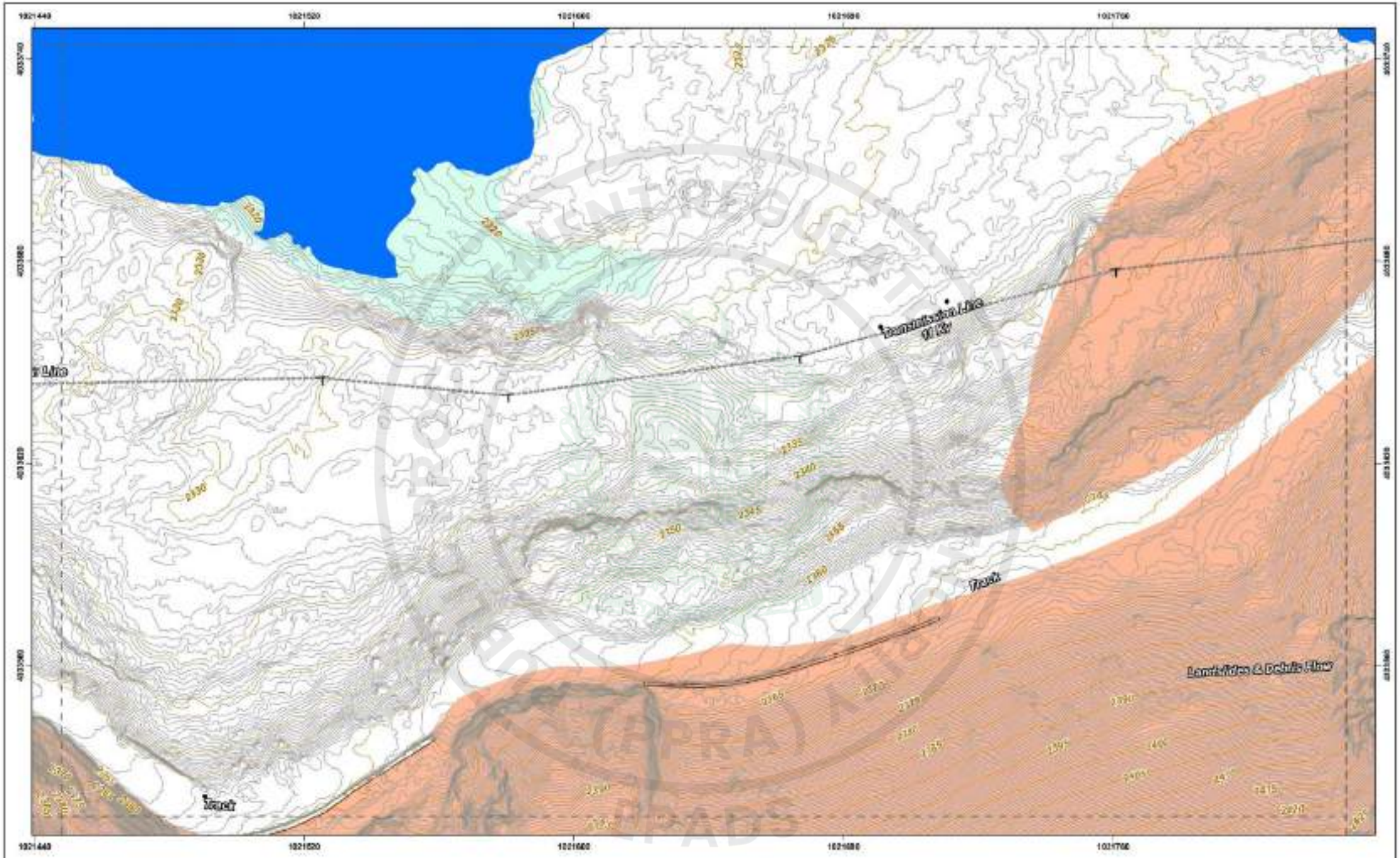


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| CLIENT<br>WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | CONSULTANT<br>ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: 5 FARAK HOUSE, 1-E, BLOCK-R MODEL TOWN EXTENSION, LAHORE, PAKISTAN | LEGEND | INDEX MAP | DISCLAIMER<br>1. This Map has been prepared by National Engineering Services Pakistan (Pvt.) Ltd. (NESPAK) for the exclusive use of WAPDA's ATTABAD HYDROPOWER PROJECT (54 MW).<br>2. The Topographic Survey has been prepared by Aerial Photogrammetric Survey Method in October 2021.<br>3. This information is only for the use of the authorized recipient.<br>4. In no case, will the client/ party/ users of this Map or any recipient or an employee or his made liable or it, are the responsibility of the such party and NESPAK accepts no responsibility for damages, if any, suffered by any third party as a result of such decisions or actions. | PROJECT<br>ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TITLE<br>TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM<br>DATE: FEB 2026<br>SHEET NO.: Page 39 of 73<br>SCALE BAR: | SCALE<br>1:1000 |

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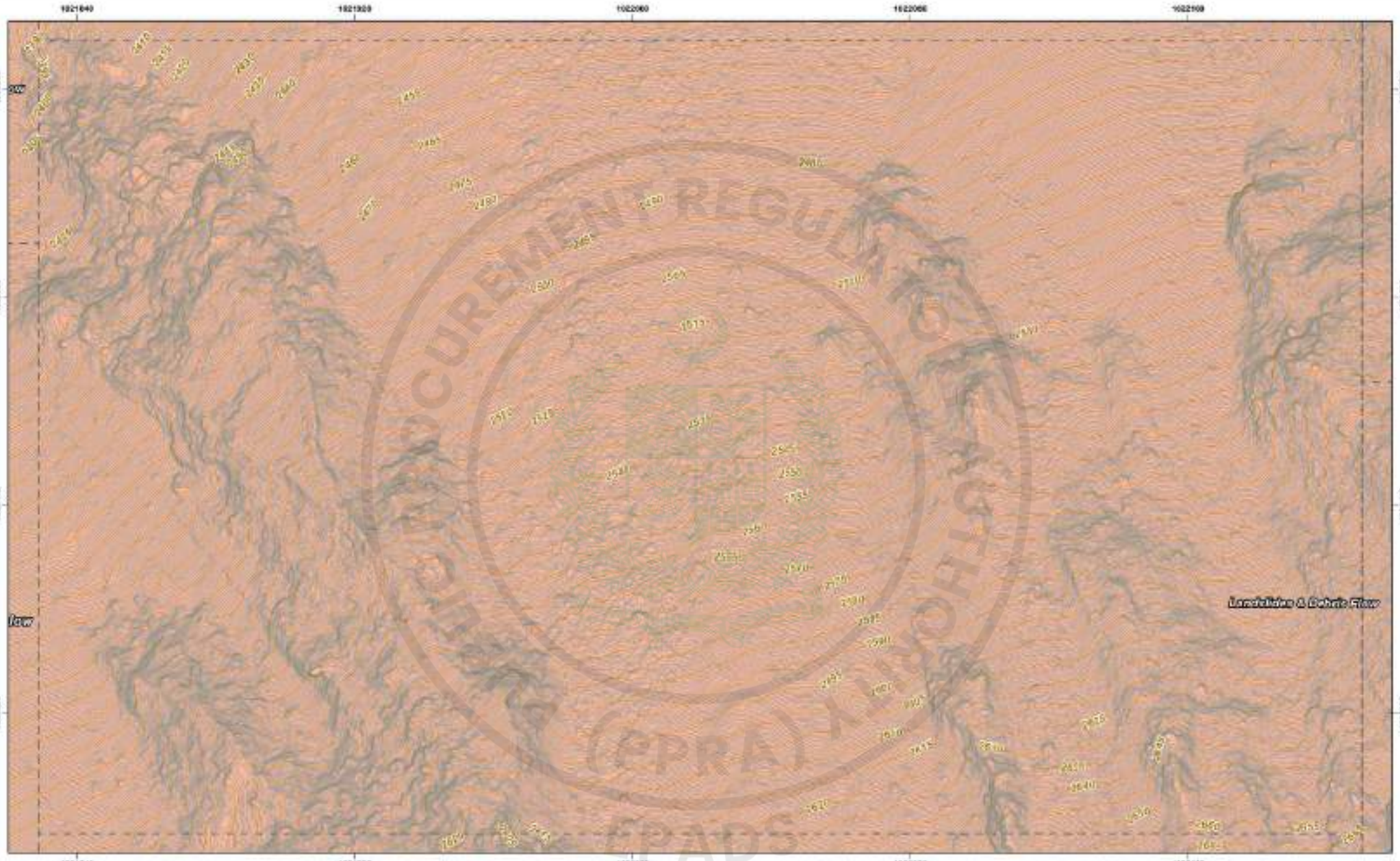


| CLIENT | CONSULTANT | LEGEND | INDEX MAP | DISCLAIMER | PROJECT | TITLE | SCALE |
|---|---|---|---|---|---|---|---|
| WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: ILEGRAM HOUSE, 1-E, BLOCK-R, MODEL TOWN EXTENSION, LAHORE, PAKISTAN | Control Point, Tree, Tax Division Line, Tax Division Line, Intervention Contour, Water Course, River, Dry Land, Agriculture Land, Rooftop, Road, Electricity, Landslide Zone, Project Site, HRWM, Drain, Culvert, Bridge, Shed, 11 KV Line | | 1. This Map has been prepared by National Engineering Services Pakistan (PVT) Ltd exclusively for the Technical Inquiry purposes in the ROAD ENTRY to Inlet Area DRIVELINE ORIGIN FOR CONSTRUCTION OF ATTABAD LAKE HYDROPOWER PROJECT (54 MW).<br>2. The Topographic Survey has been prepared by using Total Station and details of the main roads have been taken from the project authority obtained through aerial mapping executed in October 2020.<br>3. The information on survey for the use of the authorized request.<br>4. In no case, will be a third party replace of this Report and responsible on an exclusive basis made based on it, are the responsibility of the such party, and NESPAK accepts no responsibility for damages, if any, suffered by any third party as a result of such decisions or actions. | ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM | 1:1000 |

| DATE | SHEET NO. | SCALE BAR: |
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| FEB 2026 | Page 40 of 73 | |

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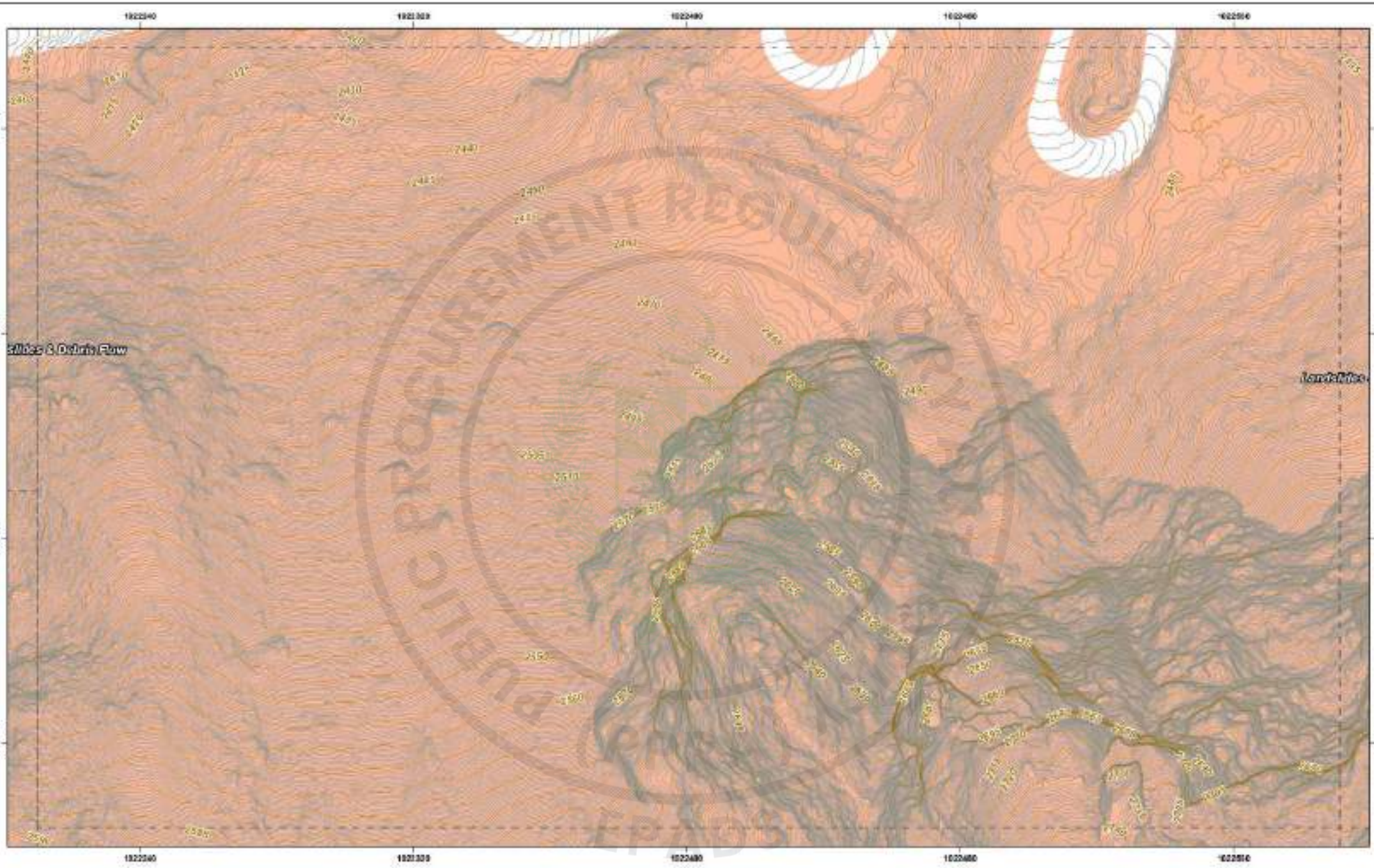


| CLIENT | CONSULTANT | LEGEND | INDEX MAP | DISCLAIMER | PROJECT | TITLE | SCALE |
|---|---|---|---|---|---|---|---|
| WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: 5 FARAK HOUSE, 1-E, BLOCK-R, GOWAL TOWN EXTENSION, LAHORE, PAKISTAN | Control Point, Tel, Transmission Pole, Tunnel, Oil Line, Transmission Line, Intervention Contour, Water Course, River, Dry Land, Agriculture Land, Rooftop, Trees, Electricity, Landslide Dam, Perennial Nala, Intake, Dam, Culvert, Bridge, Road, Water Line | | 1. This Map has been prepared by National Engineering Services Pakistan (PVT) Ltd exclusively for the Individual / Inquiry purpose(s) only. It has been prepared for the above mentioned project and should not be used for any other purpose.<br>2. The Topographic Survey has been prepared by the Consultant and details of the main roads have been taken from the project authority obtained through aerial mapping executed in October 2024.<br>3. The information and survey for this sort of the authorized request.<br>4. In any case, we as a third party replies of this Map or any response on an extension to be made based on it, are the responsibility of the such party, and NESPAK accepts no responsibility for damages, if any, suffered by any third party as a result of such decisions or actions. | ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM | 1:1000 |

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| FEB 2026 | Page 61 of 73 | |

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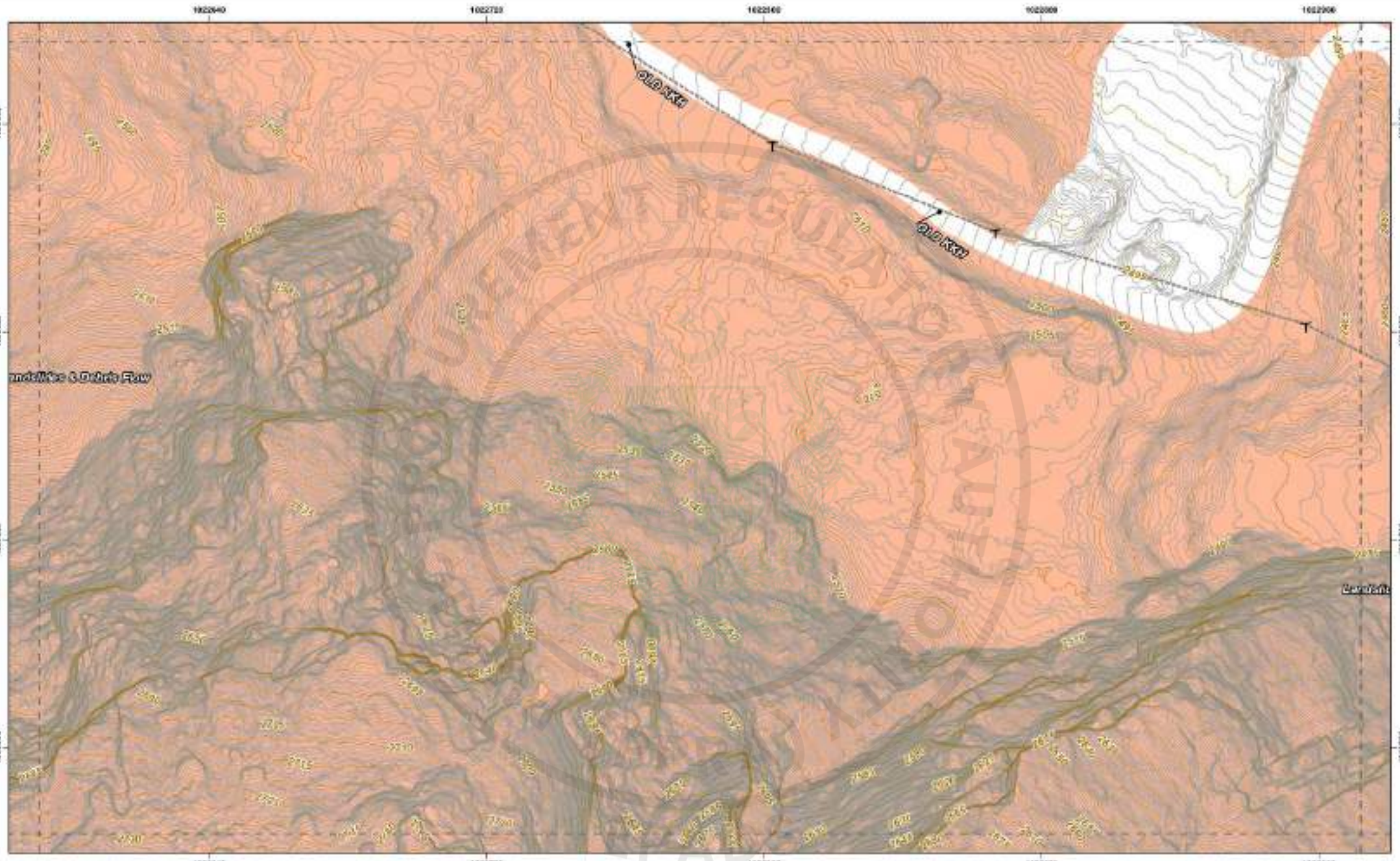


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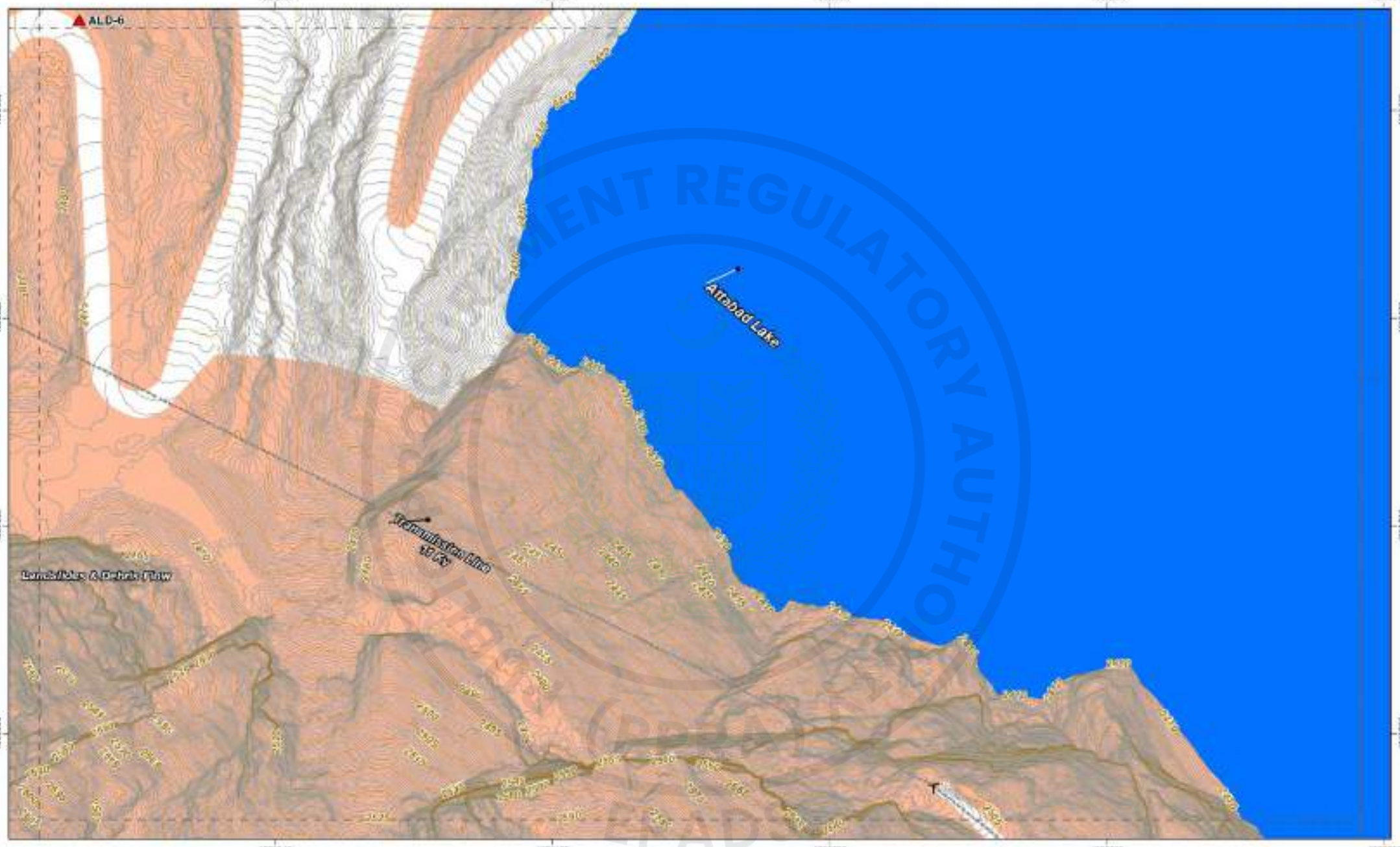
| CLIENT<br>WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | CONSULTANT<br>ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: 5 FARAK HOUSE, 1-E, BLOCK-R, MODEL TOWN EXTENSION, LAHORE, PAKISTAN | LEGEND | INDEX MAP | DISCLAIMER<br>1. This Map has been prepared by National Engineering Services Pakistan (PVT) Ltd exclusively for the purpose of "SHORT SUPPLY OF 11000 YEARS ASTTP SHEAR AND DATA FOR CONSTRUCTION OF ATTABAD LAKE HYDROPOWER PROJECT (54 MW)".<br>2. The Topographic Survey has been physical characteristics of the terrain and details of the main roads have been taken by the project personnel obtained through aerial mapping executed in October 2021.<br>3. This information and survey for the sole of the authorized request.<br>4. Any use, which a third party makes of this Report or any reliance on or decisions to be made based on it, are the responsibility of the such party, and NESPAK accepts no responsibility for damages, if any, suffered by any third party as a result of such decisions or actions. | PROJECT<br>ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TITLE<br>TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM<br>DATE: FEB 2026<br>SHEET NO: Page 42 of 73<br>SCALE BAR: | SCALE<br>1:1000 |

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| CLIENT: WAPDA — WATER AND POWER DEVELOPMENT AUTHORITY | CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS — HEAD OFFICE: 5 FARAH HOUSE, 1-C, BLOCK R, MODEL TOWN EXTENSION, LAHORE, PAKISTAN | LEGEND | INDEX MAP | DISCLAIMER | PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TITLE: TOPOGRAPHIC SURVEY PLAN ATTABAD LAKE DAM | SCALE: 1:1000 |
| | | | | | | DATE: FEB 2026 | SHEET NO.: Page 43 of 73 |
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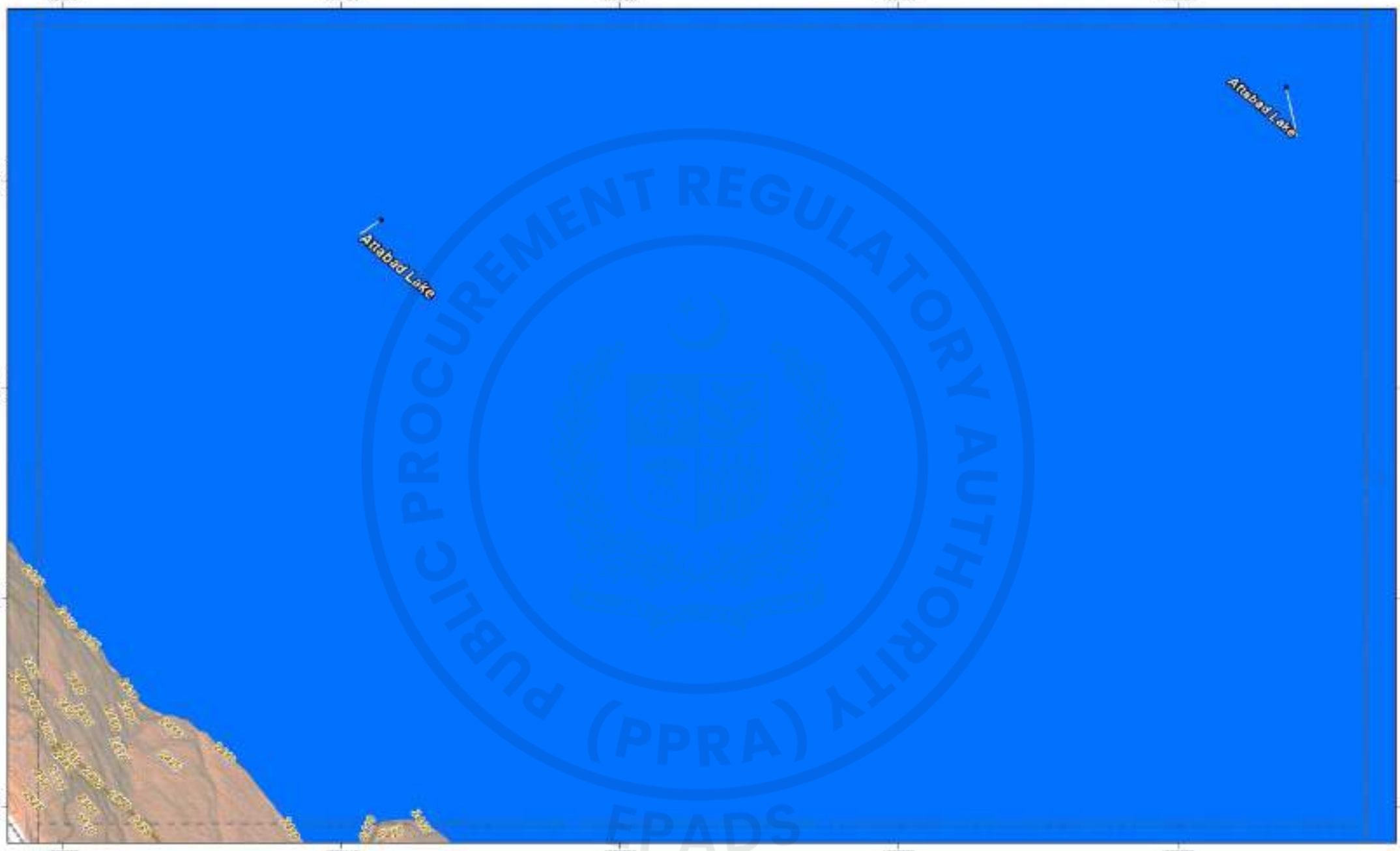


PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

| CLIENT | CONSULTANT | LEGEND | INDEX MAP | DISCLAIMER | PROJECT | TITLE | SCALE |
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| WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: 9 FARAK HOUSE, 1-E, BLOCK-R, MODEL TOWN EXTENSION, LAHORE, PAKISTAN | Control Point, Tent, Tent Erection Path, Tunnel, Oil Line, Tent Erection Line, Intervention Contour, Water Contour, Roads, Dry Land, Agriculture Land, Rooftop, Trees, Electricity, Landslide Zone, Project Site, PRMAA, Drain, Culverts, Bridge, Shed, 11 KV Electric Line | | 1. This Map has been prepared by National Engineering Services Pakistan (PVT) Ltd exclusively for the Individual / Military Settlements in Attabad Lake vicinity for any particular purpose for construction of Attabad Lake Hydropower Project (54 MW).<br>2. The Topographic Survey has been physical characteristics of the terrain and details of the main roads have been within the project patches obtained through aerial mapping executed in October 2025.<br>3. The information on survey for the use of the authorized recipient.<br>4. Any use, which a third party makes of this Report or any reliance on or decisions to be made based on it, are the responsibility of the such party, and NESPAK accepts no responsibility for damages, if any, suffered by any third party as a result of such decisions or actions. | ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TOPOGRAPHIC SURVEY PLAN ATTABAD LAKE DAM | 1:1000 |

| DATE | SHEET NO. | SCALE BAR: |
|---|---|---|
| FEB 2026 | Page 44 of 73 | |

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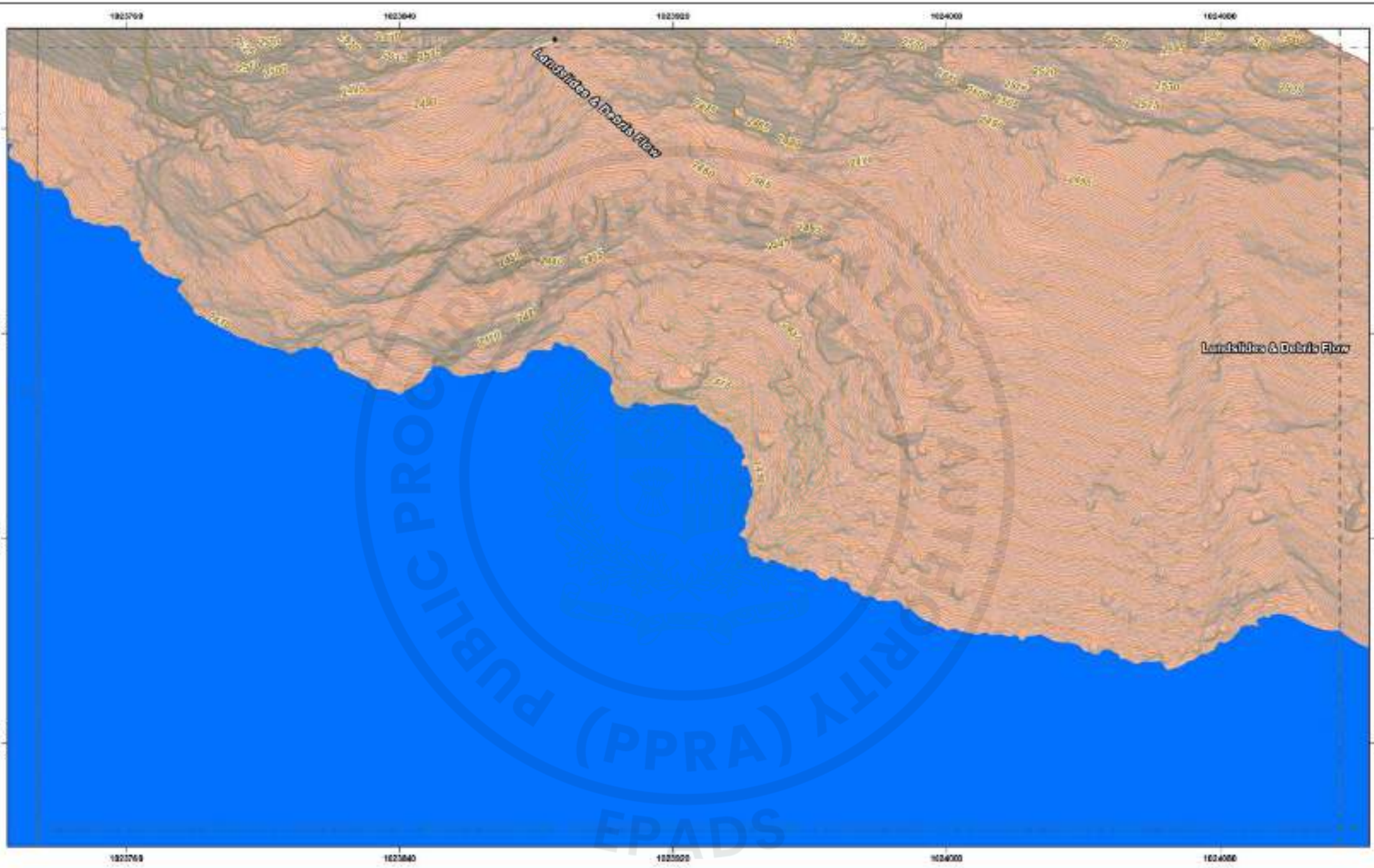


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| CLIENT<br>WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | CONSULTANT<br>ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: 11 FARAK HOUSE, 1-C, BLOCK-R MODEL TOWN EXTENSION, LAHORE, PAKISTAN | LEGEND | INDEX MAP | DISCLAIMER<br>1. This Map has been prepared by National Engineering Services Pakistan (PVT) Ltd exclusively for the internal, inhouse purposes. Under no circumstances any person, including but not limited to, any contractor, is to rely on any information contained herein for the purpose of bidding, tendering, construction or any other purpose. Any such reliance shall be entirely at the risk of such person and NESPAK accepts no responsibility for any damages, losses or liabilities arising from such reliance.<br>2. The Topographic Survey has been carried out by Aerial Photogrammetry and Ground Truthing. The Survey was carried out in October 2021.<br>3. The information on this Map is valid for the date of the survey mentioned above.<br>4. Any use, reliance or decision made by any person based on this Map is entirely at their own risk and NESPAK accepts no responsibility for any such use, reliance or decision. | PROJECT<br>ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TITLE<br>TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM | SCALE<br>1:1000 |
| | | | | | | DATE<br>FEB 2026 | SHEET NO.<br>Page 65 of 73 |
| | | | | | | SCALE BAR: | |

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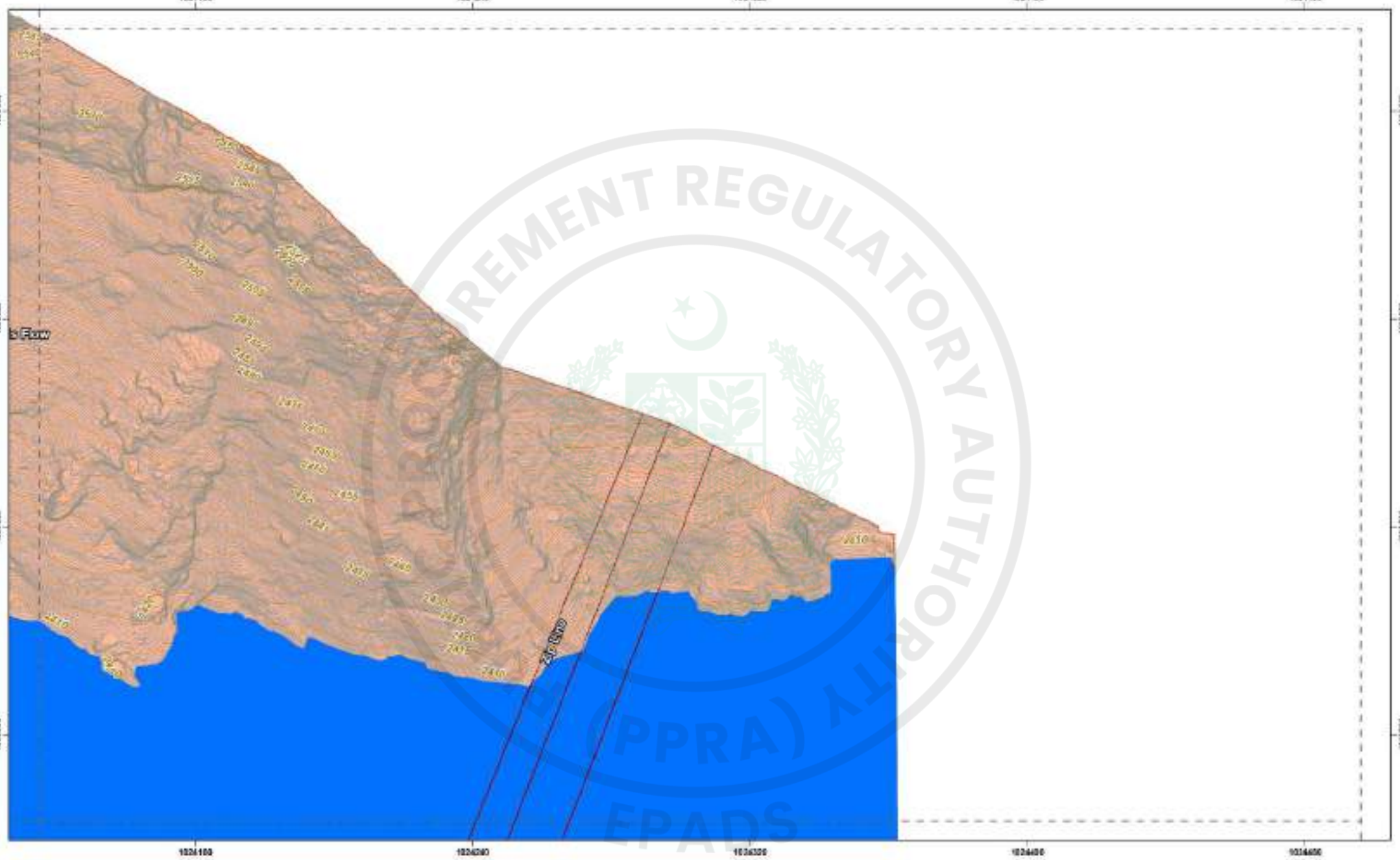
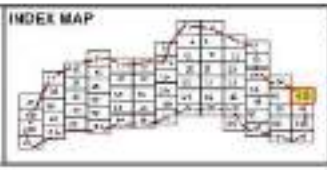



| CLIENT | CONSULTANT | LEGEND | INDEX MAP | DISCLAIMER | PROJECT | TITLE | SCALE |
|---|---|---|---|---|---|---|---|
| WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: 9 FARAK HOUSE, 1-E, BLOCK-R, GODEL TOWN EXTENSION, LAHORE, PAKISTAN | Control Point, Tree, Tube Well/Hand Pump, Tel/Electric Pole, Tunnel, Gas Line, Tel/Telecom Line, Intervention Contour, Water Course, River, Dry Land, Agriculture Land, Rooftop, Track, Electric Line, Landslide Zone, Project Site, Houses, Check, Culvert, Bridge, Road, Gas Line |  | This Map has been prepared by National Engineering Services Pakistan (Pvt.) Ltd. (NESPAK) for the exclusive, limited purpose of use by Water and Power Development Authority (WAPDA) for the ATTABAD LAKE HYDROPOWER PROJECT (54 MW).<br>The Topographic Survey has been carried out by NESPAK in the month of October 2024.<br>This information can be used by WAPDA for the use of the authorized purpose.<br>Any use, which a third party makes of this Map or any reliance on or decisions to be made based on it, are the responsibility of such party, and NESPAK accepts no responsibility for damages, if any, suffered by any third party as a result of such decisions or actions. | ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM | 1:1000 |

| DATE | SHEET NO. | SCALE BAR: |
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| FEB 2026 | Page 48 of 73 | |

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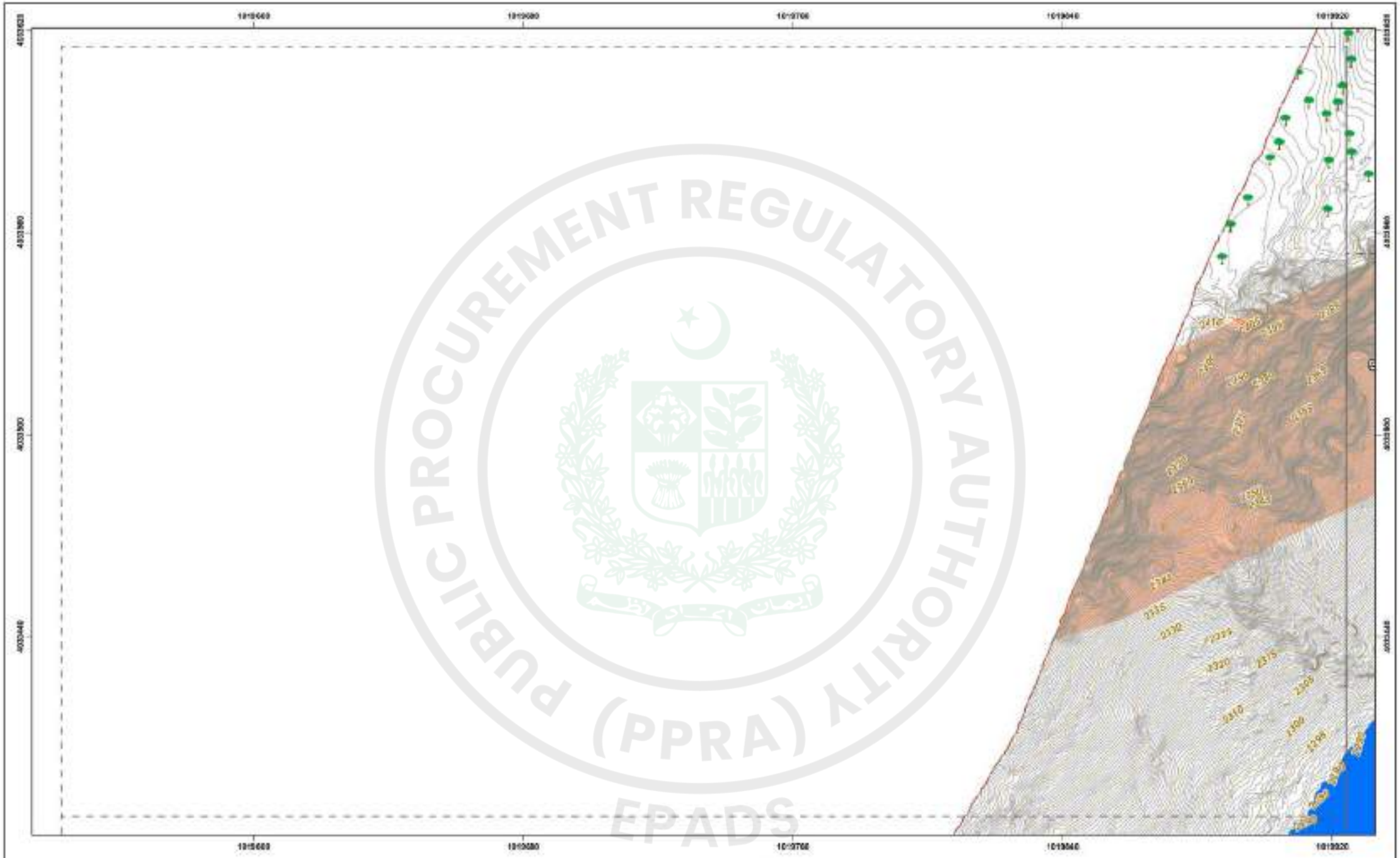


PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA)
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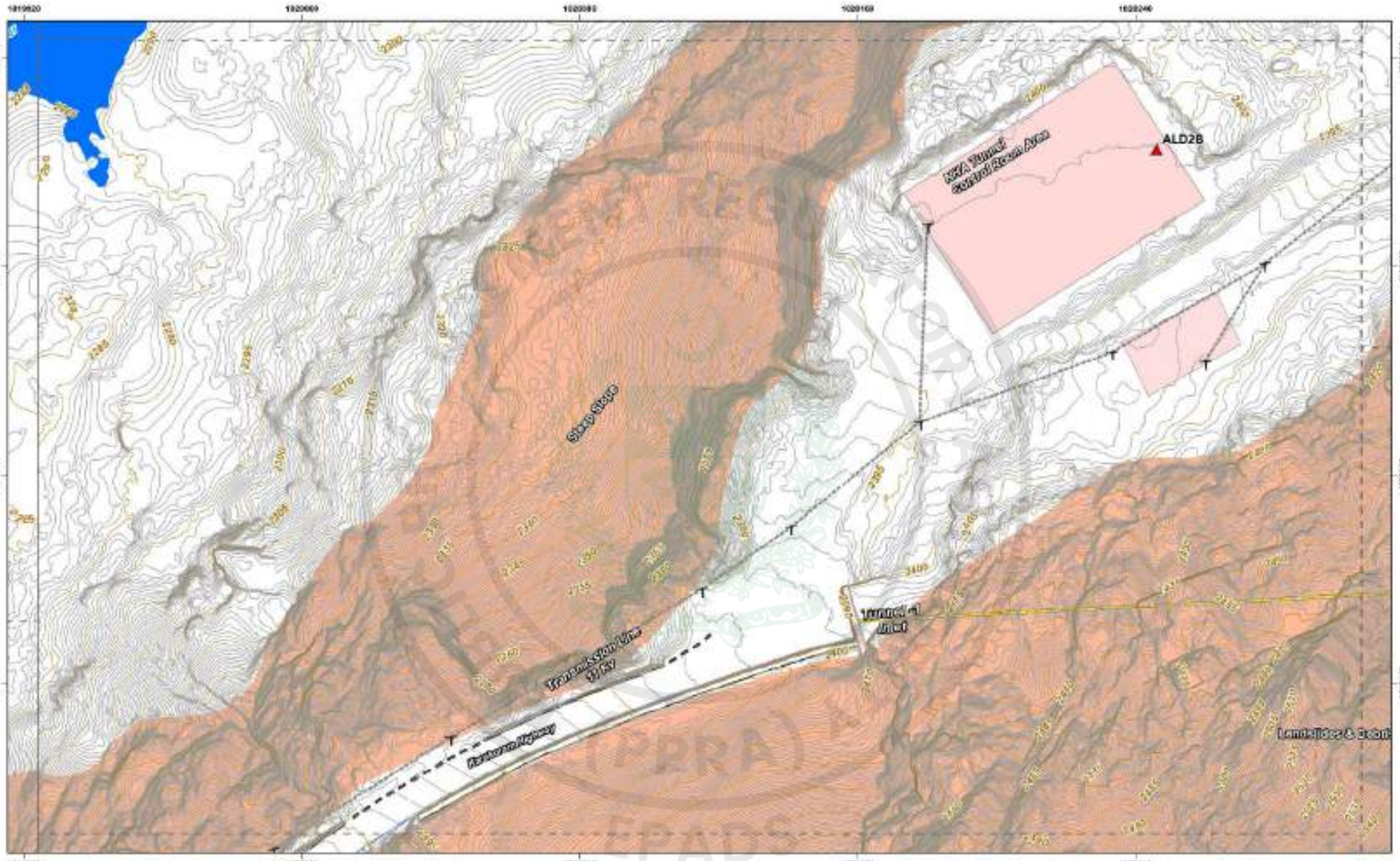
| CLIENT<br>WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | CONSULTANT<br>ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: 11-FARAK HOUSE, 1-E, BLOCK-R, MODEL TOWN EXTENSION, LAHORE, PAKISTAN | LEGEND<br>Control Point<br>Tree<br>Transmission Pole<br>Tunnel<br>Oil Line<br>Transmission Line<br>Intervention Contour<br>Water Contour<br>River<br>Tin Land<br>Agriculture Land<br>Rooftop<br>Track<br>Intervention Dam<br>Project Site<br>PRMA<br>Dam<br>Culvert<br>Bridge<br>Shed<br>L.T. WIRE LIN | INDEX MAP | DISCLAIMER<br>1. This Map has been prepared by National Engineering Services Pakistan (Pvt.) Ltd. exclusively for the Technical Inquiry Committee (TIC) for Feasibility Study and Detailed Designs for Construction of Attabad Lake Hydropower Project (54 MW).<br>2. The Topographic Survey has been prepared using Aerial Photogrammetry and Ground Truthing. Aerial photography was carried out in October 2021.<br>3. This information and survey for this sale of the above said request.<br>4. Any use, which a third party makes of this Report or any reliance on or decisions to be made based on it, are the responsibility of the such party, and NESPAK accepts no responsibility for damages, if any, suffered by any third party as a result of such decisions or actions. | PROJECT<br>ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TITLE<br>TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM<br>DATE: FEB 2026<br>SHEET NO.: Page 47 of 73<br>SCALE BAR: | SCALE<br>1:1000 |




| CLIENT | CONSULTANT | LEGEND | INDEX MAP | DISCLAIMER | PROJECT | TITLE | SCALE |
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| WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: FLEEMAK HOUSE, 1-C, BLOCK-N, GODEL TOWN EXTENSION, LAHORE, PAKISTAN | Control Point, Tree, Transmission Tower, Tunnel, 33 kV Line, Transmission Line, Water Course, River, Agricultural Land, Built-up, Forest, Scrub, Water Body, Contour, Lineament, Project Site, Offices, Quarry, Bridge, Road, 11/33 kV Line | | 1. This Map has been prepared by National Engineering Services Pakistan (Pvt.) Ltd. exclusively for the Technical Design Purposes. It is not to be used for any other purpose.<br>2. The Topographic Survey was carried out by ... in ... 2021.<br>3. This information is solely for the use of the authorized recipient.<br>4. In no case, will the above party, its employees or associates be liable to any person or entity for any loss or damage, whether direct, indirect, consequential or punitive, arising out of or in connection with the use of this map. | ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM | 1:1000 |

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| FEB 2026 | Page 68 of 73 | |

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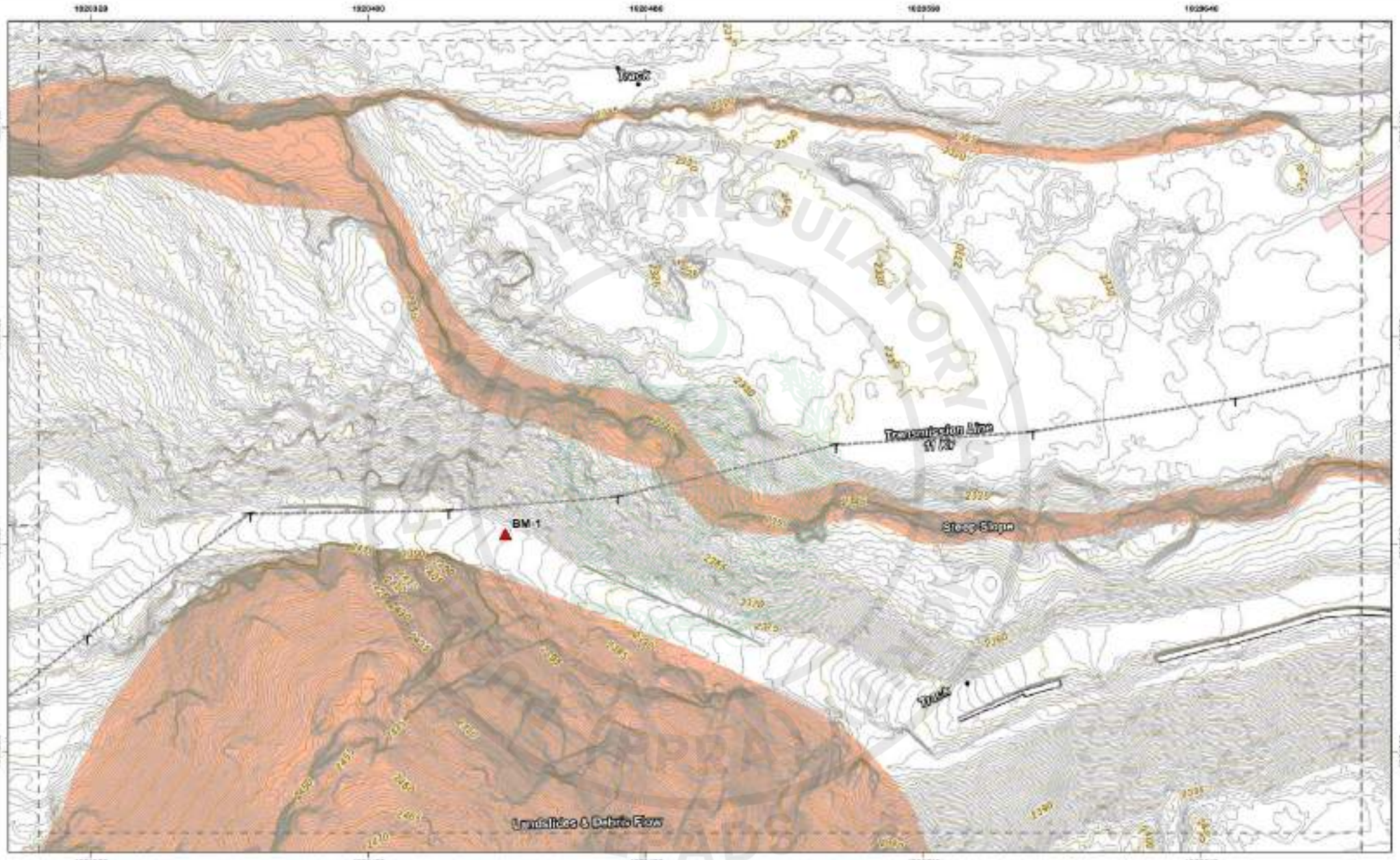


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| CLIENT<br>WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | CONSULTANT<br>ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: 5 FARAK HOUSE, 1-E, BLOCK-R, GODEL TOWN EXTENSION, LAHORE, PAKISTAN | LEGEND | INDEX MAP | DISCLAIMER<br>1. This Map has been prepared by National Engineering Services Pakistan (PVT) Ltd. exclusively for the Project. Liability, if any, to any third party is only under DETAILED DESIGN FOR CONSTRUCTION OF ATTABAD LAKE HYDROPOWER PROJECT (54 MW).<br>2. The Topographic Survey has been prepared by using Total Station and details of the main roads have been taken. The project particulars obtained through aerial mapping executed in October 2021.<br>3. This information and survey for the use of the authorized recipient.<br>4. Any use, which a third party makes of this Report or any reliance on or decisions to be made based on it, are the responsibility of the such party, and NESPAK accepts no responsibility for damages, if any, suffered by any third party as a result of such decisions or actions. | PROJECT<br>ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TITLE<br>TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM | SCALE<br>1:1000 |
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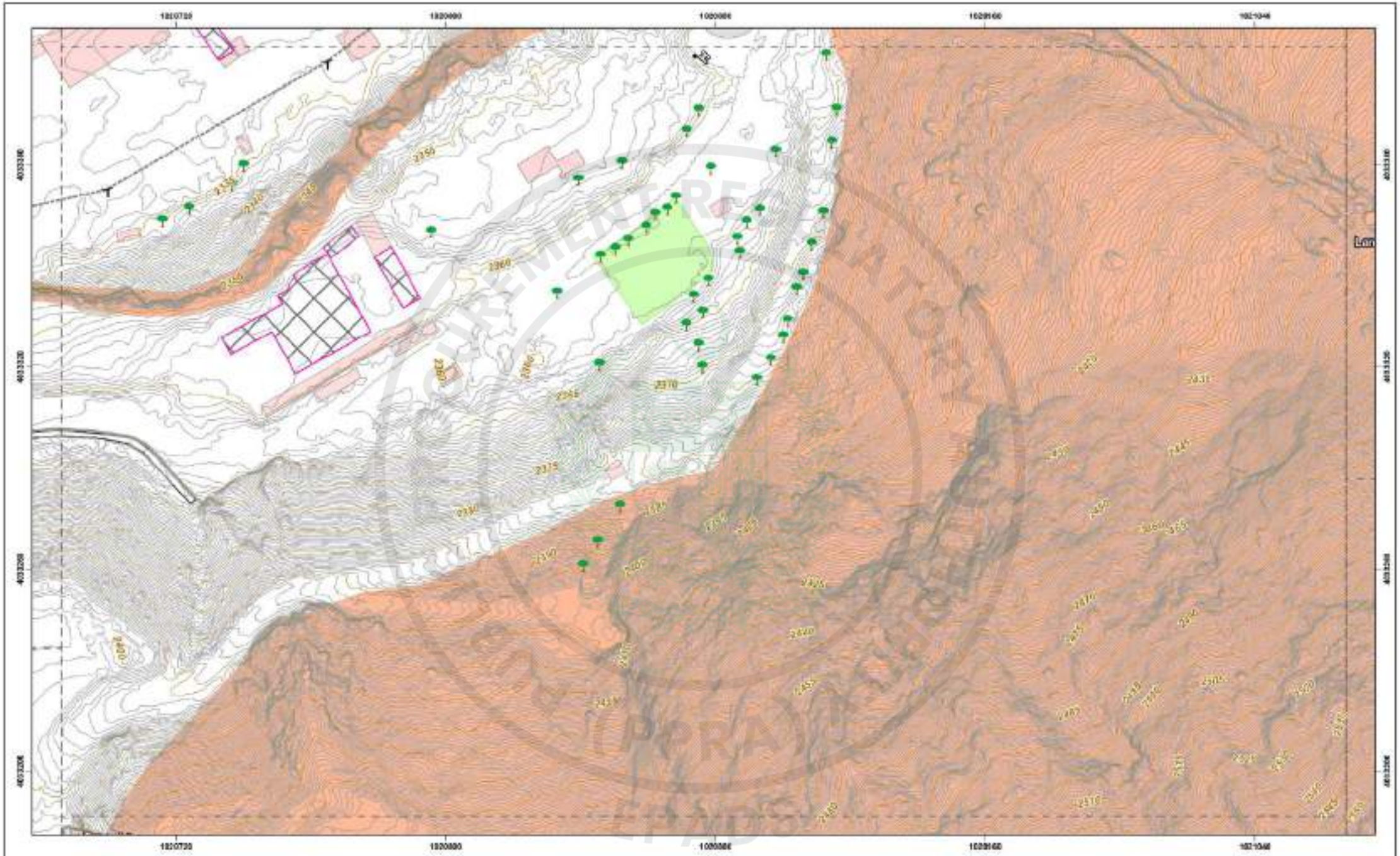
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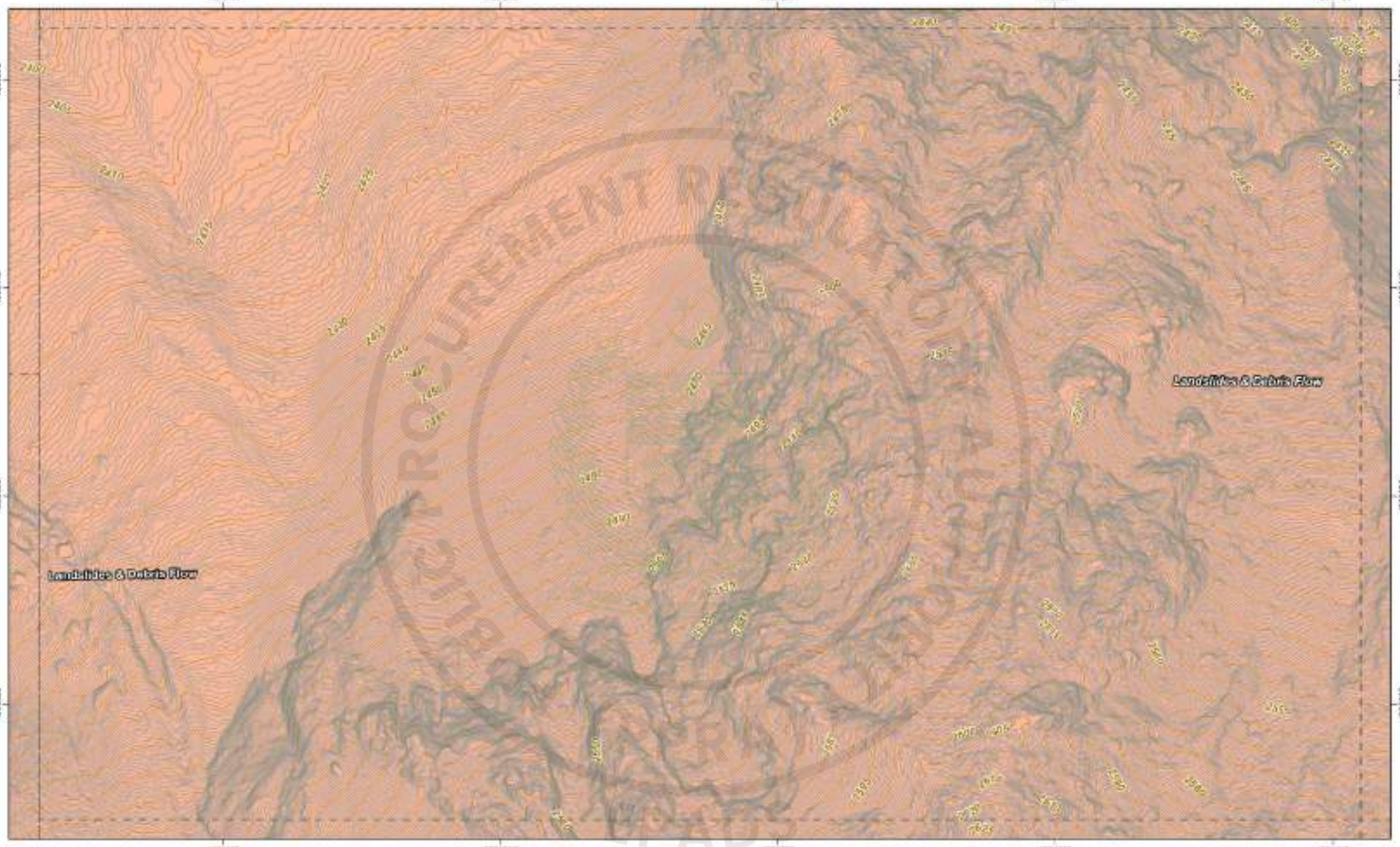


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| CLIENT<br>WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | CONSULTANT<br>ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: 5 FARAK HOUSE, 1-E, BLOCK-R, MODEL TOWN EXTENSION, LAHORE, PAKISTAN | LEGEND | INDEX MAP | DISCLAIMER<br>1. This Map has been prepared by National Engineering Services Pakistan (PVT) Ltd exclusively for the purpose of "EMERGENCY SHIFTING OF 1100 YEARS (RETURN PERIOD) FLOOD AFFECTED STRUCTURES DURING CONSTRUCTION OF ATTABAD LAKE HYDROPOWER PROJECT (54 MW)".<br>2. The Topographic Survey has been physical measurements of the levels and details of the main roads have been taken from the project authority obtained through aerial mapping executed in October 2025.<br>3. This information are solely for the use of the authorized recipient.<br>4. In no case, will the above party replace of this Map or any response on an extension be made based on it, and the responsibility of the such party, and NESPAK accepts no responsibility for damages, if any, suffered by any third party as a result of such decisions or actions. | PROJECT<br>ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TITLE<br>TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM<br>DATE: FEB 2026<br>SHEET NO: Page 51 of 73<br>SCALE BAR: | SCALE<br>1:1000 |

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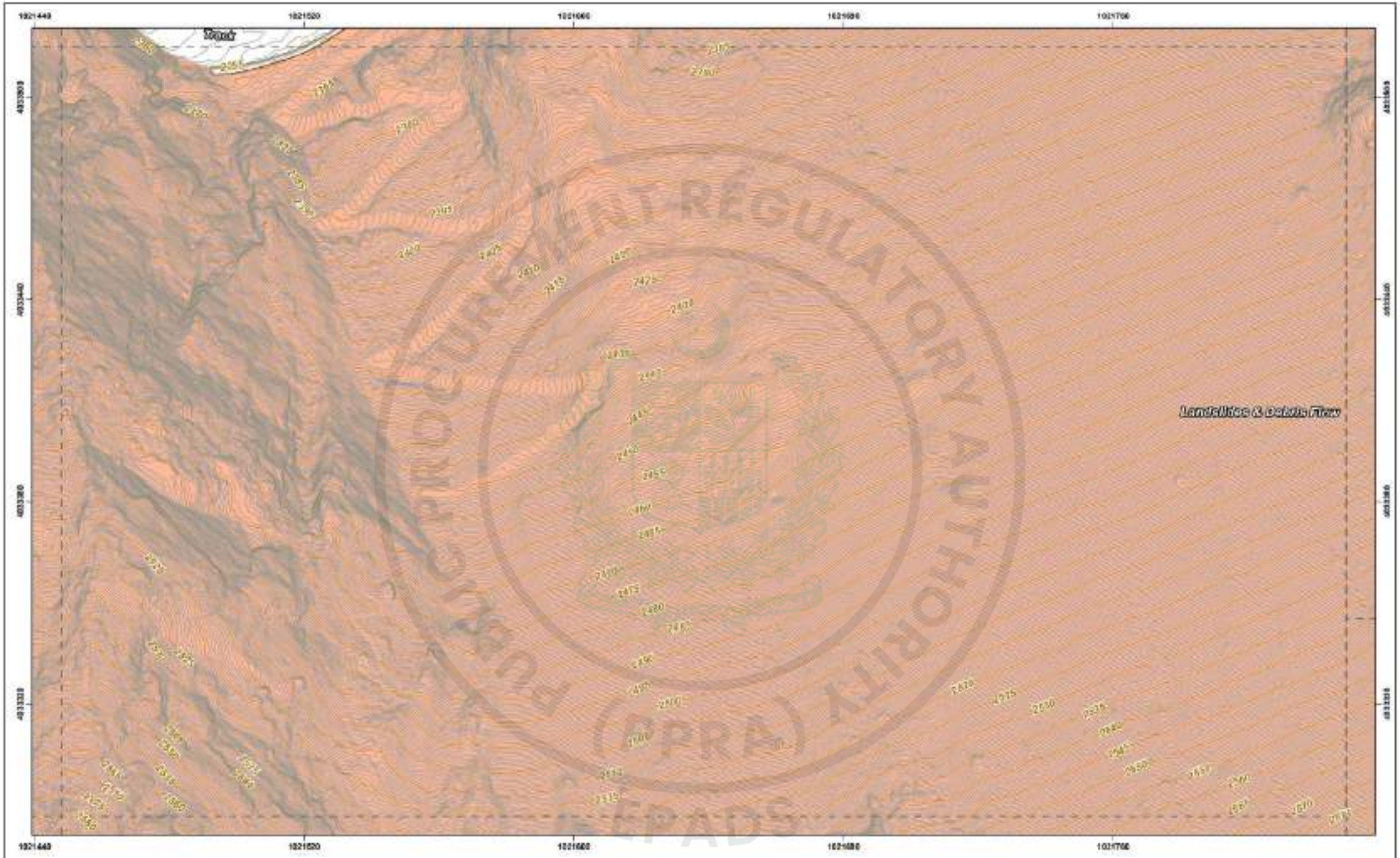


| CLIENT | CONSULTANT | LEGEND | INDEX MAP | DISCLAIMER | PROJECT | TITLE | SCALE |
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| WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: ELEPHANT HOUSE, 1-E, BLOCK-R, GOWAL TOWN EXTENSION, LAHORE, PAKISTAN | Control Point, Hut, Tax Division Pole, Tunnel, Oil Line, Tax Division Line, Intervention Contour, Water Contour, Rivers, Dry Land, Agriculture Land, Rooftop, Roads, Electricity, Landslide Zone, Peoples Area, Others, Culverts, Bridge, Shed, Gas Line | | 1. This Map has been prepared by National Engineering Services Pakistan (Pvt.) Ltd. exclusively for the purpose of PRE-CONSTRUCTION STUDY AND FEASIBILITY REPORT FOR CONSTRUCTION OF ATTABAD LAKE HYDROPOWER PROJECT (54 MW).<br>2. The Topographic Survey has been physically executed on the ground and details of the main roads have been taken by the project personnel using hand held GPS and surveyed in October 2021.<br>3. This information can solely be for the use of the authorized recipient.<br>4. In no case, will the client, party, replies of this Report and Map have an entitlement to be made liable for it, and the responsibility of the such party, and NESPAK as well as responsibility for damages, if any, suffered by any third party as a result of such decisions or actions. | ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM | 1:1000 |

| DATE | SHEET NO. | SCALE BAR: |
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| FEB 2026 | Page 62 of 73 | |

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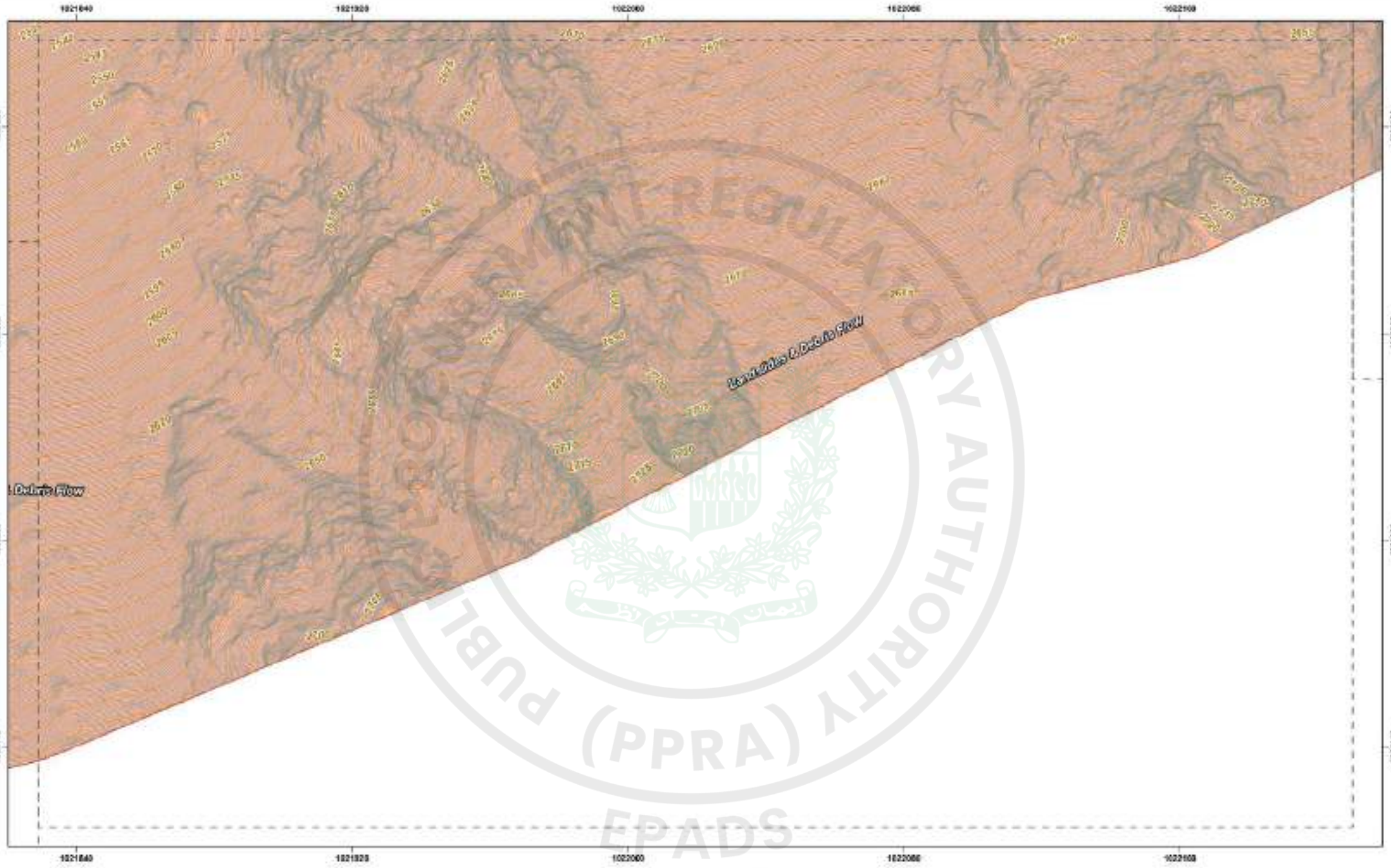


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| CLIENT: WAPDA — WATER AND POWER DEVELOPMENT AUTHORITY | CONSULTANT: APK — ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS; HEAD OFFICE: 5 FARAK HOUSE, 1-C, BLOCK-R, MODEL TOWN EXTENSION, LAHORE, PAKISTAN | LEGEND | INDEX MAP | DISCLAIMER | PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TITLE: TOPOGRAPHIC SURVEY PLAN ATTABAD LAKE DAM; SCALE: 1:1000; DATE: FEB 2026; SHEET NO: Page 63 of 73; SCALE BAR: |

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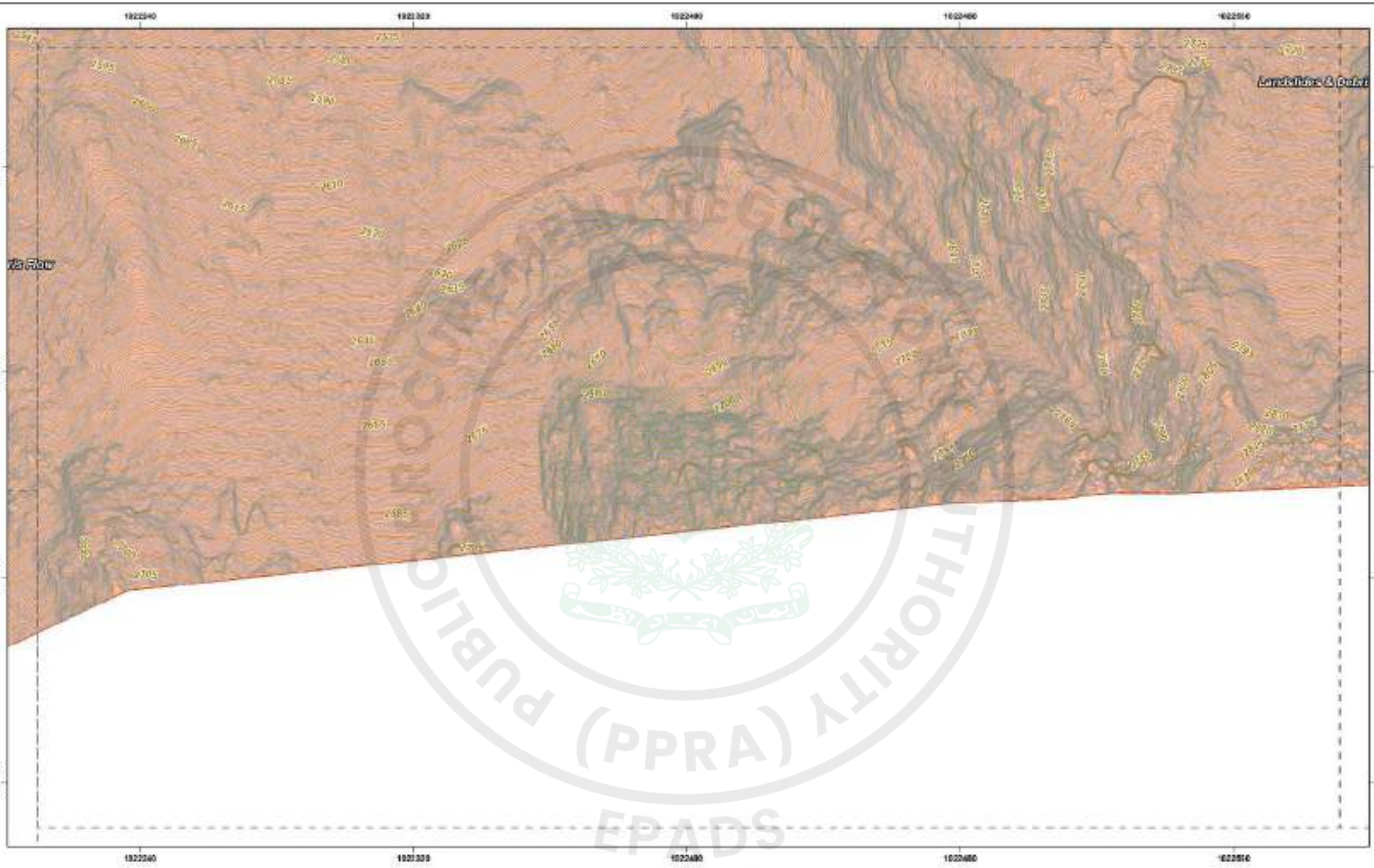


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| CLIENT<br>WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | CONSULTANT<br>ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: 15 FARAK HOUSE, 1-E, BLOCK-R, MODEL TOWN EXTENSION, LAHORE, PAKISTAN | LEGEND | INDEX MAP | DISCLAIMER<br>1. This Map has been prepared by National Engineering Services Pakistan (PVT) Ltd. exclusively for the Technical Inquiry Committee (TEC) for EOI for Engineering, Procurement, Construction and Commissioning (EPCC) of Attabad Lake Hydropower Project (54 MW).<br>2. The Topographic Survey has been prepared using Aerial Photogrammetry and Ground Truthing. The Aerial Survey was carried out in October 2025.<br>3. This information is provided for the sole purpose of the above mentioned project and shall not be used for any other purpose without the written consent of NESPAK.<br>4. In no case, will NESPAK be liable for any loss or damage, including but not limited to, loss of profits, business interruption, or any other commercial damages or losses, arising out of or in connection with the use of this Map. | PROJECT<br>ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TITLE<br>TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM | SCALE<br>1:1000 |
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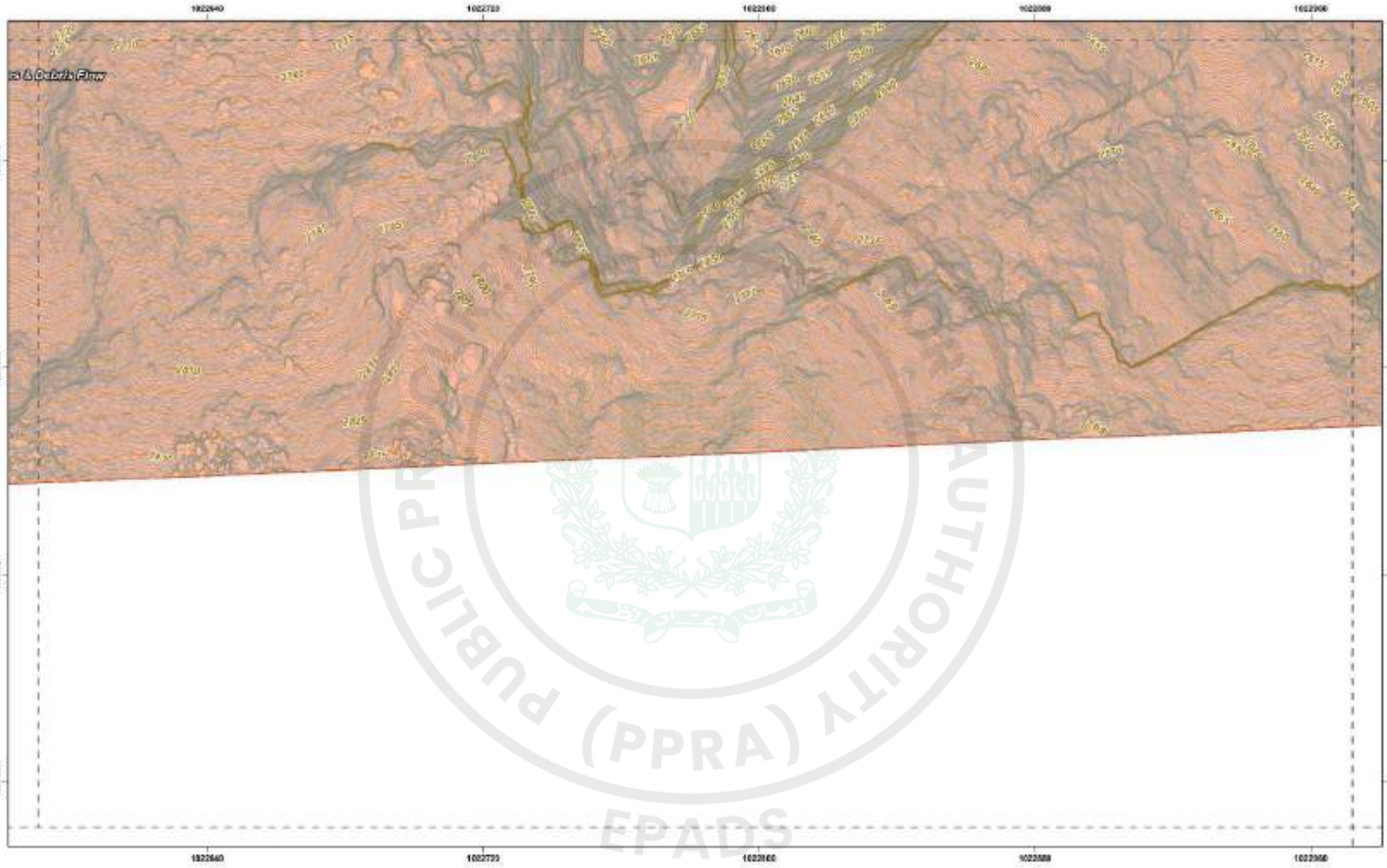


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| CLIENT<br>WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | CONSULTANT<br>ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: 5 FARAK HOUSE, 1-E, BLOCK-R MODEL TOWN EXTENSION, LAHORE, PAKISTAN | LEGEND | INDEX MAP | DISCLAIMER<br>1. This Map has been prepared by National Engineering Services Pakistan (PVT) Ltd exclusively for the Technical Inquiry Purposes in connection with Engineering Study and Detailed Design for Construction of Attabad Lake Hydropower Project (54 MW).<br>2. The Topographic Survey has been prepared using Aerial Photogrammetry and Ground Control Survey executed in October 2024.<br>3. This information can solely for the use of the authorized recipient.<br>4. In no case, will the client party, copies of this Report and reliance on an extension to be made based on it, are the responsibility of the such party, and NESPAK accepts no responsibility for damages, if any, suffered by any third party as a result of such decisions or actions. | PROJECT<br>ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TITLE<br>TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM | SCALE<br>1:1000 |
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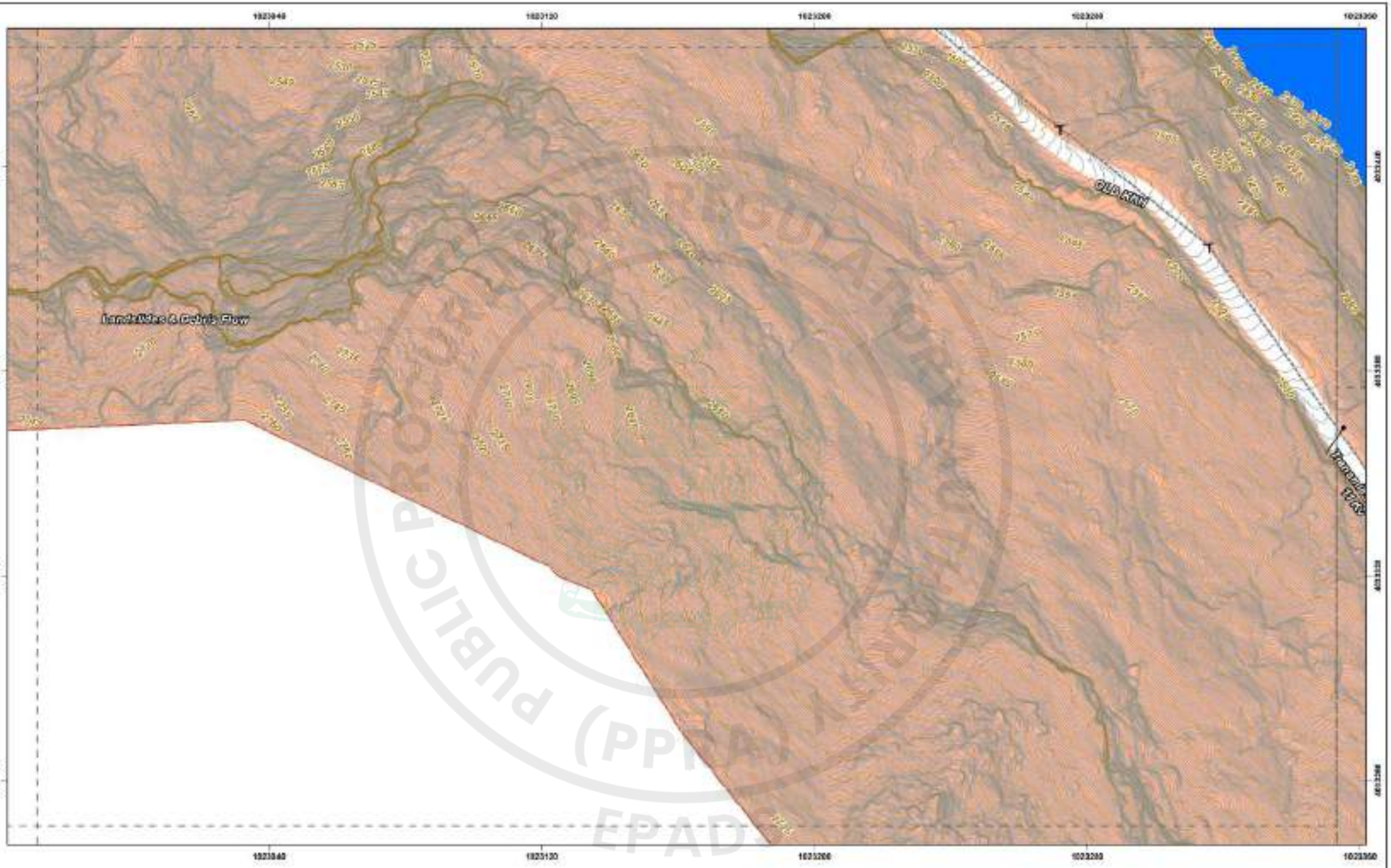


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| CLIENT: WAPDA — WATER AND POWER DEVELOPMENT AUTHORITY | CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS — HEAD OFFICE: 5 FARAK HOUSE, 1-E, BLOCK-R, MODEL TOWN EXTENSION, LAHORE, PAKISTAN | LEGEND | INDEX MAP | DISCLAIMER | PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TITLE: TOPOGRAPHIC SURVEY PLAN ATTABAD LAKE DAM | SCALE: 1:1000 |
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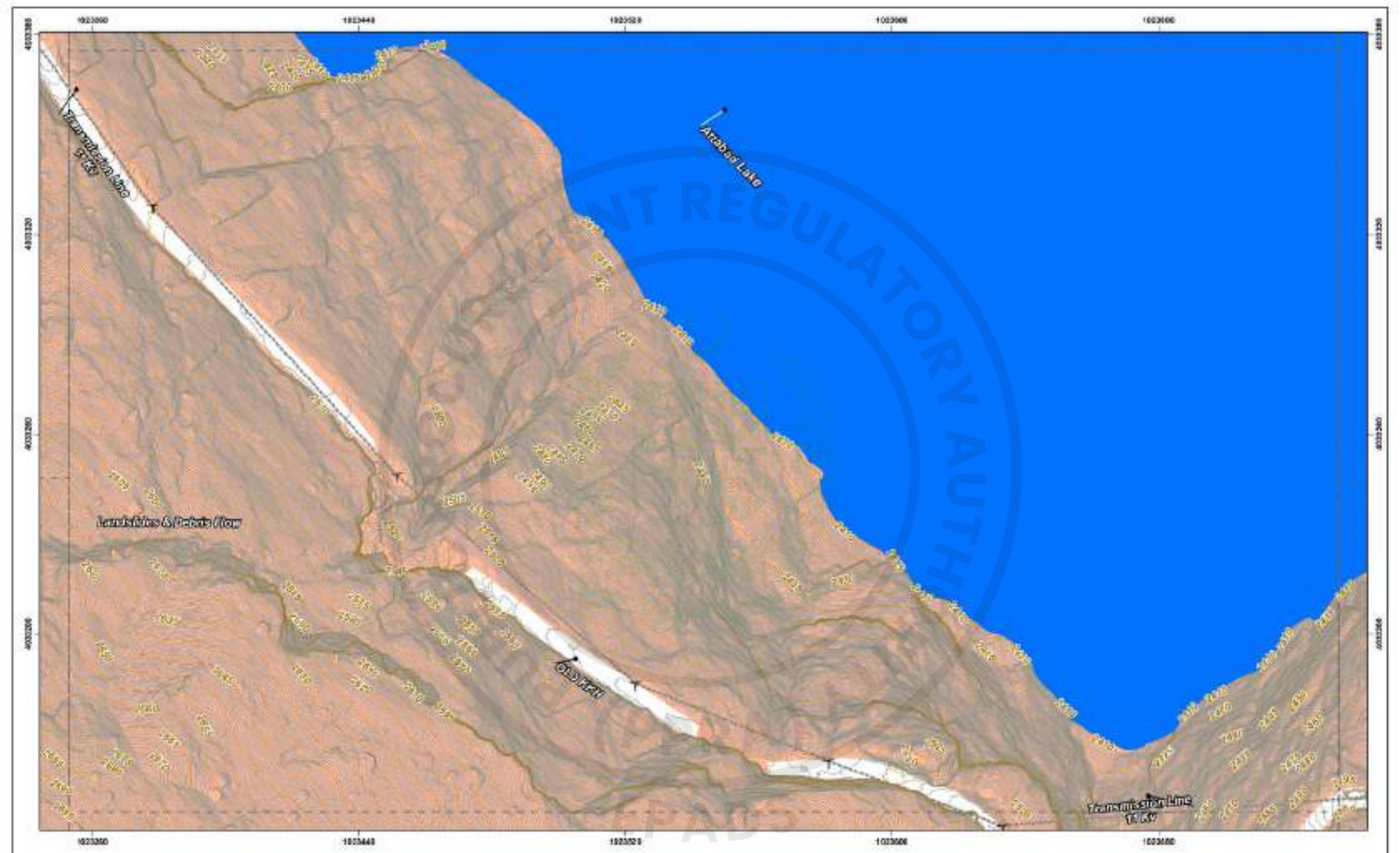


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| CLIENT: WAPDA — WATER AND POWER DEVELOPMENT AUTHORITY | CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS — HEAD OFFICE: 5 FARAK HOUSE, 1-C, BLOCK R, MODEL TOWN EXTENSION, LAHORE, PAKISTAN | LEGEND | INDEX MAP | DISCLAIMER | PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TITLE: TOPOGRAPHIC SURVEY PLAN ATTABAD LAKE DAM | SCALE: 1:1000 |
| | | | | | | DATE: FEB 2026 — SHEET NO: Page 57 of 73 — SCALE BAR: | |

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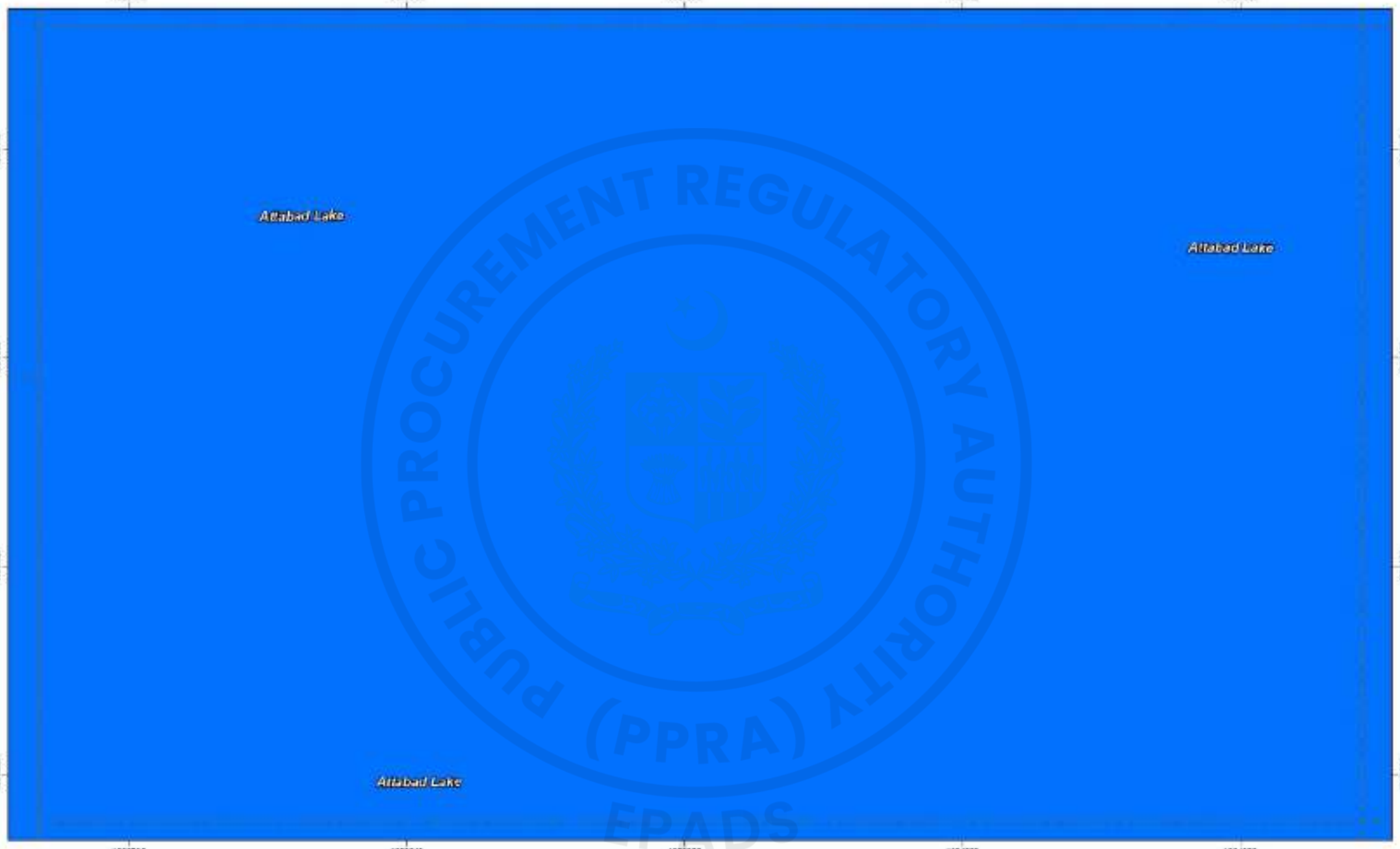


PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

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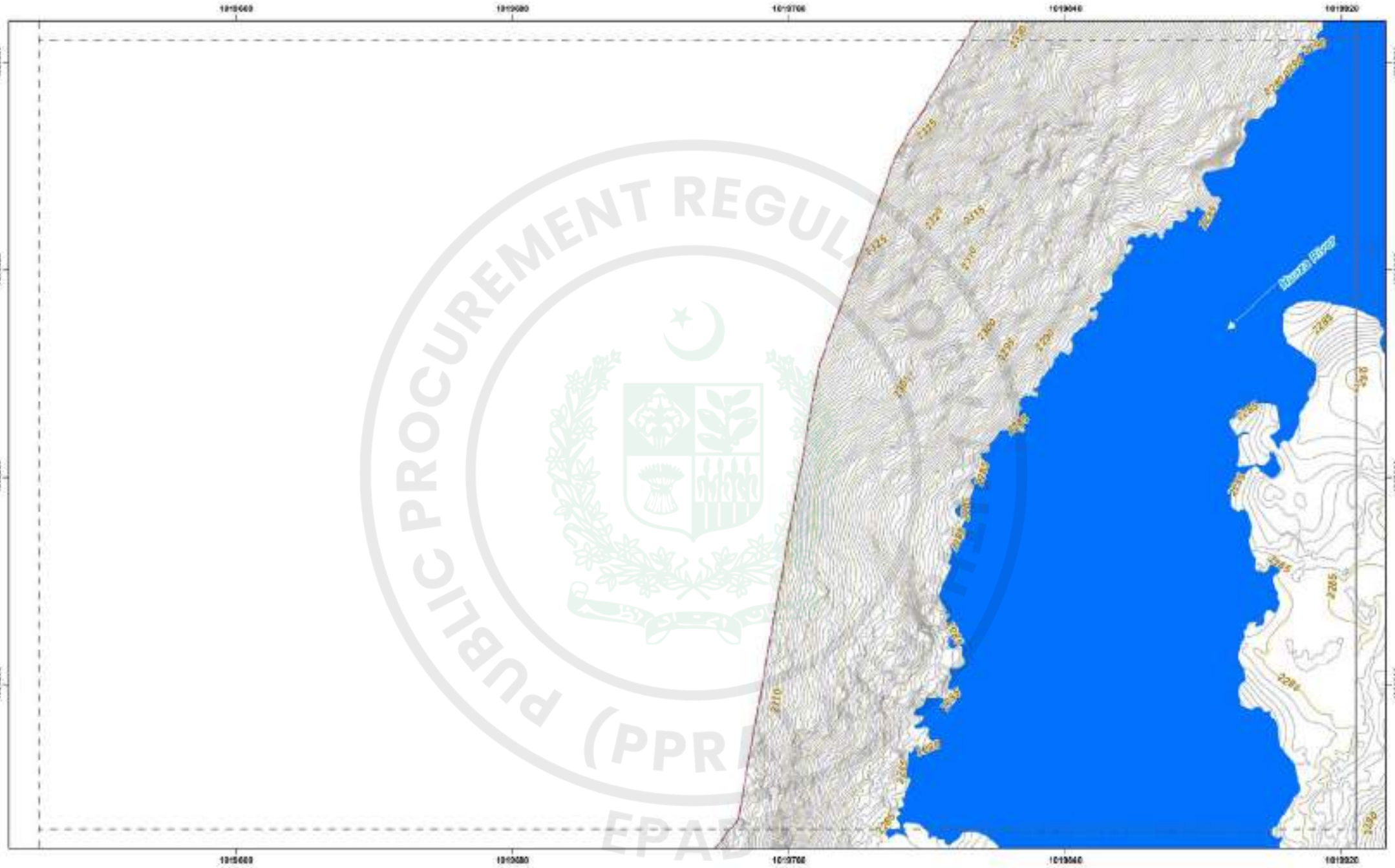
| CLIENT<br>WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | CONSULTANT<br>APK ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: 9 FARAK HOUSE, 1-E, BLOCK-R MODEL TOWN EXTENSION, LAHORE, PAKISTAN | LEGEND | INDEX MAP | DISCLAIMER<br>1. This Map has been prepared by National Engineering Services Pakistan PVT. Ltd. exclusively for the Individual / Inquiry Submitted to WAPDA ENTITY for any kind of PURSUE DESIGN FOR CONSTRUCTION OF ATTABAD LAKE HYDROPOWER PROJECT (54 MW).<br>2. The Topographic Survey has been physical characteristics of the terrain and details of the main roads have been from the project pathway obtained through aerial mapping executed in October 2021.<br>3. The information on survey for the use of the authorized request.<br>4. In no case, will be a third party replies of this Report any responsible or exclusion as to be made based on it, are the responsibility of the such party, and NESPAK accepts no responsibility for damages, if any, suffered by any third party as a result of such decisions or actions. | PROJECT<br>ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TITLE<br>TOPOGRAPHIC SURVEY PLAN ATTABAD LAKE DAM<br>DATE: FEB 2026<br>SHEET NO: Page 58 of 73<br>SCALE BAR: | SCALE<br>1:1000 |




| CLIENT | CONSULTANT | LEGEND | INDEX MAP | DISCLAIMER | PROJECT | TITLE | SCALE |
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| WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: 11-B PARK HOUSE, 1-C, BLOCK-R, MODEL TOWN EXTENSION, LAHORE, PAKISTAN | Control Point, Tail, Tail Water Profile, Tunnel, Dil Line, Transmission Line, Intervention Contour, Water Contour, River, Dry Land, Agriculture Land, Rooftop, Trees, Structure, Landslide Zone, Project Site, Houses, Road, Canal, Culvert, Bridge, Shed, L.T. 11KV Line | | 1. This Map has been prepared by National Engineering Services Pakistan (PVT) Ltd exclusively for the purpose of PRELIMINARY DESIGNS & TENDER STAGE ONLY AND DETAILED DESIGNS FOR CONSTRUCTION OF ATTABAD LAKE HYDROPOWER PROJECT (54 MW).<br>2. The Topographic Survey has been physically verified at site in May 2020 and details of the main roads have been added in the Project Area by Satellite Imagery acquired in October 2020.<br>3. This information can solely be for the use of the authorized recipient.<br>4. Any use, which a third party makes of this Map or any reliance on or decisions to be made based on it, are the responsibility of the such party, and NESPAK accepts no responsibility for damages, if any, suffered by any third party as a result of such decisions or actions. | ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM | 1:1000 |

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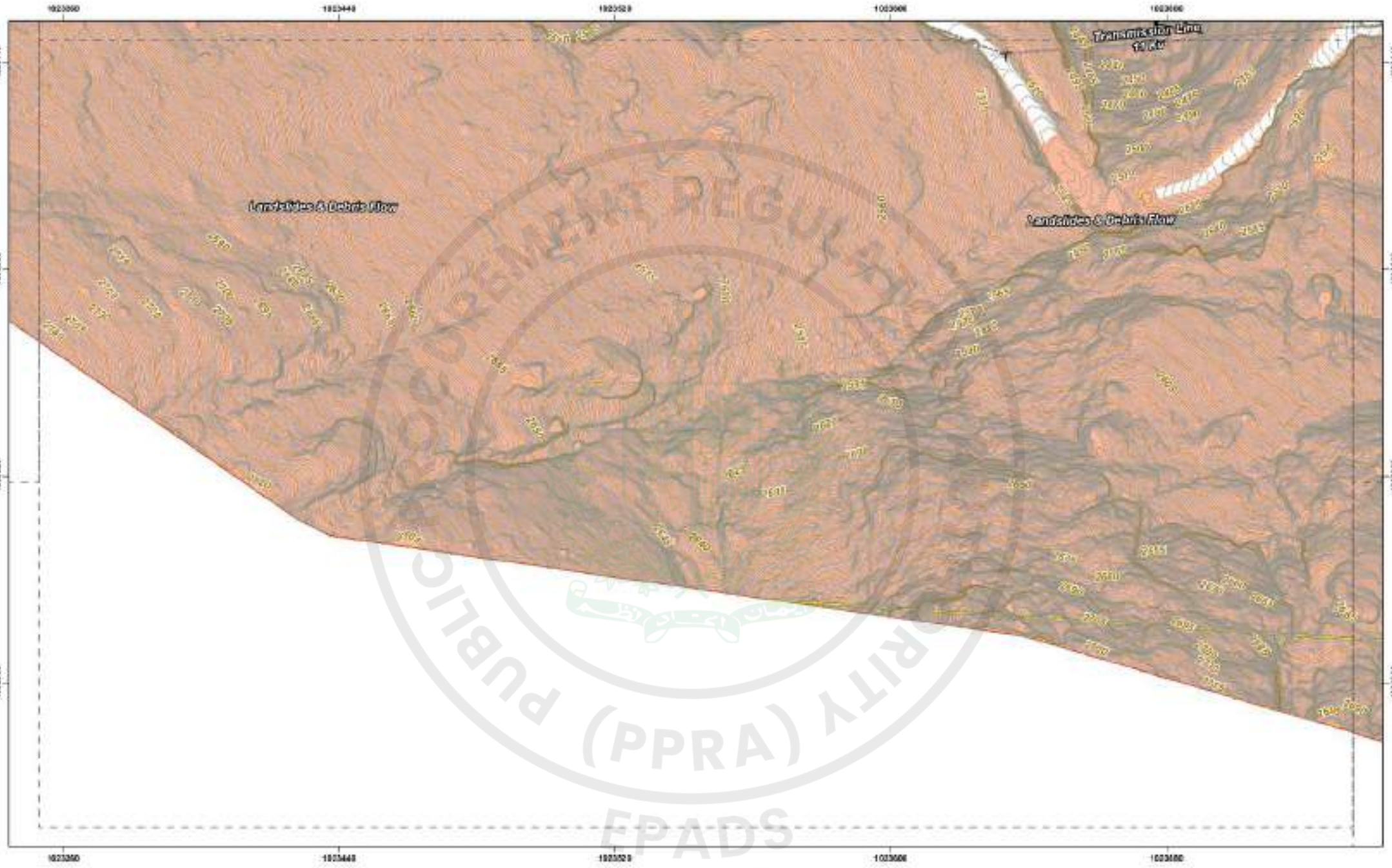
| FEB 2026 | Page 60 of 73 | |

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS




| CLIENT | CONSULTANT | LEGEND | INDEX MAP | DISCLAIMER | PROJECT | TITLE | SCALE |
|---|---|---|---|---|---|---|---|
| WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: 1 FARAK HOUSE, 1-E, BLOCK-R, MODEL TOWN EXTENSION, LAHORE, PAKISTAN | | | 1. This Map has been prepared by National Engineering Services Pakistan (Pvt.) Ltd. (NESPAK) for the exclusive, limited purpose(s) mentioned in the Report and for no other purpose. NESPAK shall not be responsible for any use of this Map for any purpose other than the purpose(s) mentioned in the Report.<br>2. The Topographic Survey has been prepared using aerial photography and ground control surveys. The accuracy of the Map is limited by the accuracy of the aerial photography and ground control surveys. NESPAK shall not be responsible for any inaccuracies in the Map due to inaccuracies in the aerial photography and ground control surveys.<br>3. This Map is provided "as is" without warranty of any kind, either expressed or implied, including but not limited to the implied warranties of merchantability and fitness for a particular purpose. NESPAK shall not be liable for any damages, including but not limited to direct, indirect, special, consequential or incidental damages, arising out of the use of this Map.<br>4. By using this Map, you agree to indemnify and hold harmless NESPAK, its officers, employees, and agents from any and all claims, losses, liabilities, and expenses (including reasonable attorneys' fees) arising out of or in connection with your use of this Map. | ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM | 1:1000 |

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| FEB 2026 | Page 67 of 73 | |

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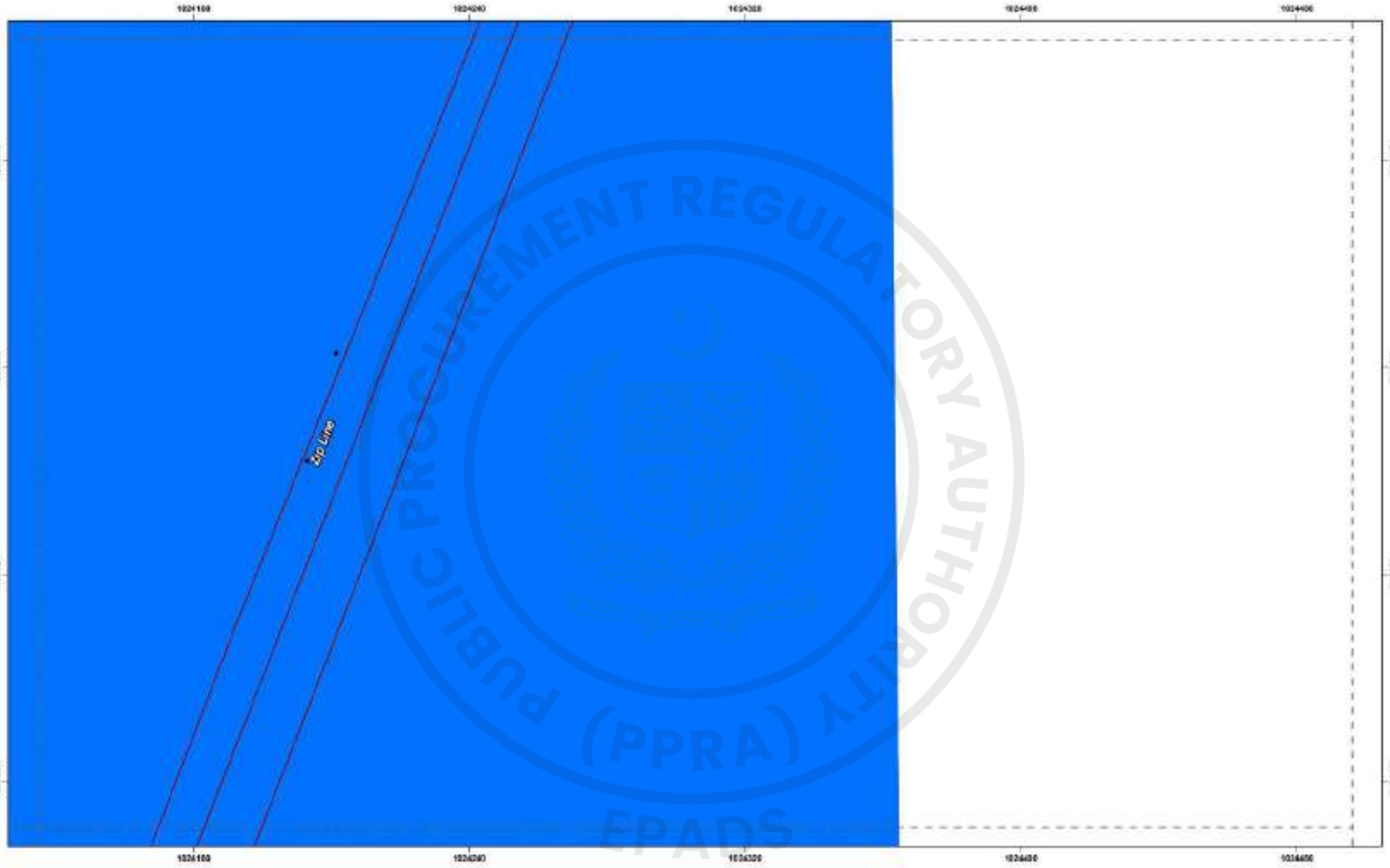


| CLIENT | CONSULTANT | LEGEND | INDEX MAP | DISCLAIMER | PROJECT | TITLE | SCALE |
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| WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE: 15 FARAK HOUSE, 1-E, BLOCK-R, MODEL TOWN EXTENSION, LAHORE, PAKISTAN | Control Point, Tree, Tax Division File, Tunnel, Tax Division Line, Intervention Contour, Water Contour, Rivers, Dry Land, Agriculture Land, Rooftop, Trees, Villa/Site, Landslide Zone, Project Site, Houses, Dam, Culvert, Bridge, Shed, L.T. / HSE LIN | | 1. This Map has been prepared by National Engineering Services Pakistan (PVT) Ltd exclusively for the individual / industry mentioned in the Heading and for any use other than the purpose for which it is prepared, NESPAK will not be responsible in any way.<br>2. The Topographical Survey has been physical observations of the terrain and details of the main roads have been taken from the project authority obtained through aerial mapping executed in October 2020.<br>3. This information on survey for the sole of the authorized recipient.<br>4. In any case, where a third party replies of this Report and makes decision or conclusion on the basis of it, any responsibility of the such party and NESPAK accepts no responsibility for damages, if any, suffered by any third party as a result of such decisions or actions. | ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM | 1:1000 |

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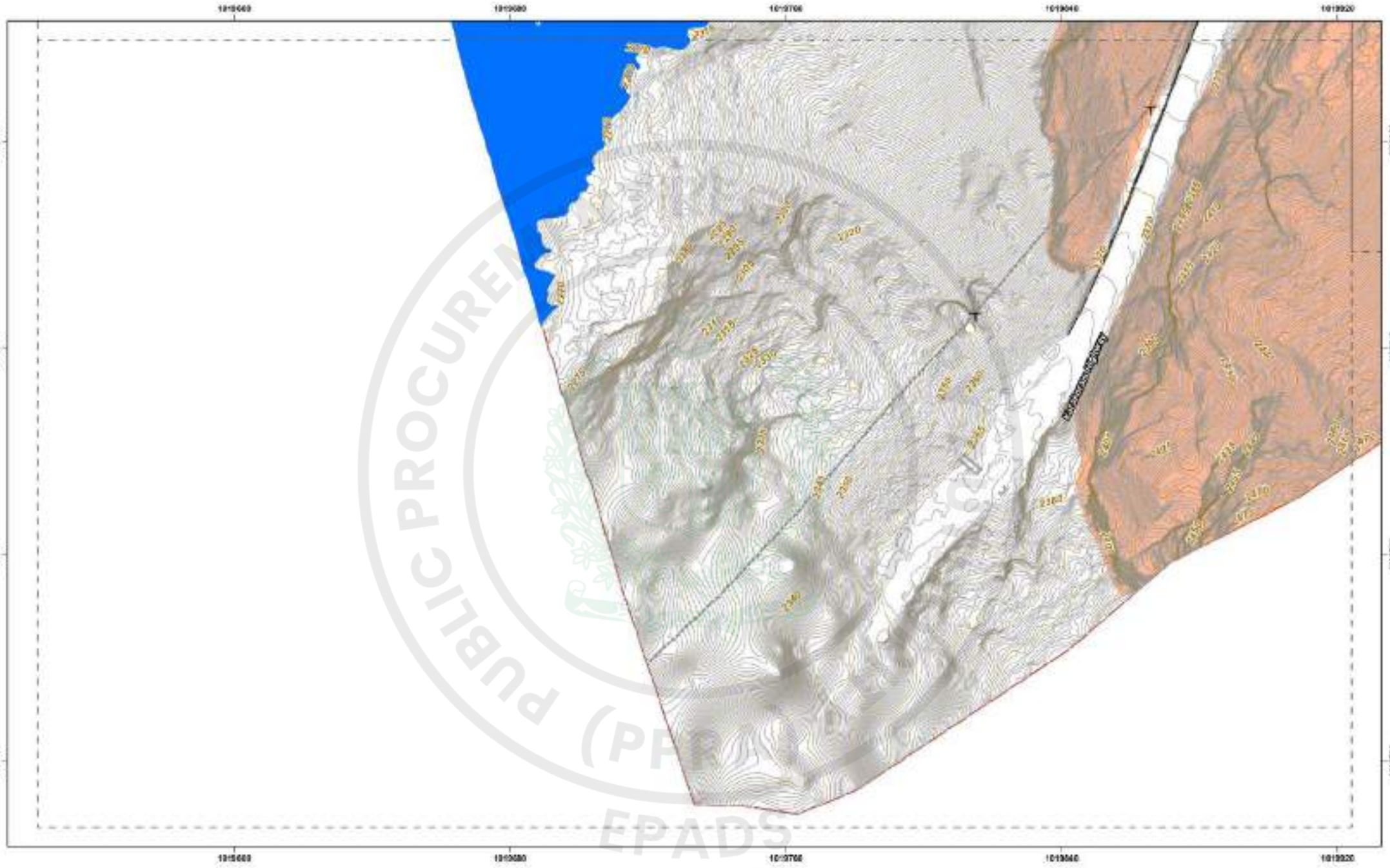
| FEB 2026 | Page 64 of 73 | |

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

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| CLIENT<br>WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | CONSULTANT<br>APK ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE : 5 FARAK HOUSE, 1-C, BLOCK-R MODEL TOWN EXTENSION, LAHORE, PAKISTAN | LEGEND | INDEX MAP | DISCLAIMER<br>1. This Map has been prepared by National Engineering Services Pakistan (PVT) Ltd exclusively for the Technical Inquiry Documents, with Road Entry to Dry Dock and Diversion Bridges for Construction of Attabad Lake Hydropower Project (54 MW).<br>2. The Topographic Survey has been physical observations of the terrain and details of the main roads have been from the project partners obtained through aerial mapping executed in October 2020.<br>3. This information are solely for the use of the authorized recipient.<br>4. Any use, which a third party makes of this Report or any reliance on or decisions to be made based on it, are the responsibility of the such party, and NESPAK accepts no responsibility for damages, if any, suffered by any third party as a result of such decisions or actions. | PROJECT<br>ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TITLE<br>TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM | SCALE<br>1:1000 |
| | | | | | | DATE<br>FEB 2026 | SHEET NO.<br>Page 73 of 73 |
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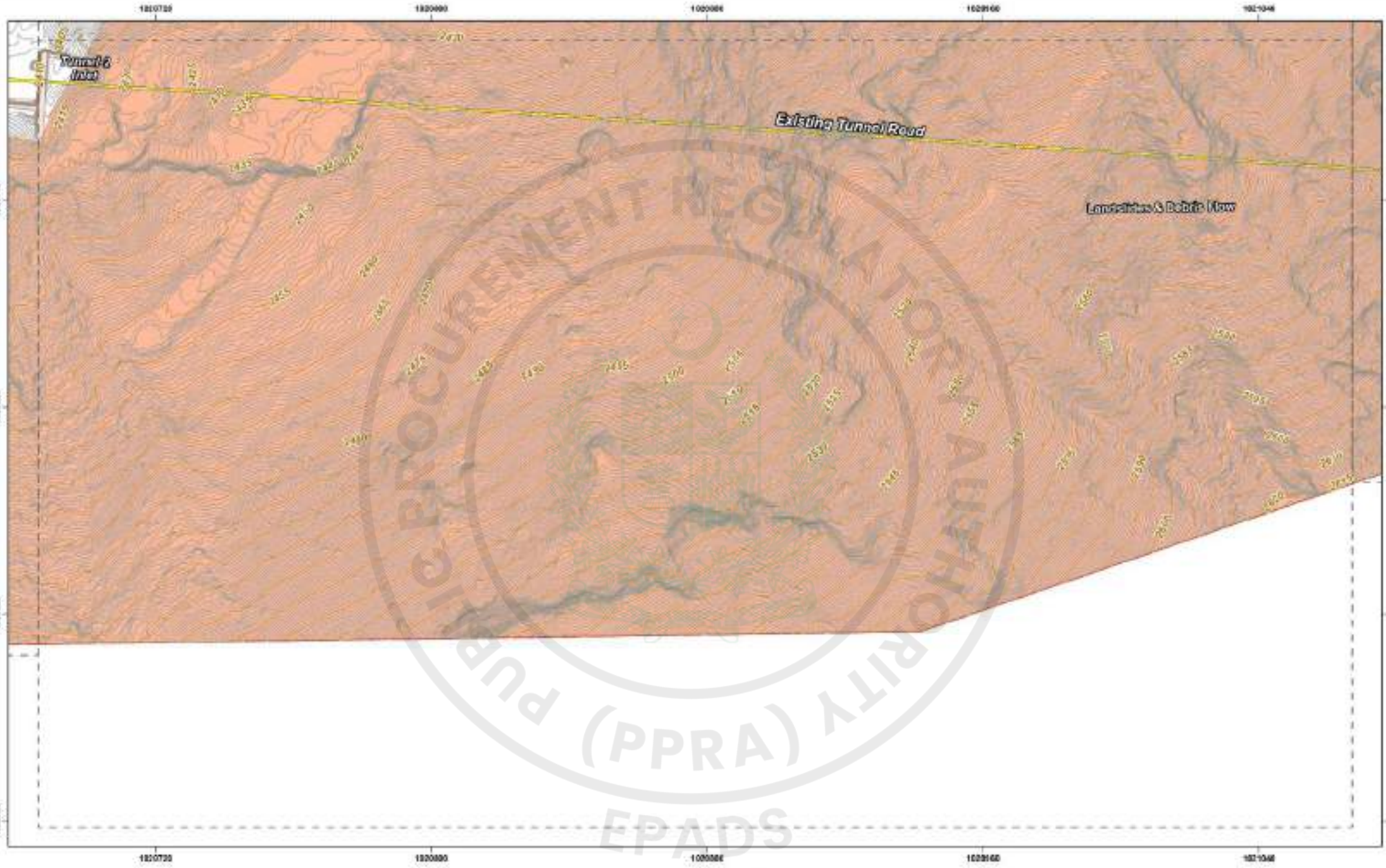


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|---|---|---|
| FEB 2026 | Page 63 of 73 | |

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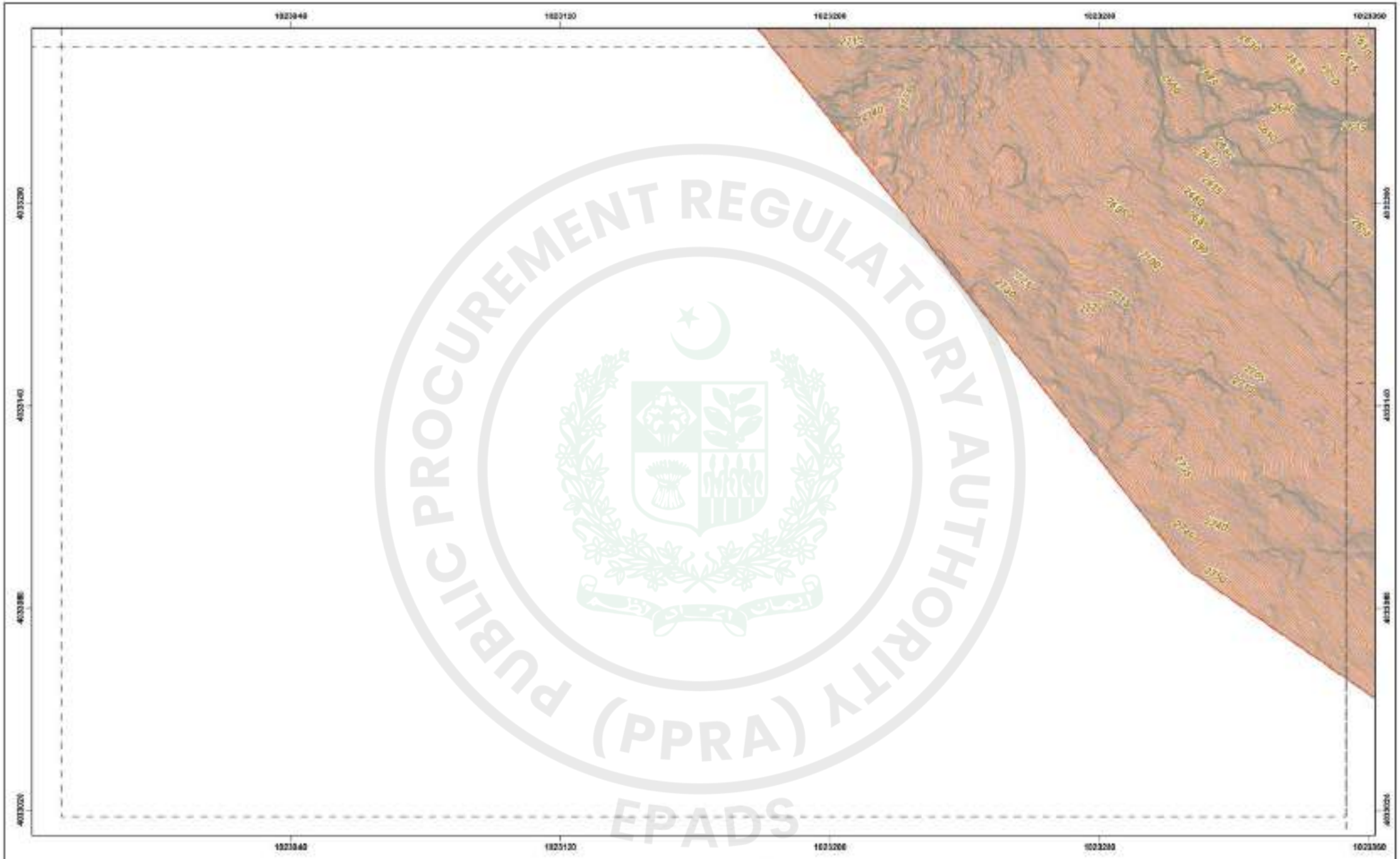


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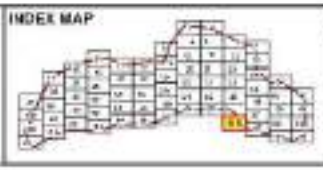
| WAPDA<br>WATER AND POWER DEVELOPMENT AUTHORITY | ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>HEAD OFFICE : 5 FARAK HOUSE, 1-C, BLOCK-R MODEL TOWN EXTENSION, LAHORE, PAKISTAN | Control Point, Tree, Transmission Pole, Tunnel, 33 KV Line, Transmission Line, Intervention Contour, Water Contour, Rivers, Ery Land, Agriculture Land, Rooftop, Trees, Villa/Hotel, Landslide Zone, Peoples Hut, PWMA, Dam, Culvert, Bridge, Road, L.T. 11/0.4 KV |  | 1. This Map has been prepared by National Engineering Services Pakistan (PVT) Ltd exclusively for the Technical Inquiry purposes only. It has been strictly subject to the FEASIBILITY STUDY AND DETAILED DESIGNS FOR CONSTRUCTION OF ATTABAD LAKE HYDROPOWER PROJECT (54 MW).<br>2. The Topographic Survey has been physically executed on the terrain and details of the main roads have been taken from the project pathway obtained through aerial mapping executed in October 2020.<br>3. The information on survey for the use of the authorized recipient.<br>4. In no case, will the client party, copies of this Report and reliance on or decisions to be made based on it, nor the responsibility of the such party, and NESPAK accepts no responsibility for damages, if any, suffered by any third party as a result of such decisions or actions. | ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | TOPOGRAPHIC SURVEY PLAN<br>ATTABAD LAKE DAM | 1:1000 |
| | | | | | | DATE: FEB 2026 | SHEET NO: Page 66 of 73 | SCALE BAR: |

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

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| SCALE | DATE | SHEET NO. | SCALE BAR: |
|---|---|---|---|
| 1:1000 | FEB 2026 | Page 68 of 73 | |

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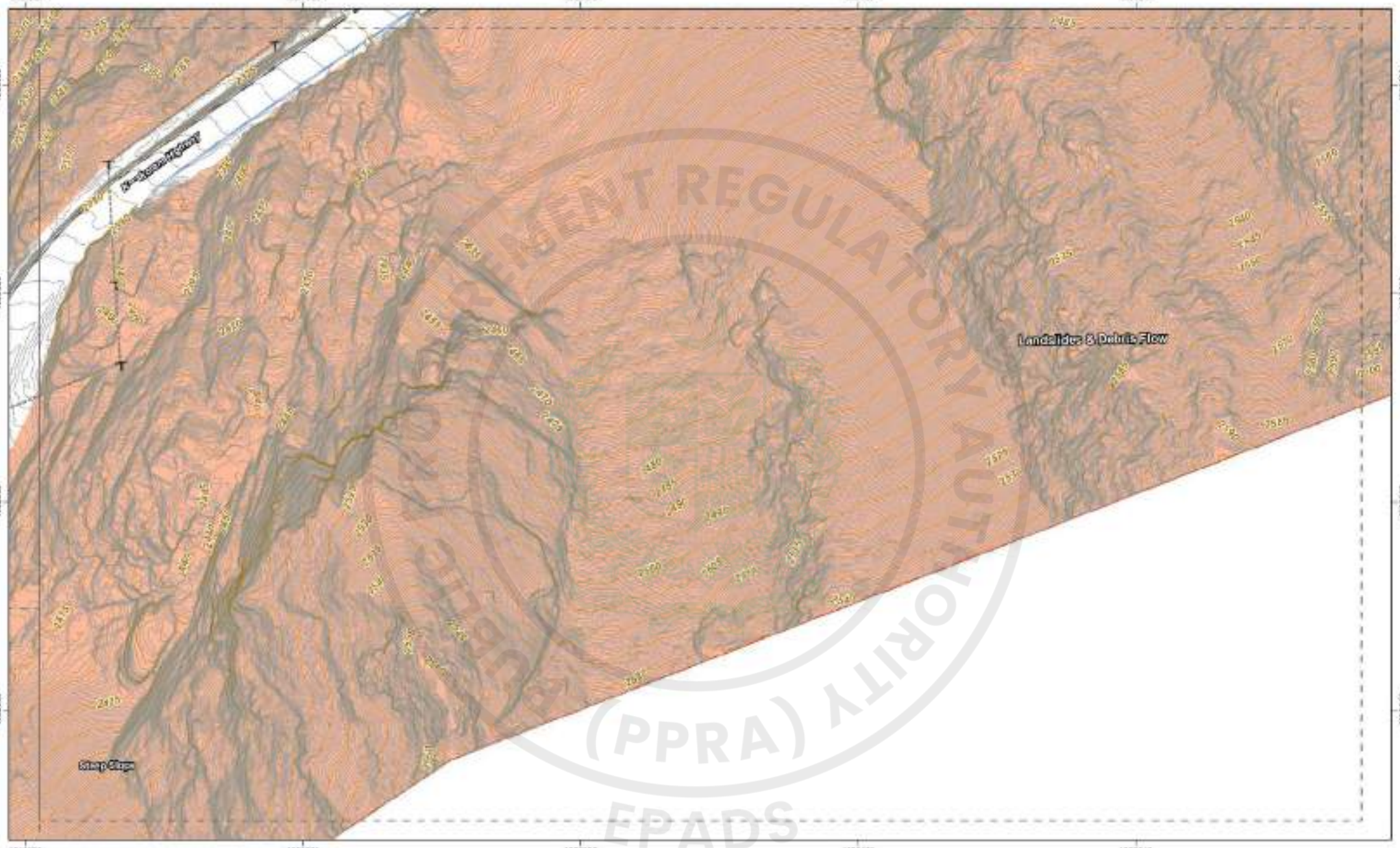


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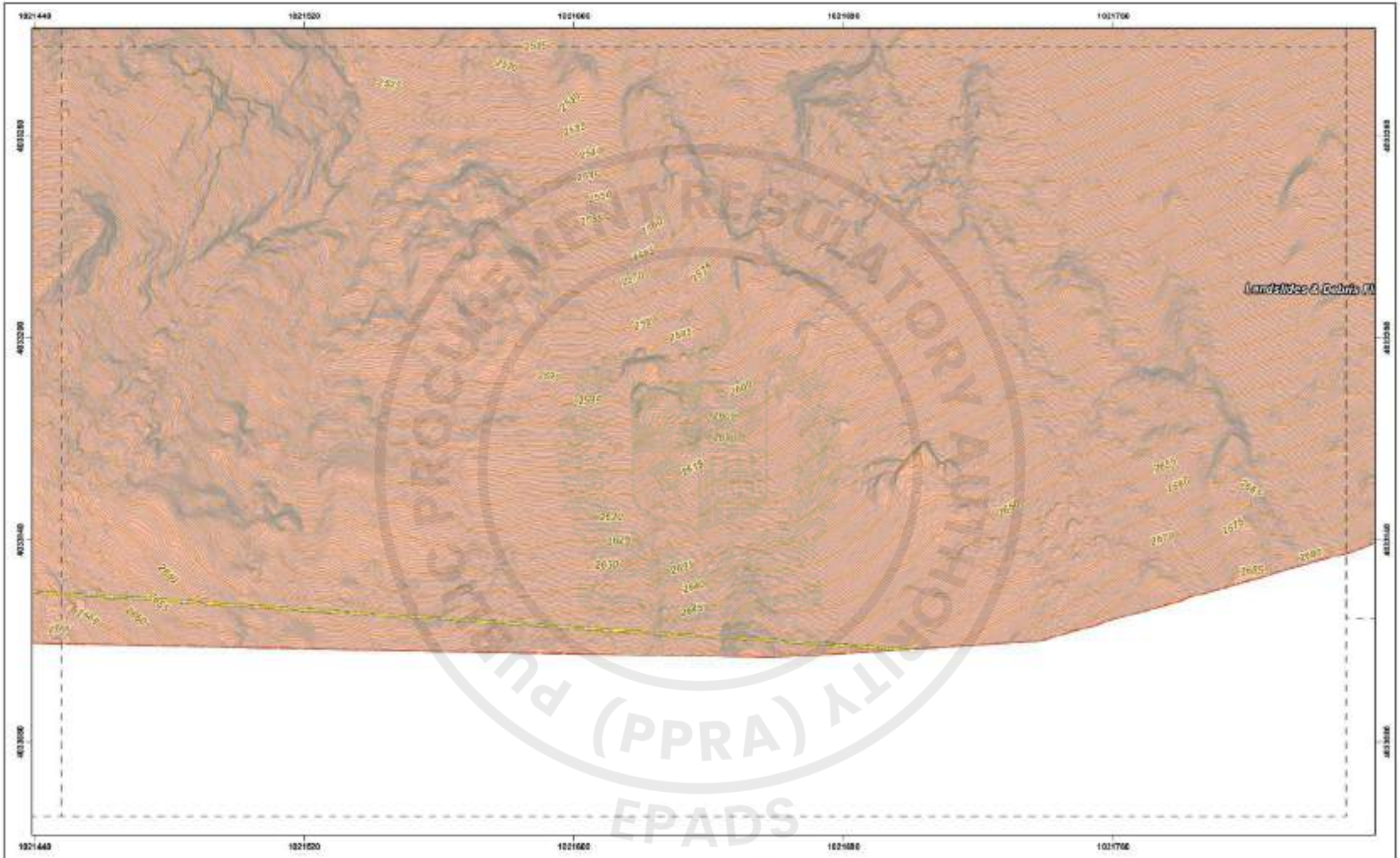


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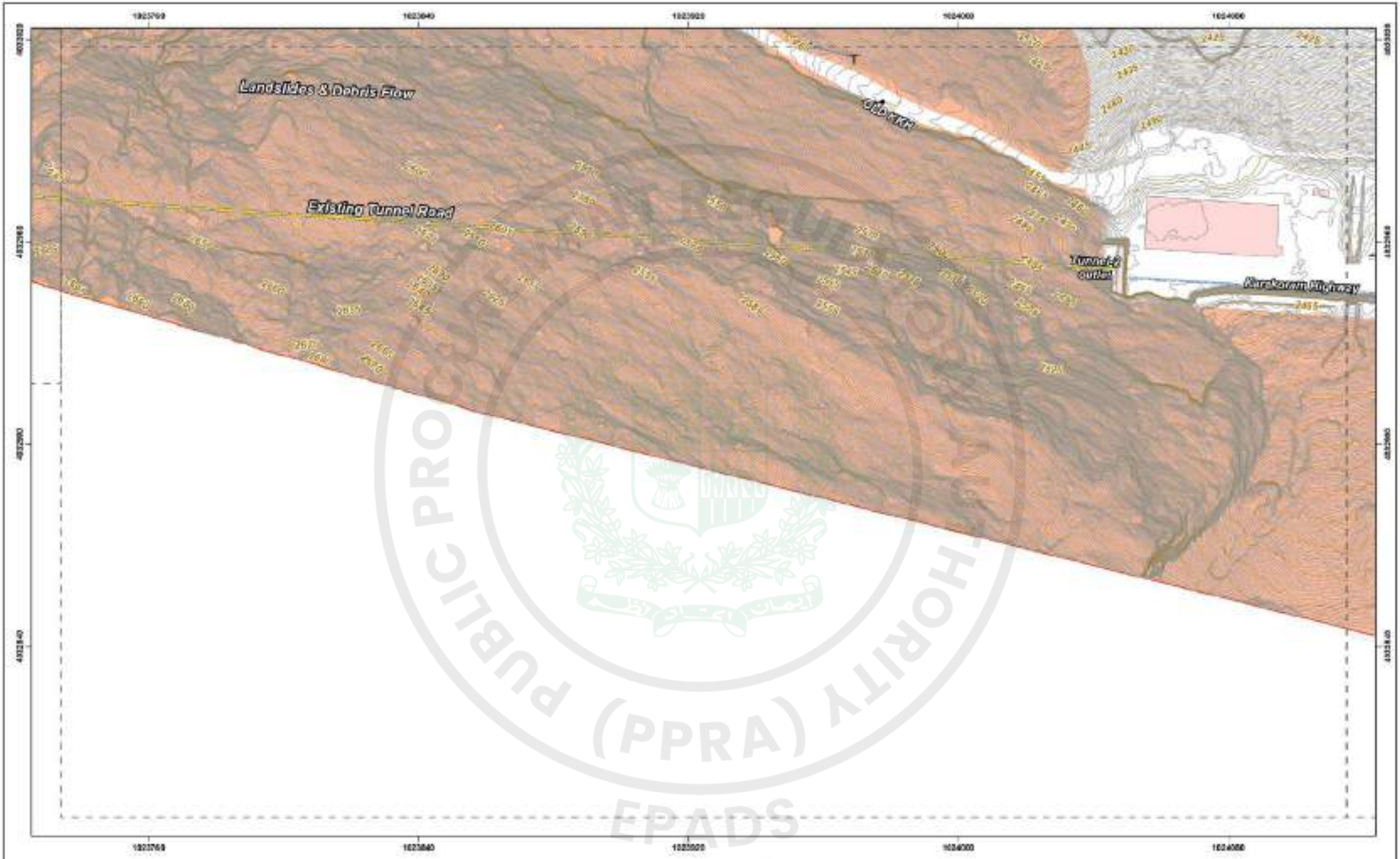


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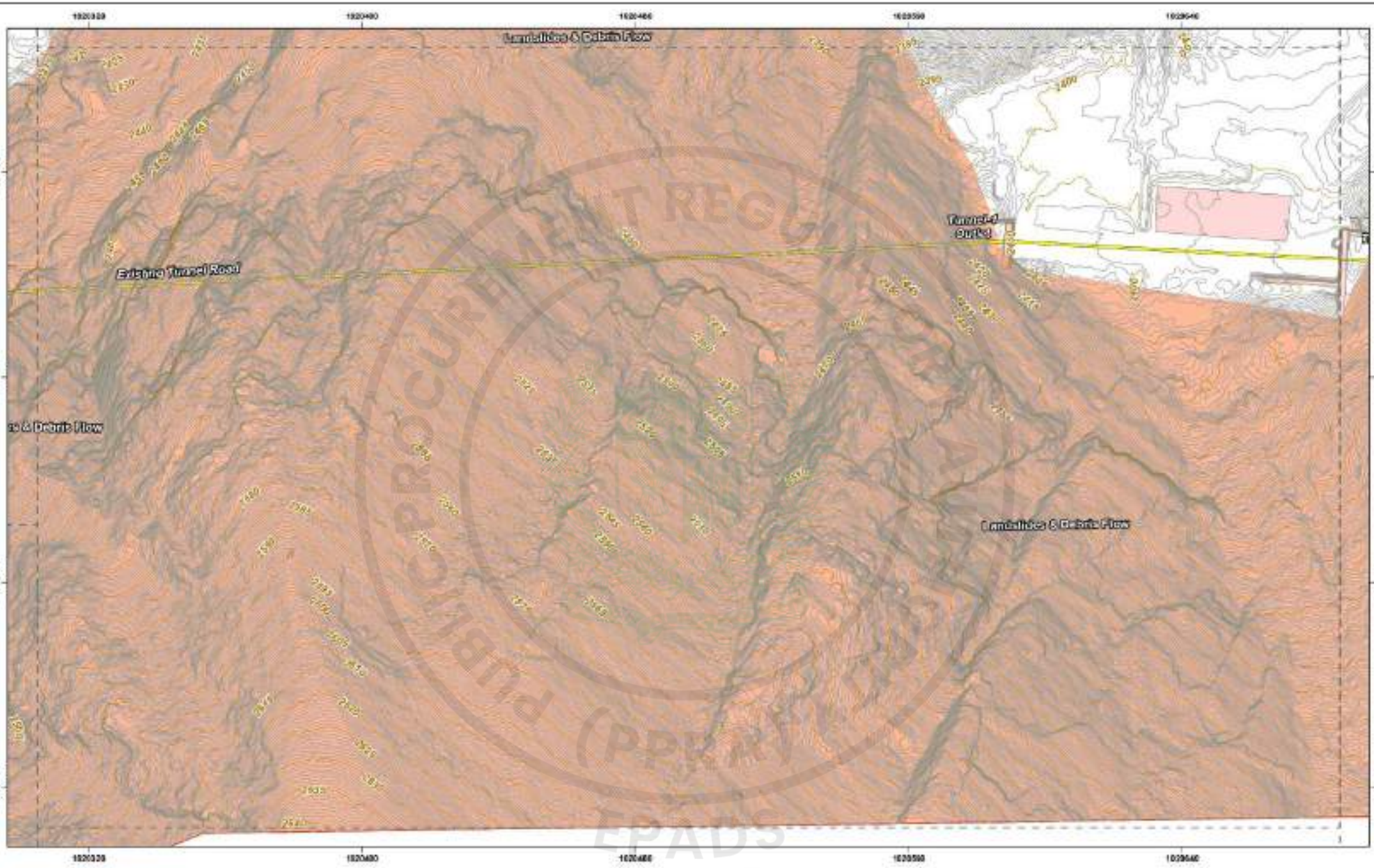


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| | | | | | | DATE: FEB 2026 | SHEET NO: Page62 of 73 |
| | | | | | | | SCALE BAR: |

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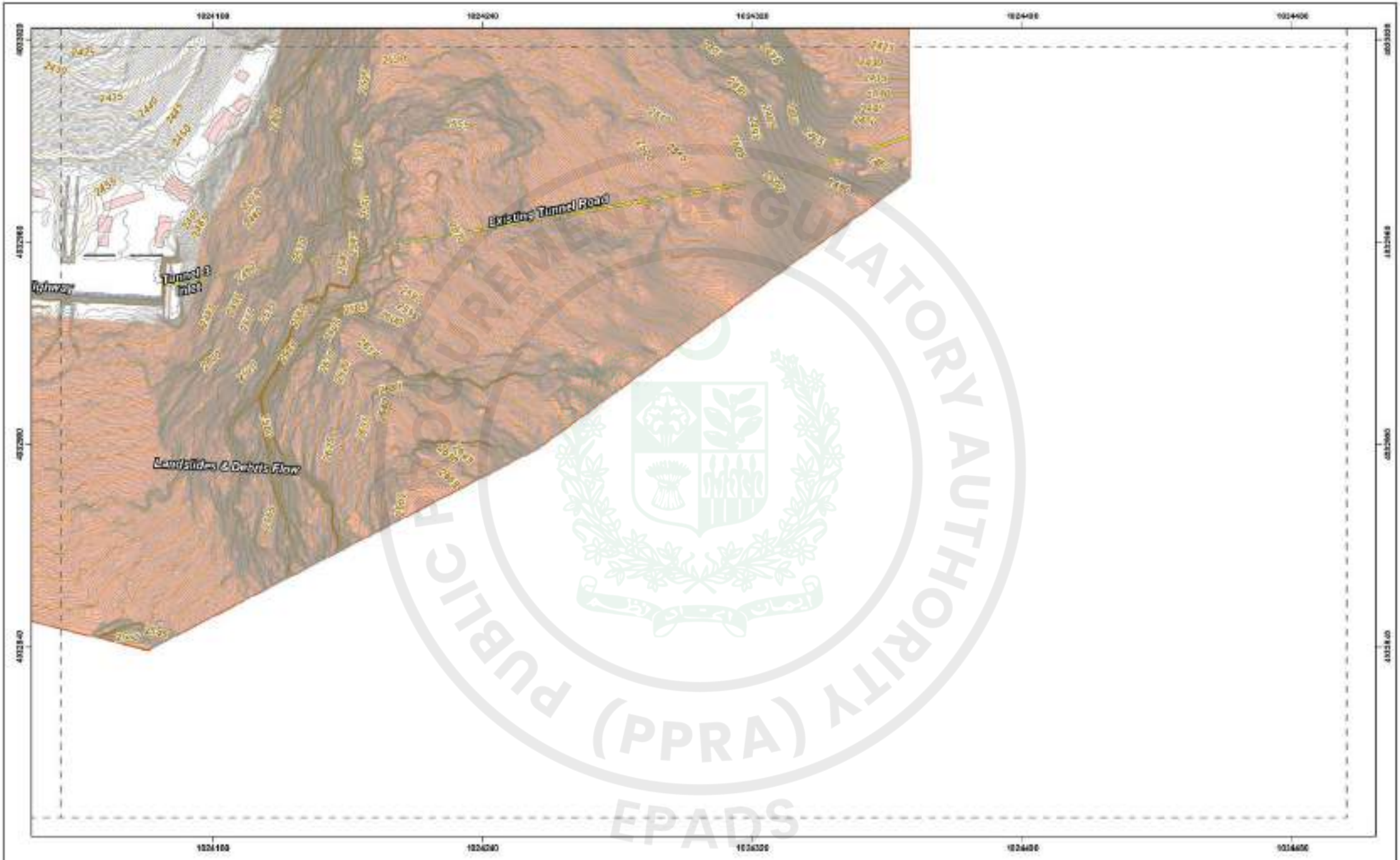


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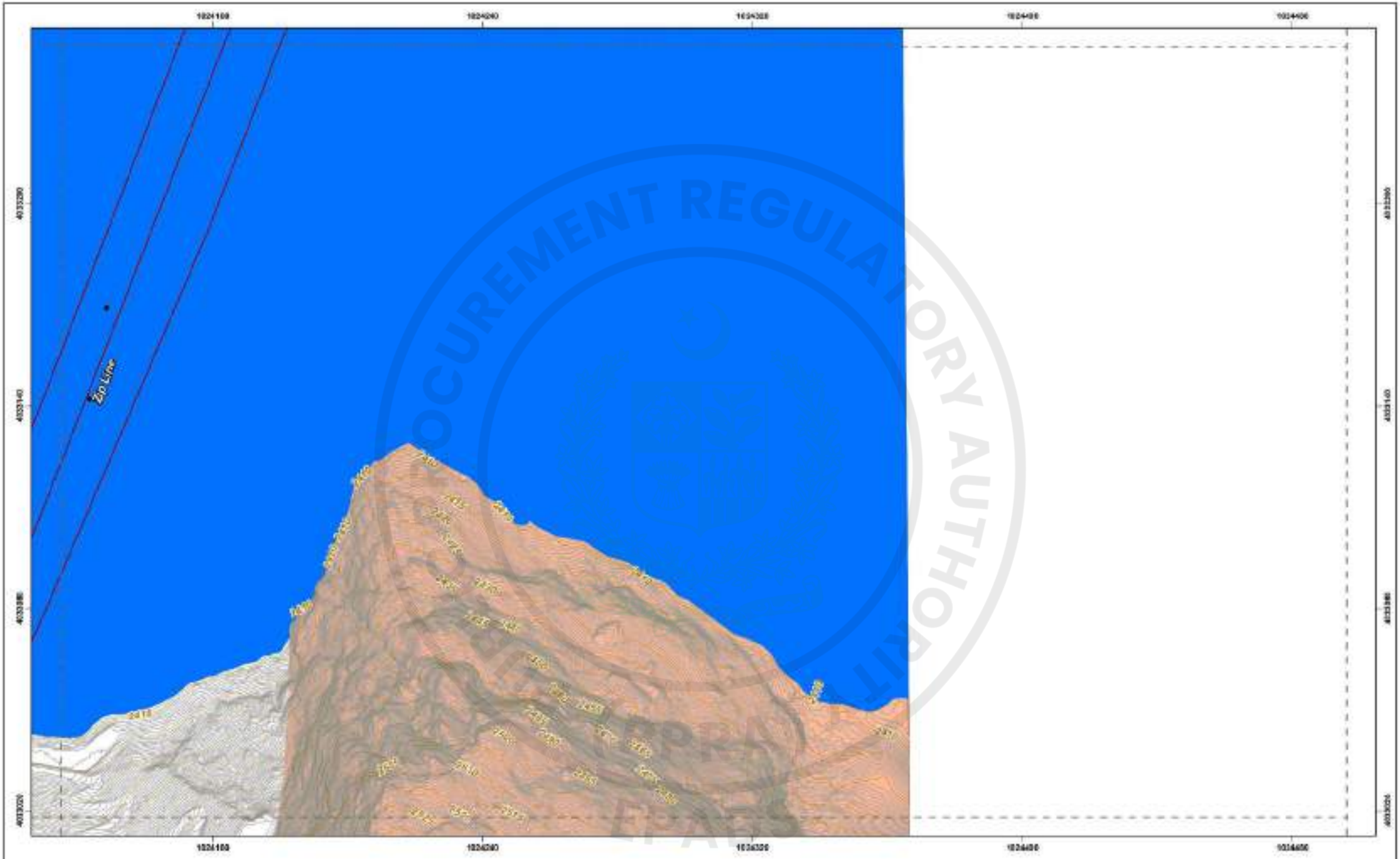


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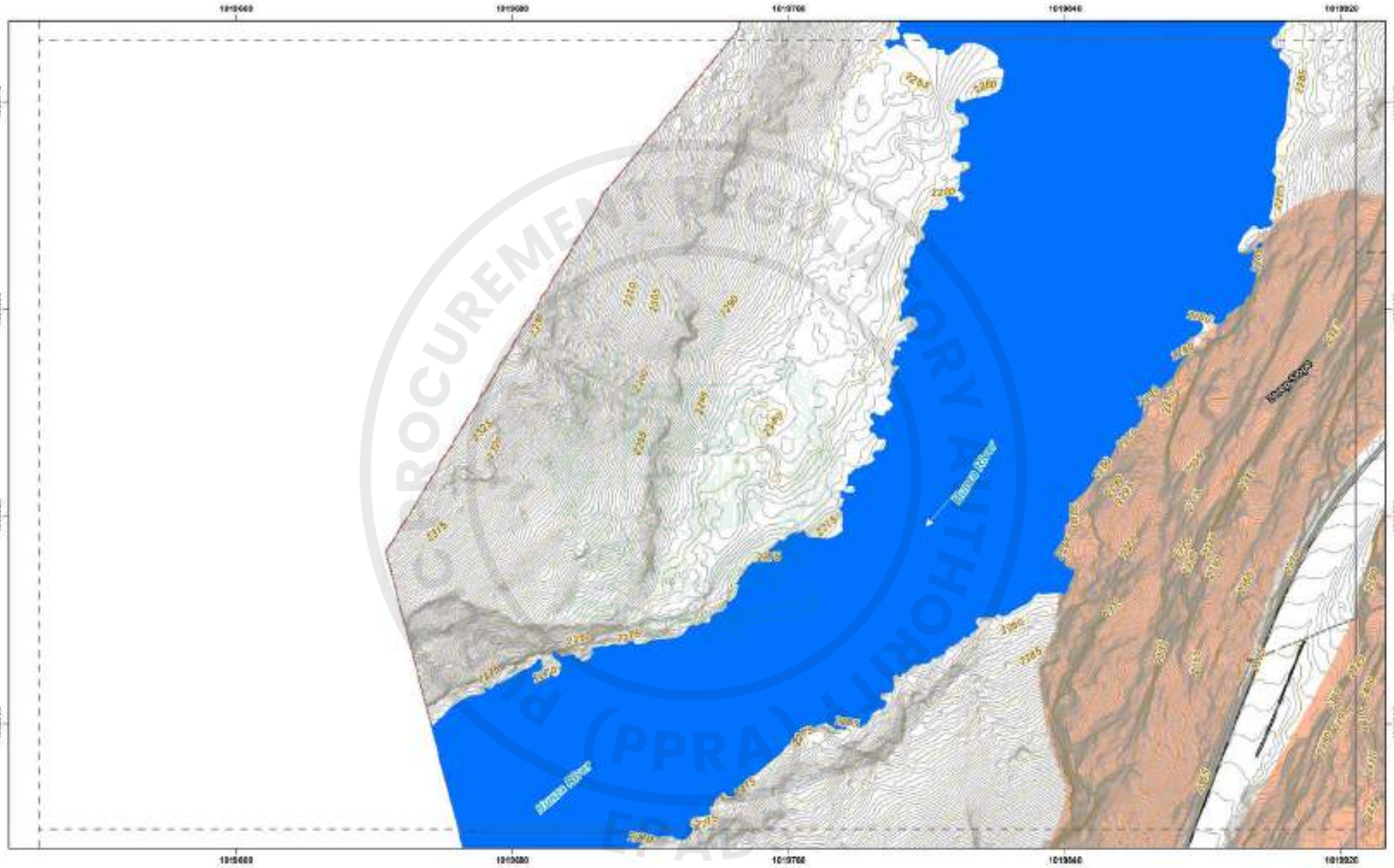


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INDEX MAP

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PROJECT

ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

TITLE

TOPOGRAPHIC SURVEY PLAN
ATTABAD LAKE DAM

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Page 70 of 73

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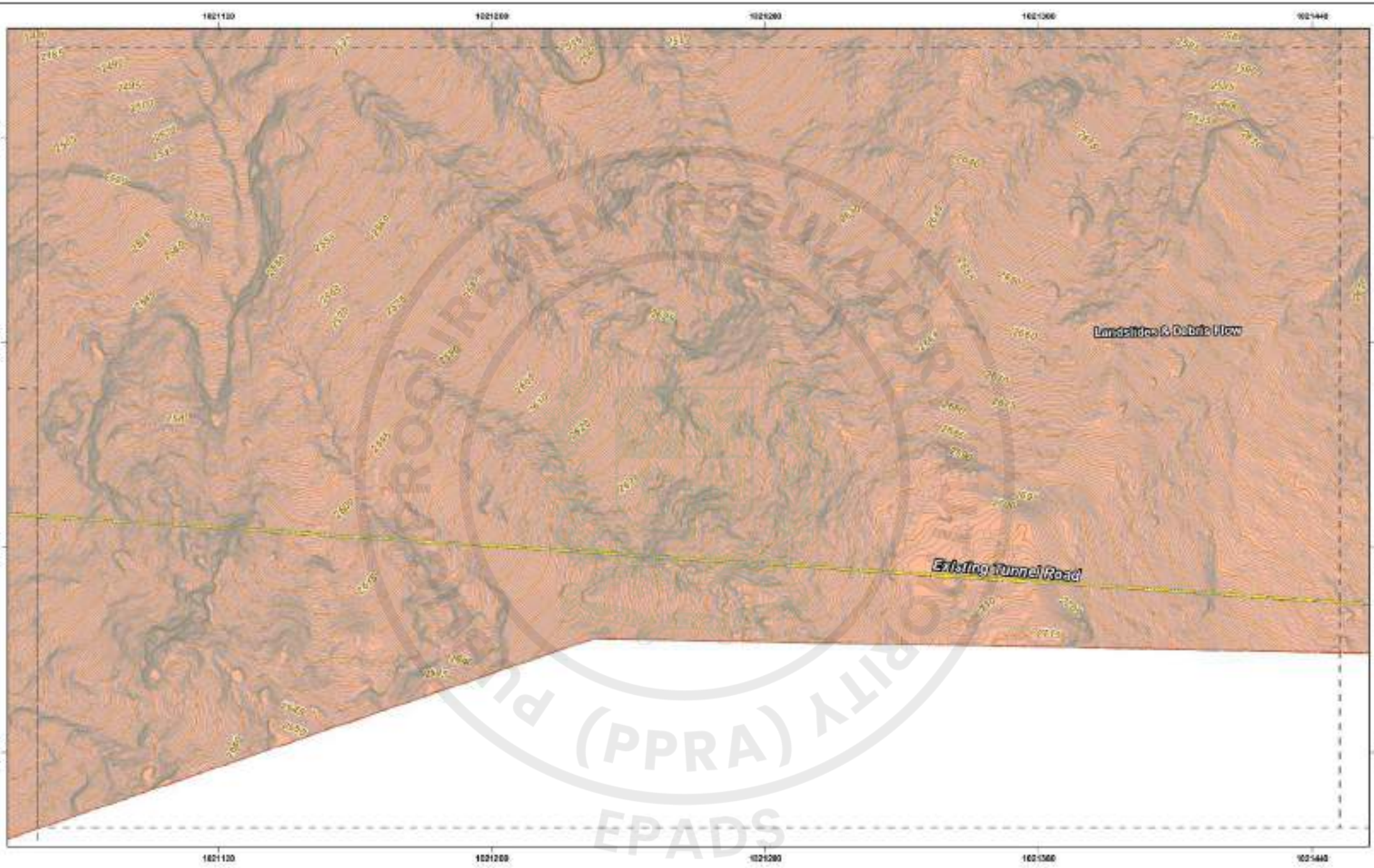


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|---|---|---|
| FEB 2026 | Page 66 of 73 | |

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WATER AND POWER DEVELOPMENT AUTHORITY
PAKISTAN

# RFP/EPC BIDDING DOCUMENT

PACKAGE- III:
ELECTRO-MECHANICAL WORKS

# ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

## VOLUME-III
## ADDITIONAL INFORMATION
## PART-IV ENVIRONMENTAL IMPACT ASSESSMENT (EIA) REPORT

BOOK 8

MARCH 2026

AHMC ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

NESPAK PES DOLSAR ENGINEERING

**DOCUMENT NO:**
**BD-ALHPP-03 (V3-EIA)**

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**MANAGEMENT CONSULTING SERVICES FOR REVIEW/VALIDATION OF FEASIBILITY STUDY, PROCUREMENT OF EPC CONTRACTOR, CONTRACT MANAGEMENT & ADMINISTRATION AND DETAILED DESIGN FOR OVERFLOW WEIR AND LANDSLIDE SLOPE TREATMENT OF THE ATTABAD LAKE HYDROPOWER PROJECT (54MW)**

# ENVIRONMENTAL IMPACT ASSESSMENT (EIA) REPORT

## TABLE OF CONTENTS


| | | Page No. |
|---|---|---|
| **TABLE OF CONTENTS** | | **I** |
| **LIST OF TABLES** | | **IX** |
| **LIST OF FIGURES** | | **XI** |
| **LIST OF ABBREVIATONS** | | **XII** |
| **EXECUTIVE SUMMARY** | | **1** |
| **1** | **INTRODUCTION** | **1-1** |
| 1.1 | PROJECT BACKGROUND | 1-1 |
| 1.2 | OBJECTIVES OF THE PROJECT | 1-2 |
| 1.3 | NEED FOR EIA STUDY | 1-2 |
| 1.4 | THE PROPONENT AND CONSULTANT | 1-2 |
| 1.5 | NATURE, MAGNITUDE AND LOCATION OF THE PROJECT | 1-3 |
| 1.1 | OBJECTIVE OF EIA | 1-5 |
| 1.6 | DELINEATION OF THE STUDY AREA/AREA OF INFLUENCE (AOI) | 1-5 |
| 1.2 | EIA TEAM | 1-9 |
| 1.7 | APPROACH AND METHODOLOGY ADOPTED | 1-9 |
| 1.8 | ORGANIZATION OF REPORT | 1-11 |
| **2** | **POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORKS** | **2-1** |
| 2.1 | GENERAL | 2-1 |
| 2.2 | SUMMARY OF RELEVANT STRATEGIES, POLICIES, ACTS AND LEGISLATION | 2-1 |
| 2.3 | COMPLIANCE PROCEDURE FOR OBTAINING NOC FROM GB EPA | 2-9 |
| 2.4 | INTERNATIONAL PROTOCOL/CONVENTIONS | 2-11 |
| **3** | **PROJECT DESCRIPTION** | **3-1** |
| 3.1 | GENERAL | 3-1 |
| 3.2 | OBJECTIVES OF THE PROJECT | 3-1 |



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3.3 PROJECT LOCATION ..... 3-1
3.4 PROJECT ACCESSIBILITY ..... 3-1
3.5 CATCHMENT AREA ..... 3-1
3.6 PROJECT COMPONENTS ..... 3-4
3.7 PROJECT DESIGN ..... 3-5
3.7.1 Coffer Dams ..... 3-5
3.7.2 Sediment Flushing Tunnel ..... 3-6
3.7.3 Power Intake ..... 3-6
3.7.4 Overflow Structure / Spillway ..... 3-6
3.7.5 Headrace Tunnel ..... 3-6
3.7.6 Surge Tank ..... 3-6
3.7.7 Penstock ..... 3-6
3.7.8 Powerhouse ..... 3-7
3.7.9 Tailrace Channel ..... 3-7
3.7.10 Switchyard ..... 3-7
3.7.11 Residential Colony ..... 3-7
3.7.12 Contractor Camp ..... 3-7
3.7.13 Other Site Facilities ..... 3-8
3.7.14 Detailed Engineering Design ..... 3-8
3.8 LAND ACQUISITION ..... 3-15
3.9 PROJECT ADMINISTRATIVE JURISDICTION ..... 3-15
3.10 CONSTRUCTION ASPECTS ..... 3-15
3.10.1 Construction Materials ..... 3-15
3.10.2 Procurement of Construction Materials ..... 3-15
3.10.3 Work Force ..... 3-16
3.10.4 Construction Activities and Required Machinery ..... 3-16
3.10.5 Water Requirement ..... 3-17
3.10.6 Solid Waste Estimation ..... 3-17
3.10.7 Power Requirement/ Power Source ..... 3-18
3.11 PROJECT IMPLEMENTATION SCHEDULE ..... 3-18
3.12 COST OF THE PROJECT ..... 3-18
**4 PROJECT ALTERNATIVES ..... 4-19**
4.1 GENERAL ..... 4-19
4.2 NO PROJECT OPTION ..... 4-19




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4.3 PROJECT LAYOUT ALTERNATIVES ..... 4-20
4.3.1 Alternative-I: Project Layout on the Left Bank ..... 4-20
4.3.2 Alternative-II: Project Layout on the Right Bank ..... 4-21
4.4 HEADRACE ALTERNATIVES ..... 4-21
4.4.1 Alternative-I A Headrace Tunnel Option ..... 4-21
4.5 PENSTOCK ALTERNATIVES ..... 4-22
4.6 POWERHOUSE LOCATION ALTERNATIVES ..... 4-22
**5 DESCRIPTION OF THE ENVIRONMENT ..... 5-1**
5.1 GENERAL ..... 5-1
5.2 PHYSICAL ENVIRONMENT ..... 5-1
5.2.1 Topography and Geomorphology ..... 5-1
5.2.2 Regional Geology ..... 5-2
5.2.3 Seismicity ..... 5-5
5.2.4 Land Erosion ..... 5-7
5.2.5 Hydrogeology ..... 5-7
5.2.6 Flooding ..... 5-8
5.2.7 Climate ..... 5-9
5.2.8 Solid Waste and Sewerage System ..... 5-13
5.2.9 Land Use ..... 5-15
5.2.10 Environmental Sensitive Receptors ..... 5-15
5.2.11 Environmental Parameters for Monitoring ..... 5-17
5.2.12 Air Quality and Noise Level ..... 5-17
5.2.13 Surface/Wastewater Quality ..... 5-17
5.2.14 Mining ..... 5-22
5.2.15 Natural Disaster ..... 5-22
5.2.16 Tourism ..... 5-22
5.3 ECOLOGICAL ENVIRONMENT ..... 5-22
5.3.1 Methodology ..... 5-22
5.3.2 Introduction and General Information Related to Biological Component of the Project Area ..... 5-22
5.3.3 Flora ..... 5-23
5.3.4 Agriculture ..... 5-25
5.3.5 Fauna ..... 5-29
5.3.6 Aquatic Ecology ..... 5-32


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5.4 SOCIO-ECONOMIC ENVIRONMENT ..... 5-33
5.4.1 APPROACH AND METHODOLOGY FOR THE STUDY ..... 5-34
5.4.2 Literature Review ..... 5-34
5.4.3 Field Reconnaissance Visit ..... 5-35
5.4.4 Sampling Technique ..... 5-35
5.4.5 Developing Survey Instruments ..... 5-35
5.4.6 Implementation of Data Collection Survey ..... 5-35
5.4.7 Rapid Appraisal Methods ..... 5-35
5.4.8 Participative Approach ..... 5-36
5.4.9 Data Processing and Analysis ..... 5-36
5.4.10 FINDINGS OF SOCIO–ECONOMIC SURVEY ..... 5-36
5.4.11 Demography of Sampled households ..... 5-38
5.4.12 GENDER ASPECTS / ROLES AND RESPONSIBILITIES ..... 5-43
**6 PUBLIC CONSULTATION ..... 6-1**
6.1 GENERAL ..... 6-1
6.2 OBJECTIVES ..... 6-1
6.3 STAKEHOLDER IDENTIFICATION ..... 6-2
6.3.1 District Level Stakeholders ..... 6-2
6.3.2 Village Level Consultations ..... 6-2
6.4 DEPARTMENTAL CONSULTATIONS ..... 6-4
6.4.1 Views & Suggestions of the Officials of Departments ..... 6-5
6.5 COMMUNITY CONSULTATIONS ..... 6-7
6.6 APPROACH FOR THE CONSULTATION AND INFORMATION DISSEMINATION 6-7
6.6.1 Locations of the Public Consultations and Participation ..... 6-7
6.6.2 Findings of Community Consultations ..... 6-7
6.7 STAKEHOLDER CONSULTATIONS FRAMEWORK FOR CONSTRUCTION AND OPERATION PHASE ..... 6-9
**7 GRIEVANCE REDRESS MECHANISM ..... 7-1**
7.1 COMPOSITION OF GRC ..... 7-1
7.2 RESPONSIBILITIES OF GRC ..... 7-1
7.3 PROCEDURES FOR FILING THE COMPLAINTS ..... 7-2
7.4 TYPE OF GRIEVANCE ..... 7-2
**8 ANTICIPATED ENVIRONMENTAL IMPACTS & MITIGATION MEASURES ... 8-1**


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8.1 GENERAL ..... 8-1
8.2 METHODOLOGY FOR IMPACT IDENTIFICATION ..... 8-1
8.2.1 Screening Checklist ..... 8-1
8.2.2 Impact Matrices ..... 8-1
8.2.3 Overlays ..... 8-2
8.2.4 Notion of Significance ..... 8-2
8.3 ANTICIPATED POSITIVE IMPACTS OF THE PROJECT ..... 8-4
8.3.1 Environmental Benefits ..... 8-4
8.3.2 Employment ..... 8-4
8.3.3 Impact on the Local Economy ..... 8-4
8.3.4 Exploitation of Natural Resources ..... 8-4
8.3.5 Tourism ..... 8-5
8.3.6 Trade Route to China ..... 8-5
8.3.7 Impacts on Social Life ..... 8-5
8.3.8 Clean Development Mechanism (CDM) Benefits ..... 8-5
8.4 ANTICIPATED IMPACTS DURING PRE-CONSTRUCTION PHASE ..... 8-5
8.4.1 Physical Environment ..... 8-6
8.4.2 Ecological Environment ..... 8-9
8.4.3 Socio-Economic Environment ..... 8-11
8.5 ANTICIPATED IMPACTS DURING CONSTRUCTION PHASE ..... 8-14
8.5.1 Physical Environment ..... 8-14
8.5.2 Ecological Environment ..... 8-23
8.5.3 Socio Economic Environment ..... 8-26
8.6 ANTICIPATED IMPACTS DURING OPERATIONAL PHASE ..... 8-36
8.6.1 Physical Environment ..... 8-36
8.6.2 Ecological Environment ..... 8-40
8.6.3 Socio-economic Environment ..... 8-42
**9 ENVIRONMENTAL MANAGEMENT PLAN ..... 9-1**
9.1 GENERAL ..... 9-1
9.2 OBJECTIVES OF EMP ..... 9-1
9.3 LEGAL REQUIREMENT ..... 9-1
9.4 INSTITUTIONAL SETUP FOR IMPLEMENTATION AND MANAGEMENT OF EMP 9-2
9.4.1 Institutional Setup for Implementation and Management of EMP ..... 9-2


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9.4.2 Roles and Responsibilities for EMP Implementation during construction Phase 9-2
9.5 PARTICIPATORY CONSULTATION FRAMEWORK ..... 9-5
9.6 PLANNING FOR EMP IMPLEMENTATION ..... 9-6
9.6.1 NOC and Other Approvals ..... 9-6
9.6.2 Stakeholder Coordination ..... 9-6
9.7 ENVIRONMENTAL MANAGEMENT PLAN ..... 9-7
9.8 ENVIRONMENTAL MONITORING PLAN ..... 9-57
9.9 GENERAL ..... 9-57
9.10 MONITORING STRATEGY ..... 9-57
9.11 IMPLEMENTATION AND MONITORING ..... 9-58
9.12 COMMUNICATION AND DOCUMENTATION (MONITORING PERIOD) ..... 9-58
9.13 DATA RECORDING AND MAINTENANCE ..... 9-58
9.14 DATABASE ..... 9-58
9.15 MEETINGS AND REPORTING ..... 9-59
9.16 SOCIAL COMPLAINT REGISTER ..... 9-60
9.17 PHOTOGRAPHIC RECORDS ..... 9-60
9.18 NON-COMPLIANCE OF THE EMP ..... 9-60
9.19 REVIEW OF RECORDED DATA ..... 9-60
9.20 THIRD PARTY MONITORING ..... 9-60
9.21 OBJECTIVES ..... 9-60
9.22 ENVIRONMENTAL TRAINING PROGRAM ..... 9-61
9.23 TRAINING STRATEGY ..... 9-61
9.24 TRAINING OBJECTIVES ..... 9-61
9.25 TRAINING MATERIAL ..... 9-62
9.26 TRAINING PROGRAM ..... 9-62
9.27 MANAGEMENT PLANS ..... 9-64
9.28 TREE PLANTATION PLAN ..... 9-64
9.29 HSE MANAGEMENT PLAN ..... 9-64
9.30 EMERGENCY PREPAREDNESS AND RESPONSE FRAMEWORK ..... 9-65
9.31 BORROW AREAS MANAGEMENT / REHABILITATION PLAN ..... 9-66
9.32 RESTORATION AND REHABILITATION PLAN ..... 9-67
9.33 WASTE MANAGEMENT PLAN ..... 9-67
9.34 TRAFFIC MANAGEMENT PLAN ..... 9-68
9.35 CHANGE MANAGEMENT PLAN ..... 9-68


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9.36 CHANCE FIND PROCEDURE ..... 9-69
9.37 CODES OF PRACTICE ..... 9-69
9.38 GENERAL ..... 9-69
9.39 GOOD ENGINEERING PRACTICES ..... 9-70
9.40 CULTURAL NORMS ..... 9-70
9.41 ENVIRONMENTAL MITIGATION COST ..... 9-71
**10 CONCLUSIONS AND RECOMMENDATIONS ..... 10-1**
10.1 CONCLUSIONS ..... 10-1
10.2 RECOMMENDATIONS ..... 10-3

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## ANNEXES

| | |
|---|---|
| Annex-I: | List of Participants-Community Consultations |
| Annex-II: | Tree Plantation Plan |
| Annex-III: | Chance Find Procedure |
| Annex-IV: | Guideline Occupational Health and Safety Plan |
| Annex-V: | Breakup of Health and Safety Cost |
| Annex–VI: | Gender Action Plan |
| Annex-VII: | Key Performance Indicators (KPI) |

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# LIST OF TABLES


Table 1-1: Salient Features of the Proposed Project ..... 2

Table 1-1: EIA Study Team ..... 1-9

Table 2-1: Main Strategies/Policies Related to Environment and Relevance to the Project 2-1

Table 2-2: Main Legislation/Acts Related to Environment and Their Relevance to the Project ..... 2-4

Table 2-3: International Agreements/Conventions Relevant to the Project ..... 2-11

Table 3-1: Salient Features of the Proposed Project ..... 3-4

Table 3-2: Machinery and Equipment Requirement ..... 3-17

Table 5-1: Average Minimum and Maximum Temperature in Hunza from 2010-20 ..... 5-9

Table 5-2: Mean Monthly Precipitation (mm) 2010-2020 ..... 5-10

Table 5-3: Mean Monthly Relative Humidity (%) 2010-2020 ..... 5-11

Table 5-4: Summary of Land Use within Study Area of Project ..... 5-15

Table 5-5: Range of Gaseous Pollutant Concentration & Noise Emission Level ..... 5-17

Table 5-6: Chemical Parameters Results of the Samples (Surface Water) ..... 5-18

Table 5-7: Bacteriological and Physical Parameters Results of the Samples (Surface Water) ..... 5-20

Table 5-8: Important medicinal plants report in GB Forests ..... 5-24

Table 5-9: Plantation Plan in Hunza District for the year 2021 ..... 5-25

Table 5-10: Land Use Statistics of District Hunza ..... 5-26

Table 5-11: Cropping Pattern of Hunza District ..... 5-26

Table 5-12: Potential of crops in various agro-ecological zones of Hunza ..... 5-27

Table 5-13: Fauna available in Project area of Hunza District ..... 5-30

Table 5-14: Game Reserves Areas ..... 5-31

Table 5-15: Survey Objectives, Key Indicators, and Methods ..... 5-34

Table 5-16: Number of Respondents ..... 5-35

Table 5-17: Gender Composition of Households' Population ..... 5-39

Table 5-18: Age Group of Respondents ..... 5-39

Table 5-19: Educational Level ..... 5-39

Table 5-20: Source of Income ..... 5-40

Table 5-21: Monthly Household Income ..... 5-40

Table 5-22: Monthly Household Expenditures ..... 5-41

Table 5-23: Source of Energy in Winter Season ..... 5-42





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Table 5-24: Source of Energy in Summer Season ..... 5-42
Table 5-25: Basic Social Amenities in the Proposed Project Area ..... 5-42
Table 5-26: Mode of Transport ..... 5-43
Table 5-27: Women Participation in the Various Activities ..... 5-44
Table 6-1: Tasks and Purposes of Consultations ..... 6-1
Table 6-2: Roles of Concerned Agencies/Departments ..... 6-3
Table 6-3: List of Government Officials Consulted ..... 6-4
Table 6-4: Detail of Issues/Points Raised/Discussed during Departmental Consultations .. 6-5
Table 6-5: Consultation Locations and Number of Participants ..... 6-7
Table 6-6: Consultation Meetings ..... 6-8
Table 6-7: Future Consultations Framework ..... 6-9
Table 8-1: Estimated Wastewater Generated by Workers in Construction Camp ..... 8-18
Table 9-1: Environmental Management Plan ..... 9-8
Table 9-2: Periodic Reporting Mechanism ..... 9-59
Table 9-3: Training Program ..... 9-62
Table 9-4: Estimated Cost for the Implementation f Environmental Monitoring and Management ..... 9-72


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# LIST OF FIGURES


Figure 1-1: Project Location Map ..... 1-4
Figure 1-2: Study Area Map ..... 1-8
Figure 2-1: EIA and IEE Procedure in Pakistan ..... 2-10
Figure 3-1: Site Accessibility Map ..... 3-3
Figure 3-2: Project Component Map ..... 3-10
Figure 3-3: Weir Longitudinal Section ..... 3-11
Figure 3-4: Weir Cross Section ..... 3-12
Figure 3-5: Powerhouse Longitudinal Section ..... 3-13
Figure 3-6: Powerhouse Cross Section ..... 3-14
Figure 5-1: Topography Map ..... 5-3
Figure 5-2: Regional Geological Map ..... 5-4
Figure 5-3: Seismic Zoning Map of the Project Area ..... 5-6
Figure 5-4 Instantaneous Peak Flows at Attabad Lake HPP Site ..... 5-8
Figure 5-5: Average Minimum and Maximum Temperature in Hunza from 2010-20 ..... 5-10
Figure 5-6: Mean Monthly Precipitation (mm) 2010-2020 ..... 5-11
Figure 5-7: Average Relative Humidity ..... 5-13
Figure 5-8: Hydrological Map ..... 5-14
Figure 5-9: Landuse Map of the Study Area ..... 5-16
Figure 8-1: Project Impact Evaluation Matrix ..... 8-3
Figure 8-2: Instantaneous Peak Flows at Attabad Lake HPP Site ..... 8-8
Figure 8-3: General Drawing of Septic Tank ..... 8-19
Figure 9-1: Institutional Arrangement for Implementation of EMP ..... 9-2




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## LIST OF ABBREVIATONS

| | |
|---|---|
| ADB | Asian Development Bank |
| ADP | Annual Development Programme |
| AJK | Azad Jammu and Kashmir |
| ALHPP | Attabad Lake Hydropower Project |
| AOI | Area of Influence |
| BCP | Building Code of Pakistan |
| BOD | Biochemical Oxygen demand |
| CAD | Computer Aided Design |
| CBOs | Community Based Organizations |
| CBD | Convention on Biological Diversity |
| CCHA | Community Controlled Hunting Area |
| CDM | Clean Development Mechanisms |
| CER | Certified Emission Reductions |
| CITES | Convention on the International Trade of Endangered Species |
| dBA | Decibels (Equivalent to Scale A) |
| EA | Environmental Assessment |
| EIA | Environmental Impact Assessment |
| EMP | Environmental Management Plan |
| EPA | Environmental Protection Agency |
| EPC | Engineering Procurement Construction |
| GB | Gilgit Baltistan |
| GBDMA | Gilgit Baltistan Disaster Management Authority |
| GHG | Green House Gases |
| GLOF | Glacial Lake Outburst Floods |
| GOP | Government of Pakistan |
| GRC | Grievance Redress Committee |
| GRM | Grievance Redress Mechanism |
| GT | General Topographic |
| IEE | Initial Environmental Examination |
| IFC | International Finance Corporation |
| KKH | Karakorum Highway |
| KNP | Khunjerab National Park |
| KP | Khyber Pakhtunkhwa |
| LAA | Land Acquisition Act |
| LPG | Liquefied Petroleum Gas |
| M.a.s.l. | Meters Above Sea Level |
| MW | Megawatt |


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| | |
|---|---|
| MSDS | Material Safety Data Sheets |
| NESPAK | National Engineering Services Pakistan (Pvt.) Limited |
| NCS | National Conservation Strategy |
| NEP | National Environmental Policy |
| NEQS | National Environmental Quality Standards |
| NGOs | Non-Governmental Organization |
| NPO | No Project Option |
| O&M | Operation and Maintenance |
| OBE | Operating Basis Earthquake |
| OSHA | Occupational Safety and Health Administration |
| PAPs | Project Affected Persons |
| PD | Project Director |
| PGA | Peak Ground Acceleration |
| PMU | Project Management Unit |
| RCC | Reinforced Cement Concrete |
| MC | Management Consultant |
| SOPs | Standard Operating Procedures |
| SPSS | Statistical Package for Social Sciences |
| TWA | Time-Weighted Average |
| TMP | Traffic Management Plan |
| WPD GB | Water and Power Department, Gilgit Baltistan |
| WAPDA | Water and Power Development Authority |
| WEC | WAPDA Environment Cell |
| WHO | World Health Organization |


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# EXECUTIVE SUMMARY

Water and Power Development Authority (WAPDA) intends to develop 54 MW Attabad Lake Hydropower Project (ALHPP[1]) on Attabad Lake situated in the Hunza Valley of GB, Pakistan. ALHPP (36°8'28.87"N and 74°49'19.44"E) has been identified on Hunza River on Attabad Lake. Attabad Lake was formed on January 4, 2010, when a huge mass from the right bank of Hunza River slided down near Attabad Village and blocked Hunza River. The inflow filled upstream valley created a reservoir 12 km long till the end of May 2010. Attabad Lake is about 15 km upstream of Ganish Bridge and about 111 km upstream from Gilgit. Therefore, ALHHP will utilize the Attabad Lake water and head for the generation of the Hydel Electricity. Therefore, due to the implementation of Attabad Lake HPP, no major adverse impacts are anticipated.

Presently, there is a huge demand and supply gap of electricity in GB resulting in load shedding along with low voltage issues. Locals have no option for commercial and industrial demand to be partly fulfilled from diesel generators. Apart from the high cost of fuel, the use of these diesel generators is affecting the environment as well as tourism in the area.

WAPDA hired a joint venture of Attabad Hydropower Management Consultants (AHMC) with M/s National Engineering Services Pakistan (NESPAK) as its lead firm for the Review / Validation of the Feasibility Study, Procurement of the EPC Contractor, and Contract Management & Administration of ALHPP. As a part of this Contract, review of the Environmental Impact Assessment (EIA) Study (prepared by WAPDA in 2021) was also included in the scope of work. This EIA study has been updated based on the available information at this stage of the Project as an additional scope of work. The proposed project will be implemented in EPC Contract mode therefore; Detailed Engineering Design including Basic Design will be available after the selection of EPC Contractor.

As per Gilgit Baltistan Environmental Protection Act, 2014 the project Proponent should acquire NOC / Environmental Approval from EPA, GB before the start of the construction of any Project. As per Pakistan Environmental Protection Agency Review of Initial Environmental Examination and Environmental Impact Assessment Regulations, 2000.The proposed Project falls under Schedule II (Category A "Energy": Hydroelectric Power Generation over Fifty (50) Mega Watt), which requires an EIA to initiate the process of NOC from Gilgit Baltistan Environmental Protection Agency (GB EPA). Thus, to fulfil the legal requirements an EIA Study has been carried for the proposed Project.

This EIA study has been prepared to address the requirements detailed in the Gilgit Baltistan Environmental Protection Act, 2014 addressing environmental and social aspects and considerations. In addition, the EIA Study also addresses the requirements defined in the applicable national and local regulations.

The main components are: Weir (Overflow Structure) and its associate structures, Sediment Flushing Tunnel, Headrace Tunnel, Surge Tank, Penstock, Powerhouse, Tailrace and Switchyard. Reservoir has already been created as a result of natural disaster. Total land to be acquired is approximately 183 acres for project components which includes both Private and Government land. The estimated total land to be acquired is 777.5 acres due to the

[1] *The term ALHPP in this report is referred as Proposed Project.*


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impounding of reservoir up to maximum conservation level including free board i.e. El. 2424 m.a.s.l, including river bed. The proposed Project site is accessible through Motorway from Islamabad to Thakot (M-15) and afterwards by Karakorum Highway (KKH) from Thakot to Project Area.

Following are the salient features provided in **Table ES-1**:

**Table 1-1: Salient Features of the Proposed Project**

| Sr. No. | Items | Description |
|---|---|---|
| 1 | Location | 27 km from Aliabad Town |
| 2 | River | Hunza River |
| 3 | Catchment Area | 8901 $km^2$ |
| 4 | River Mean Annual Flow | 209 $m^3/s$ |
| 5 | Purpose | Power Generation |
| 6 | Type of Development | High Head Run of River with Peaking |
| 7 | Type of Weir | Overflow |
| 8 | Weir Crest Elevation | 2414 m.a.s.l |
| 9 | Weir Crest Length | 60 m |
| 10 | Weir Height | 30 m |
| 11 | Design Flood | 3250 $m^3/s$ |
| 12 | Maximum Conservation Level including free Board | 2424 m.a.s.l |
| 13 | Maximum Flood Level | 2421 m.a.s.l |
| 14 | Minimum Operating Level | 2412 m.a.s.l |
| 15 | Gross Head | 112.0 m |
| 16 | Net Head | 106.0 m |
| 17 | Installed Capacity | 54 MW |
| 18 | Headrace Tunnel Length | 2320 m |
| 19 | Headrace Tunnel Diameter | 5.5 m |
| 20 | Penstock Length | 480 m |
| 21 | Penstock Diameter | 3.6 m |
| 22 | Type of Turbine | Francis (Vertical) |


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| Sr. No. | Items | Description |
|---|---|---|
| 23 | No. of Units | 03 |
| 24 | Design Discharge | 60.00 $m^3/s$ (20 $m^3/s$ to each unit) |
| 25 | Length of Weir | 55 m |
| 26 | Length of Power tunnel | 2320 m |
| 27 | Type of Powerhouse | External |
| 28 | Annual Energy | 374 GWh |
| 29 | Plant Factor | 76.5 % |
| 30 | Tailrace Length | 88 m |
| 31 | Design Life | 30 Years |

The proposed project will be implemented by the EPC Contract including Detailed Engineering Design.

The proposed project construction schedule spans over a period of 55 months, which include 36 months for construction activities and 19 months for pre-construction activities. The estimated cost of the proposed Project is PKR 24.246 billion.

The various alternatives which have been considered during the conduct of the study are: No Project Option (NPO), Project Layout Flexible overflow structure Alternatives, Flushing Tunnel Alternatives, Penstock reduced length Alternatives, relocated Powerhouse Alternatives, and increased length of Tailrace Channel.

For the collection of baseline information checklists / proformas, Satellite Imagery (Google Earth), and General Topographic (GT) sheets were used. Study Area / Area of Influence (AOI) was delineated based on field surveys (primary data), Consultant's experience, study of available maps and data collected through secondary sources and results of the consultation with the relevant departments. In this report, the Study Area/AOI is considered as area where the Project impacts on the Environment due to the proposed Project activities are assessed.

The segment of Hunza valley wherein the various components of the proposed project are situated reflects very high relief conditions marked by relatively steeply inclined extensive mountain slopes along right side of the valley as compared to the left bank mountain slopes. The mountain slopes are mostly marked by erratic slopes instabilities along with relatively less extensive segments of casuistic slopes. The Project Area lies in Karakorum Block, where rocks of meta igneous provenance are exposed. The rock units represent acidic igneous rocks including Granodiorite and Granitic Gneiss. Many local as well as regional faults are present in Project Area.

According to Seismic Provisions in the Pakistan Building Code 2007, the Project area falls in Seismic Zone 2B (moderate), which represents Peak ground acceleration from 0.16 to 0.24g, where g represents acceleration due to gravity.


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The climate of Hunza valley is characterized by mild summer and cold winters. Wide spread snow fall occurs in winter. During winter the northern winds blow constantly bringing the temperature down considerably. At Hunza, the mean temperature recorded from 2010-20 is 21.20 °C in July, the hottest month and the coldest month is January with an average temperature of -0.42 °C. Hunza receives maximum rainfall in spring i.e., in April.

In the Study Area, no proper solid waste management system exists. The areas lack proper sewerage system with only some open drains constructed in the vicinity for the discharge of wastewater.

Major Land use of the proposed project is barren hilly land and some built up area at the site of powerhouse while agricultural land is also present in the reservoir considering maximum conservation level of 2424 m.a.s.l.

Five distinct zones of flora in the Study Area can be identified including Dry Alpine Scrub, Moist Alpine Pastures, Dry Alpine Plateau Pastures and Sub Alpine Scrub and Birch Forests. A large number of medicinal plants grow in the natural forests of Hunza Valley. There are no endangered species of fauna, Community Controlled Hunting, Protected Areas game reserve, wild sanctuaries and National Park found in the Project Area. Agriculture and livestock grazing area are also important aspects and present in the Project Area.

According to socio-economic survey in the Study Area, 58 respondents were selected from villages/settlements (Sarat, Ganish, Attabad, Ayeenabad, Shishkat, Gulmit, Gulkin, and Passu) of Hunza district. The respondents of the study area included local residents, farmers, shop keepers, pedestrians, drivers, and Govt employees etc. the survey findings revealed that there is no group of people that can be termed as “Indigenous Community”.

The stakeholder consultations were held with relevant departments such as GB EPA, Revenue Department, Water & Power Dept. GB, District Health Department Hunza, District Agriculture Department Hunza, District Education Department, Wildlife Department Hunza, Forest Department Hunza, and Fisheries Department Hunza etc. Moreover, Four (04) community consultative meetings were held with more than 42 participants in the Study Area. The major categories participated in these meetings were local population, community groups, landowners, and Project Affected Persons (PAPs).

Impact assessment has been conducted for various phases of the proposed Project and the project envisages following potential positive impacts:

- The Project not only reduces or replaces equivalent electricity generation sources with all the associated environmental benefits but it will also help to avoid all associated pollution caused through extraction, processing, storage and transportation of conventional fuels required for fossil fuel power generation plants.
- The sustainable power supply with the development of the proposed Project is likely to attract more tourists in the Project area and will increase the local business and recreational activities.
- The proposed Project will also provide skilled and unskilled jobs during the implementation phase and a limited number of jobs during operation and maintenance.


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- Hunza and Nagar valleys have precious mineral resources which have remained unexploited. The availability of electricity will certainly develop a set up on large scale to preserve fruits and for exploration of minerals.
- The requirements of electricity have increased in homes, both public and private offices, education institutions, hospitals, and health care centers in towns and habitats in the remote rural areas of valleys in Gilgit-Baltistan region, the electricity shortfall can be decreased with implementation of this Project.
- Access roads will be built as part of the Project and will facilitate the people for goods and services accessibility. After completion of the Project, these facilities and infrastructure will be available to the general public. Moreover, health facilities created during the construction phase will be available to local communities

Following potential adverse impacts have been anticipated during different especially construction phase of the proposed Project:

- Permanent Land acquisition;
- Temporary Land on rental/lease basis;
- Cutting of trees/bushes falling within the proposed Project Boundary.
- Landslide Hazards;
- Temporary Impact on aquatic fauna;
- Disturbance to infrastructure and public utilities;
- Disturbance to the public movement during construction;
- Noise and air pollution due to the working of construction machinery during construction and traffic during O&M phases of the Project;
- Solid waste and wastewater generation during construction;
- Oil spillages from construction machinery, resulting in soil and water contamination;
- Occupational and community health and safety issues; and
- Social and Cultural Conflicts.

Sedimentation, Environmental flow, dam safety and emergencies etc. are the anticipated environmental impacts during operation and maintenance phase of the proposed project.

The impact assessment, revealed that with the help of appropriate mitigation and control measures provided in this EIA Study, most of these potential impacts will either be avoided altogether, or their likelihood of occurrence and severity will be reduced, thus making this project environmentally and socially feasible.

WAPDA will establish a Grievance Redress Committee (GRC) to facilitate the resolution of complaints by Project Affected People (PAPs) and grievances about the project's environmental and social performance. The GRC will be coordinated by the Chief Resident Engineer and Environment Head. The GRC will address affected people's concerns and complaints promptly, using an understandable and transparent process.

The Environmental constraints will have to be monitored by concerned agencies, including Environment Specialist of Proponent and GB EPA. An EMP has been developed as part of the report which provides a detailed mitigation matrix that covers impacts, mitigation measures roles and responsibilities and timings to avoid, minimize or mitigate the adverse impacts of the


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project.

The EIA, EMP, mitigation and monitoring programs, contained herewith are recommended to include within the bidding documents for project works for all project components. The Bidding documents shall clearly state that the EPC Contractor will be responsible for the implementation of the requirements of the EMP through his own Site Specific Environmental Management Plan (SSEMP) and Site Specific Health and Safety Management Plan (SSHSMP), based on the guidelines provided in the EIA report, which will adopt all of the conditions of the EMP and add site specific elements as per advice of Environmental Specialist. This will ensure that all potential bidders are aware of the environmental requirements of the project and its associated environmental costs.

The tentative cost estimates to implement EMP is estimated as **PKR. 126.5 Million**. This tentative cost will be included in the overall project cost. This cost will be reviewed and firmed up periodically to ensure realism.

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# 1 INTRODUCTION

## 1.1 PROJECT BACKGROUND

Water and Power Development Authority (WAPDA) intends to develop 54 MW Attabad Lake Hydropower Project (ALHHP[2]) on Attabad Lake situated in the Hunza Valley of GB, Pakistan. ALHPP (36º8'28.87"N and 74º49'19.44"E) has been identified on Hunza River on Attabad Lake. Attabad Lake was formed on January 4, 2010, when a huge mass from the right bank of Hunza River slided down near Attabad Village and blocked Hunza River. The inflow filled upstream valley created a reservoir 22 km long till the end of May 2010. Attabad Lake is about 15 km upstream of Ganish Bridge and about 111 km upstream from Gilgit. Therefore, ALHHP will utilize the Attabad Lake water and head for the generation of the Hydel Electricity. Therefore, due to the implementation of Attabad Lake HPP, no major adverse impacts are anticipated. The location of the Project is shown in **Figure 1.1**.

Presently, there is a huge demand and supply gap of electricity in GB resulting in load shedding along with low voltage issues. Locals have no option for commercial and industrial demand to be partly fulfilled from diesel generators. Apart from the high cost of fuel, the use of these diesel generators is affecting the environment as well as tourism in the area.

Gilgit-Baltistan of Pakistan is blessed with abundant renewable hydropower resources. More than 95% of Pakistan hydel potential is located in mountainous areas of Gilgit-Baltistan (Gilgit-Baltistan), Khyber Pakhtunkhwa (KPK) and Azad Jammu and Kashmir (AJK). The reconnaissance study of hydel potential for whole Gilgit-Baltistan is almost complete, and identified potential sites are still to be optimized in terms of capacity, cost and need of power for growing load centers

On November, 2015 Prime Minister Government of Pakistan announced the construction of Attabad Lake Hydropower Project (ALHPP), Accordingly Government of Gilgit-Baltistan undertook its Feasibility Study through Annual Development Programme (ADP) for Financial Year 2016-17. In the beginning Feasibility Study of ALHPP of 32.5 MW was carried out by local consultant of Gilgit-Baltistan. On July 2019, a meeting was held between Chairman WAPDA and Chief Secretary Gilgit-Baltistan. It was agreed that Feasibility Study would be again carried out by Hydro Planning Organization (HPO), WAPDA because of its expertise in the field of Hydro Power Planning. WAPDA prepared a feasibility report for the proposed project in June, 2021. The proposed Project is scheduled to be implemented by the EPC Contractor.

WAPDA hired a joint venture of Attabad Hydropower Management Consultants (AHMC) with M/s National Engineering Services Pakistan (NESPAK) as its lead firm for the Review / Validation of the Feasibility Study, Procurement of the EPC Contractor, and Contract Management & Administration of ALHPP. As a part of this Contract, review of the Environmental Impact Assessment (EIA) Study (prepared by WAPDA in 2021) was also included in the scope of work. This EIA study has been updated based on the available information at this stage of the Project as an additional scope of work. The proposed project will be implemented in EPC Contract mode therefore, Detailed Engineering Design including Basic Design will be available after the selection of EPC Contractor.

[2] *The term ALHPP in this report is referred as Proposed Project.*


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## 1.2 OBJECTIVES OF THE PROJECT

Following are the main objectives of the Project:

- The prime objective of the implementation of the Project is to develop the Power Potential, available in GB on sustainable basis by providing cheaper, renewable, environmental friendly and most needed power, keeping in view the present and future requirements of Pakistan especially rural and remote areas for the development of the country; and
- Transmit energy to Hunza and adjoining suburbs for meeting Power requirements of the region. Ensured availability of Power will reduce reliance and consumption of diesel, timber and other fuels. This will overall reduce the Greenhouse Gases (GHGs).

## 1.3 NEED FOR EIA STUDY

The proposed project is located in GB therefore, GB Environmental Protection Act 2014[3] is the core environmental law for the proposed Project. Hence for the proposed Project, the GB EPA is the concerned authority with respect to environmental approvals.

According to the Pakistan Environmental Protection Agency Review of Initial Environmental Examination and Environmental Impact Assessment Regulations 2000, the proposed project falls under category A of schedule II (Energy: Hydroelectric power generation over fifty megawatts), which requires EIA before commencement of construction.

Thus, to fulfil legal requirements, an EIA study has been conducted for the proposed Project to initiate the process of NOC/ environmental approval from the GB EPA.

## 1.4 THE PROPONENT AND CONSULTANT

The proponent of the project is Water and Power Development Authority (WAPDA), Government of Pakistan while the Consultant is Attabad Hydropower Management Consultants (AHMC). The details are given as under:

**a) Proponent Contact Address**

Office of the Project Director
Attabad Lake Hydropower Project
Aliabad, Hunza, GB
Phone: +92-042-99204981, +92-05813-920813
Email:pdalhpp@gmail.com

**b) Consultant Contact Address**

Attabad Lake Hydropower Project Management Consultants (AHMC)
37-B, Block – N, Model Town Extension, Lahore-54700
Phone: +92 42 35194885
Email: alhpp.nespak@gmail.com

[3] *Section 16 (1) of the Act states that: "No proponent of a project shall commence construction or operation unless he has filed with the Agency an initial environmental examination or environmental impact assessment, and has obtained from the Agency approval in respect thereof."*


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## 1.5 NATURE, MAGNITUDE AND LOCATION OF THE PROJECT

The proposed Project is a hydroelectric power generation having 54 MW capacity. The proposed Project comprises various components of linear and non-linear nature. The main components are: Weir (Overflow Structure) and its associate structures, Sediment Flushing Tunnel, Headrace Tunnel, Surge Tank, Penstock, Powerhouse, Switchyard and Tailrace.

The proposed Project is located at about 119 km from Gilgit city and 27 km from Aliabad town in Hunza Valley. The Powerhouse location is on the left bank of river and easily accessible from Karakoram Highway. The intake weir site is selected at current exit point of Attabad Lake which was formed in the year 2010 due to a huge natural landslide from right bank mountain.

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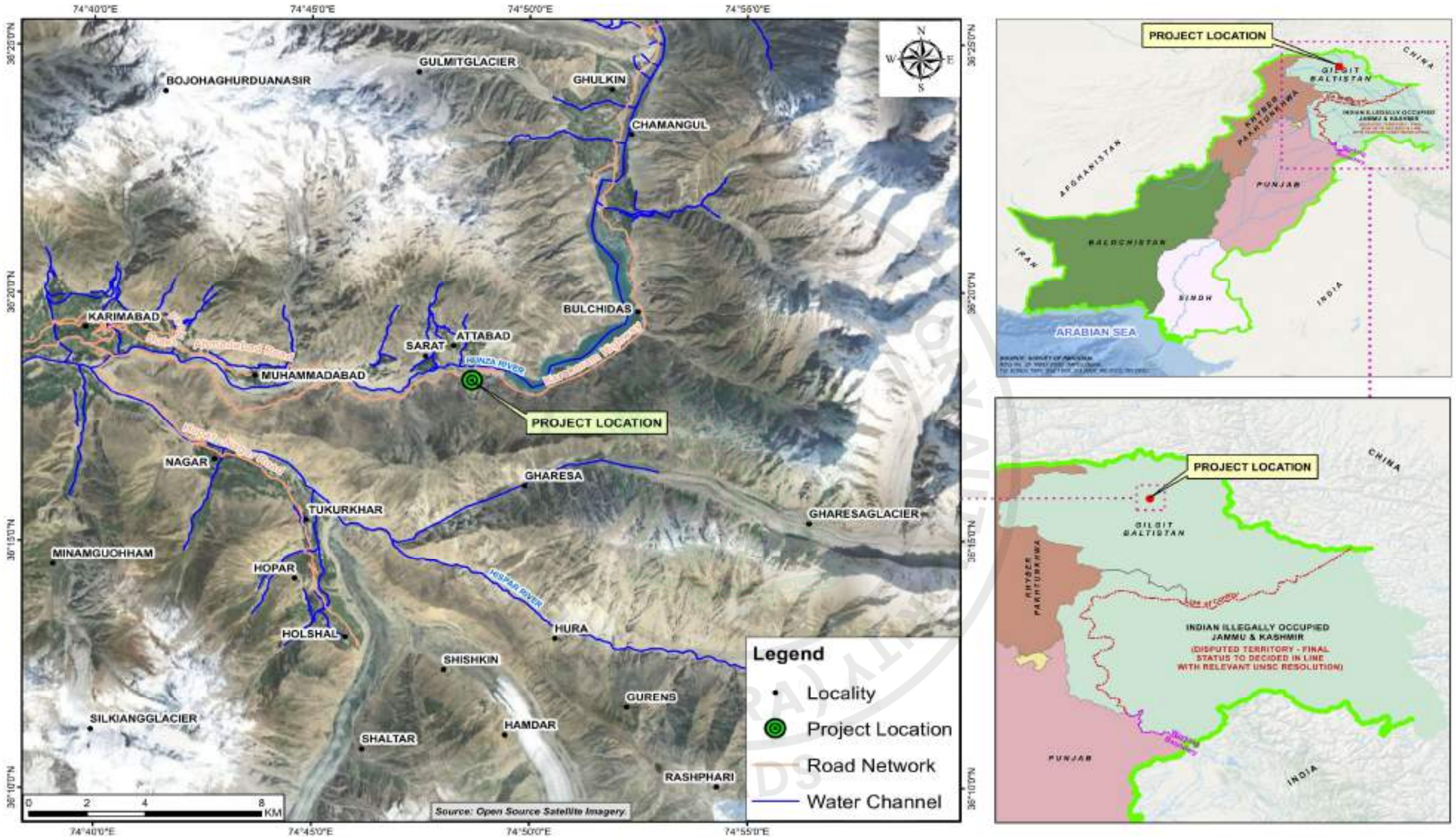


**Figure 1-1: Project Location Map**


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## 1.1 OBJECTIVE OF EIA

The prime objective of the EIA study is to fully meet the statutory requirements set forth by the GB Environmental Protection Act - 2014 and to facilitate decision making by the GB EPA regarding grant of NOC/Environmental approval for the proposed Project.

The overall objective of this EIA is to elucidate the anticipated aspects of the proposed intervention and to propose necessary mitigation measures to prevent/minimize adverse impacts on surrounding environment and community. To achieve this objective, an assessment of the existing environmental conditions of the project area is a prerequisite and therefore, included after collecting the baseline data of major environmental attributes acquired from primary and secondary sources. This EIA has been prepared to ensure adequate environmental and social management during construction and implementation stages of the proposed project. It provides mechanisms to ensure that potentially significant environmental and social impacts of the proposed project are identified, assessed and mitigated as appropriate.

More specific objectives of this EIA report are to:

- Facilitate proponents of the project in ensuring environmental and social sustainability of the project;
- Establish a baseline of existing social and environmental conditions prior to project initiation by collecting secondary and primary data/information on physical, biological and socio-economic environment of the project area;
- Identify potentially significant environmental and social impacts (both positive and negative) during all stages of the project;
- Avoid, minimize, and suggest mitigation and compensation measures for significant adverse impacts;
- Conduct, record, report and ensure public consultation, participation with major stakeholders; and
- Provide EMP for all stages of the project as a tool for the implementation of the suggested measures along with monitoring and evaluation mechanism with adequate resources including implementing agencies capacity building.

## 1.6 DELINEATION OF THE STUDY AREA/AREA OF INFLUENCE (AOI)

For an EIA Study, a clear delineation of the Study Area/ Area of Influence (AOI)[4] is required. Study Area/AOI is the area within which the potentially significant impacts of the proposed Project activities (direct or indirect) are envisaged. In this report, the Study Area/AOI is the area where the Project impacts on the environment due to the proposed Project activities are assessed. The proposed Project comprises various components of linear and non-linear nature.

Based on the available Google Earth Imagery and ARC GIS software, Project components were overlaid on the existing Project Area Imagery. Utilizing the information collected through the study of previous documents including the Feasibility Study, reconnaissance visit, consultations with the locals and concerned departments and foreseen impacts of the

[4] *Term Study Area/ Area of Influence (AOI) interchangeable in this document. Moreover, the Study Area/AOI also includes actual project area.*


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hydropower, a tentative Study Area of 10 to 20 m was delineated which was firmed up during the detailed design stage. Map of the Study Area is shown as **Figure 1.2.**

Based on the proposed Project components, geographical location and nature of the Project following is the description of the Study Area of the Project:

The catchment area of Hunza River upstream of the Project Site is about 8,900 km² which mostly consists of glaciers and snow deposits. Hunza River cuts through the Karakoram Range and flows approx. 250 km with an average slope of 0.90% from north to south before it merges into the Gilgit River. The discharge of Hunza River has its peak in months from May to September due to melting of snow/glaciers. Based on the hydrology, proposed Project activities have no potentially significant impacts on whole catchment area. Below is the description of the Study Area component wise.

a) **Weir Area:** The overflow weir is a concrete gravity type, un-gated section (60 m wide) with downstream stilling basin along with the construction of upstream and downstream coffer dams to facilitate the working of the main civil structures. The weir would be founded on overburden / slided mass with crest elevation of 2414 m.a.s.l.

b) **Sediment Flushing Tunnel: T**he sediment flushing tunnel will be constructed at the left side under Headrace Tunnel section, consisting of low level tunnel with gated arrangement. The invert level of sediment flushing tunnel section is planned at El. 2380 m.a.s.l. The sediment flushing tunnel would be founded mostly on hard rock with minor outlet length on slided mass.

c) **Headrace Tunnel:** From power intake, approximately 2,320 m long low pressure headrace tunnel (horse shoe shape), having 5.5 m diameter would run along the left bank of Hunza River leading to surge tank.

d) **Surge Tank:** A circular surge tank having 10 m diameter and 45 m high will be constructed at the intersection of the headrace tunnel and penstock.

e) **Penstock:** A Penstock of 3.6 m diameter will be laid under the left bank slopes for conveying water from headrace tunnel to Powerhouse. The penstock will cross horizontally the rock starting from the bottom of surge tank lined with an embedded steel lining.

f) **Power House:** The Powerhouse is proposed 52 m long, 25 m wide and 22.5 m high with four floors at different levels. The main hall would accommodate three vertical Francis Turbine units, each of 19.3 MW, along with three Generators, switchgear cabinets, trifurcation of penstock pipes and erection bay.

g) **Tailrace Channel:** The draft tube of each turbine unit will drain water in the 88 m long tailrace channel and it finally will be discharged into Hunza River.

h) **Switchyard:** A surface AIS 132 kV switchyard will be located near Powerhouse.

i) **Residential Colony:** A colony containing offices, residential blocks for O&M Staff including Engineers, supervisory and lower staff, rest house, mosque, basic health unit, shops and other allied services including roads, water supply / sewage disposal system and the electricity arrangement etc. will be developed near Powerhouse Site.

j) **Contractor's Camp Area:** The contractor's construction camp and construction of operation and maintenance staff building are proposed to be established near the


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Powerhouse Site. The exact location of the contractor's construction camp will be finalized by the EPC Contractor at detailed design stage.

k) **Quarry Area:** The details of the identified material sites are discussed in the Chapter 3 of this report. The final source of material will be finalized by the EPC Contractor at detailed design stage.

l) **Access Roads (Temporary and Permanent):** The project will also include the construction of both temporary and permanent access roads.

m) **Reservoir Area:** The reservoir area of the lake extends upstream to Gulkin Village. The total length of the reservoir is approximately 12 km based on 2424 m.a.s.l.

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**Figure 1-2: Study Area Map**


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## 1.2 EIA TEAM

A multidisciplinary team was formulated to conduct the study. The team comprises the following professionals (refer **Table 1.1**):

**Table 1-1: EIA Study Team**

| Sr. No. | Name of Expert | Designation |
|---|---|---|
| 1. | Mr. Muhammad Shariq Ahmed | Head ERSD |
| 2. | Mr. Muhammad Farooq | Biodiversity Expert |
| 3. | Ms. Uzma Iqbal | Senior Environmental Scientist |
| 4. | Mr. Hafiz Muhammad Abid Saleem | Senior Environmental Engineer |
| 5. | Mr. Shoaib Aziz | Senior Engineer |
| 6. | Mr. Kamran Ahmed | Senior Sociologist |
| 7. | Mr. Waleed Farooq | HSE Engineer |
| 8. | Mr. Muneeb Yousuf | GIS Expert |

## 1.7 APPROACH AND METHODOLOGY ADOPTED

This EIA study has been updated based on the available information as an additional scope of work. The proposed project will be implemented by the EPC Contractor including Detailed Engineering Design. Following is the approach and methodology adopted to update the EIA study.

### a) Orientation

Meetings and discussions were held among the members of the EIA and design Team. This activity was aimed at achieving a common ground of understanding of various issues related to proposed Project. Subsequent to the concept clarification and understanding, a detailed data acquisition plan was developed for the internal use of the EIA consulting team. The plan identified specific data requirements and their sources; determined time schedules and responsibilities for their collection; and indicated the logistics and facilitation needs for the execution of the data acquisition plan.

### b) Desktop Studies

After the award of the contract, the Consultants acquired various Project specific studies, relevant studies to the regions, available maps, Google Earth Imagery of the Area, published reports, previous Feasibility Study Report, 2021 etc.

After the acquisition of data, reports, maps and relevant information, Consultant relevant experts started the desktop studies. The main objective of the desktop study was to conceptualize the Project, familiarize with the project layout, design, status of the Project, identification of the issues related to the Project.


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### c) Analysis of Alternatives

It is a mandatory requirement for any EIA study to analyze each potential alternative available that could have been developed to meet the objectives and recommend the option which is environmentally and economically feasible.

In order to select the most viable route keeping in view the technical, environmental, economic and social constraints, the analysis of different alternatives was carried out for the selection of the most feasible option. Moreover, the NPO was also considered. This exercise confirmed the justification for the need of the proposed Project.

### d) Environmental and Social Baseline Information

After the selection of the most project option, based on satellite images and the delineation of Study Area/AOI, detailed environmental survey was carried out within the Study Area. Detailed investigations/surveys were carried out for environmental parameters on which any adverse or positive impacts were envisaged by the implementation of the proposed project. Prior to the start of field activities, comprehensive checklists, proformas and maps were developed covering the main parameters for physical, biological and socio-economic environment. Primary and secondary data has been compiled and analyzed to update baseline conditions in the Study Area.

### e) Stakeholder Consultations

The consultants identified project stakeholders during inception/scoping stage and held meetings and e-communication with them during the surveys to receive feedback on the expected environmental issues related to the project impacts and suggested mitigation measures. Meetings were carried out with the project affectees, relevant departments to discuss the issues/constraints and get their views and feedback to mitigate the potential environmental impacts associated with the implementation and operation of the proposed project.

### f) Anticipated Impacts Assessment and Mitigation Measures

A logical and systematic approach was adopted for impact identification and assessment. The process began during the screening and continued through scoping which identified the key issues and classified them into different categories. The tools, which were used for impact assessment, are:

- Checklists;
- Matrices; and
- Overlays.

Identification of potential environmental and social impacts in terms of their nature, magnitude, extent, location, timing and duration were carried out. The impacts were correlated to the project location, design stage, construction as well as operation stage. Based on the impacts prediction methods and as a result of public/stakeholder consultations, NESPAK screened the adverse environmental impacts for inclusion in the mitigation measures and environmental management plan. The same process was followed for the identification of social impacts. Public consultations (which provided feedback of the impacts from the stakeholder's viewpoint) were used to screen out the insignificant impacts. Matrices and overlays were used for the evaluation of temporal and spatial impacts respectively.


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The Consultants proposed practicable, economically feasible and socially acceptable mitigation measures for the significant adverse environmental and social impacts. These measures were based on exploring the ways to achieve the project objectives causing least disturbance to the existing environment by alternative ways, proposing changes in the project design, through improved monitoring and management practices.

**g) Environmental Management Plan**

An EMP has been prepared to ensure the adequacy and effectiveness of the proposed protocol by clearly identifying the roles and responsibilities of the agencies responsible for implementation, monitoring and auditing of EMP activities, existing and suggested framework, necessary approvals, training needs and the required further studies. The EMP also includes organizational setup, a monitoring mechanism, monitoring plan, environmental and social parameters to be monitored with their frequency. Similarly, costs for environmental monitoring, ecological and social component/social mitigation measures were also included as part of the EMP. Environmental monitoring, evaluation, auditing and reporting mechanism were also proposed in the EMP.

## 1.8 ORGANIZATION OF REPORT

This report contains ten (10) chapters. The contents of chapters are described as follows:

- **Chapter 1**– "Introduction" describes introduction, location of project, objective and purpose of the EIA report, approach and methodology;
- **Chapter 2** – "Legislative Requirements and Framework" elucidates the current legal framework including national, local laws, policies, guidelines which is applicable to the proposed project in the context of environment and sustainable development;
- **Chapter 3** – "Project Description" furnishes an overall description of the project, including its features and key components, construction planning, timeframe and cost etc.
- **Chapter 4** – "Analysis of Alternatives" presents the Analysis of Alternatives such as No Project Option, Project Layout, Headrace, Penstock and Powerhouse Location;
- **Chapter 5** – "Description of the Environment" comprises a detailed narrative of the existing (baseline) conditions of the project area, with respect to its physical, biological and socio-economic environment;
- **Chapter 6** – "Stakeholder Consultation" provides summary of consultative sessions with the local community as well as with other stakeholders including local politicians, local government officials for their opinions and suggestions on the project;
- **Chapter 7** – "Anticipated Environmental Impacts & Mitigation Measures" elaborates the likely impacts of the project on the physical, biological and socio-economic environment during the pre-construction, construction and operation stages and lays down the proposed measures to mitigate the adverse impacts of the project;
- **Chapter 8 –** "Grievance Redress Mechanism" provides the mechanism to address the complaint of workers and locals;
- **Chapter 9** – "Environmental Management Plan" provides the mechanism to be adopted for the implementation of measures and monitoring the environment during all stages; and


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- **Chapter 10** – “Conclusion and Recommendations” gives the conclusion of the impact assessment study and recommendations for the construction and operational stages.

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# 2 POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORKS

## 2.1 GENERAL

This chapter provides an overview of the policy framework and legislation that applies to control the environmental consequences as a result of proposed Project implementation and operation. The proposed Project needs to comply with all the applicable environmental policies, laws, guidelines, acts and legislations of Government of Pakistan (GoP) and the Government of GB.

## 2.2 SUMMARY OF RELEVANT STRATEGIES, POLICIES, ACTS AND LEGISLATION

The summary of major relevant strategies, policies, acts and legislation from environmental perspective are briefly described in **Tables 2.1 & 2.2** below:

**Table 2-1: Main Strategies/Policies Related to Environment and Relevance to the Project**

| Sr. No. | Policy/Strategy | Brief Coverage | Relevance to Project |
|---|---|---|---|
| 1. | National Conservation Strategy, 1992 | Pakistan National Conservation Strategy (NCS), which was approved by the federal cabinet in March 1992, is the principal policy document on environmental issues in the Country. The NCS outlines the Country's primary approach towards encouraging sustainable development, conserving natural resources and improving efficiency in the use and management of resources. The NCS has 68 specific programs in 14 core areas in which policy intervention is considered crucial for the preservation of Pakistan's natural and physical environment. | The core areas that are relevant in the context of the proposed Project are pollution prevention during construction and conserving biodiversity and forestry. |
| 2. | National Environmental Policy, 2005 | In March 2005, GoP launched its National Environmental Policy, which provides a framework for addressing the environmental issues. Section 5 of the policy commits for integration of environment into development planning as instrument for achieving the objectives of National Environmental Policy. It also provides broad guidelines to the Federal Government, Provincial Governments, Federally Administered Territories and Local Governments to address their environmental concerns and to ensure effective management of their environmental resources. | Clause (b) of sub-section 5.1 states that EIA related provisions in Environmental Protection Act, 1997, will be diligently enforced for all developmental projects. |
| 3. | National Forest Policy, 2015 | The goal of this policy is to foster the sustainable development of Renewable Natural Resources (RNR) in Pakistan, through maintenance and rehabilitation of these essential resources and enhancement of sustainable livelihoods | Proposed project involves tree cutting so the relevant clauses of preservation of the policy will be applicable, however, no |


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| Sr. No. | Policy/Strategy | Brief Coverage | Relevance to Project |
|---|---|---|---|
| | | of rural masses, particularly women, children and other deserving groups.<br>The various components of the policy include:<br>• Reducing poverty, powerlessness and unemployment;<br>• Population planning in critical ecosystems;<br>• Reducing the impact of socio-economic factors;<br>• Providing substitutes to firewood in the mountain-woods;<br>• Reducing political interferences in Forestry and Wildlife Departments;<br>• Renovating and invigorating the institutions of RNR;<br>• Supporting Local Governments in the sustainable development of their RNR;<br>• Policies for fragile ecosystems;<br>• Riverside forests;<br>• Irrigated plantations;<br>• Preservation of sensitive and unique forests;<br>• Wildlife conservation;<br>• Rangelands and desert ecosystems; and<br>• Planting trees and fodder on farmlands. | forest area falling within the project boundary. |
| 4. | Pakistan Labor Policy, 2010 | The main objective of the Labor Policy, 2010 is the social and economic well-being of the labor of Pakistan. The Labor Policy, 2010 has following 4 parts:<br>• Legal Framework;<br>• Advocacy: rights of workers and employers;<br>• Skill development and employment; and<br>• Manpower export. | The labor will be employed for construction of the proposed Project. The provision of policy will apply to all the labor employed during the execution of the project. |
| 5. | National Climate Change Policy, 2012 (Updated in 2021) | The National Climate Change Policy provides a framework for addressing the issues that Pakistan faces or will face in future due to the changing climate. In view of Pakistan's high vulnerability to the adverse impacts of climate change, in particular extreme events, adaptation effort is the focus of this policy document. The vulnerabilities of various sectors to climate change have been highlighted and appropriate adaptation measures spelled out.<br>The policy cover measures to address issues in various sectors such as water, | The proposed project involves the renewable energy resource development which will have positive impacts on the regional as well as global climate change issues.<br>The analysis shows that 373.69 GWh of electricity will be generated annually by this project which will displace about 149,476 ton of $CO^2$ at 0.40 kg/kWh. One ton of CO2 corresponds to CER which is currently valued about 1.5 US$. |


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| Sr. No. | Policy/Strategy | Brief Coverage | Relevance to Project |
|---|---|---|---|
| | | agriculture, forestry, coastal areas, biodiversity and other vulnerable ecosystems.<br><br>Notwithstanding the fact that Pakistan's contribution to global Greenhouse Gas (GHG) emissions is very small, its role as a responsible member of the global community in combating climate change has been highlighted by giving due importance to mitigation efforts in sectors such as energy, forestry, agriculture and livestock.<br><br>Furthermore, appropriate measures relating to disaster preparedness, capacity building, institutional strengthening; technology transfer; introduction of the climate change issue in higher education curricula; ensuring environmental compliance through IEE and EIA in the development process; addressing the issue of deforestation and illegal trade in timber; promoting Clean Development Mechanisms (CDM); and raising Pakistan's stance regarding climate change at various international forums, have also been incorporated as important components of the policy.<br><br>The policy thus provides a comprehensive framework for the development of Action Plans for national efforts on adaptation and mitigation. | Therefore, the CDM benefits worth will be 29.921 million PKR per annum. |
| 6. | National Sustainable Development Strategy, 2012 | The National Sustainable Development Strategy is an attempt to define sustainable development and the pathway to a "green economy" in Pakistan's context. It lays out an adaptive system and approach that can be continuously improved, through regular updates, to respond to evolving challenges. The focus has been on integrating not only across the three overall dimensions of economic, social and environment but also integrating the goals with the existing development paradigm with the aim of shifting it on to a more sustainable pathway. | This strategy is applicable as the project involves the construction of hydroelectric power to improve the power availability with least environmental burden. |
| 7. | National Electricity Policy, 2021 | The Ministry of Water and Power of the Government of Pakistan has developed an ambitious power policy to support the current and future energy needs of the country. This bold strategy will set Pakistan on a trajectory of rapid economic growth and social | The proposed project is a renewable energy production facility, and it will reduce the gaps between energy availability and demand. |


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| Sr. No. | Policy/Strategy | Brief Coverage | Relevance to Project |
|---|---|---|---|
| | | development. Simultaneously, it will address the key challenges of the power sector in order to provide much needed relief to the citizens of Pakistan. This document will frame the broad contours of the energy policy articulating the vision for the power sector, highlighting its key challenges, setting major goals, summarizing policy principles, and highlighting the strategy devised to achieve Pakistan's aspirations | |
| 8. | National Disaster Risk Reduction Policy, 2013 | National Disaster Management Authority (NDMA), being the lead focal agency for disaster preparedness and management, has therefore, embarked upon formulation of a comprehensive National Disaster Risk Reduction Policy through wider consultations with all stakeholders including all provinces, state of AJ&K and regions. This policy covers disasters risk reduction in a more holistic way and introduces a proactive and anticipatory approach by laying special emphasis on risk assessment and prevention. | This policy will be elicited if any unforeseen natural and manmade disaster occurs during construction and operation phase. |
| 9. | National Action Plan for COVID-19 Pakistan | GoP has launched the National Action Plan for COVID-19 Pakistan to combat the challenge of prevailing virus, also available at https://www.nih.org.pk/wp-content/uploads/2020/03/COVID-19-NAP-V2-13-March-2020.pdf. The GoP has launched the real-time data portal for COVID-19 http://covid.gov.pk/. These measures are mostly relating to the containment and awareness and capacity building. Besides this COVID-19 daily situation report is also available at https://www.nih.org.pk/wp-content/uploads/2020/04/COVID-19-Daily-Updated-SitRep-03-April-2020.pdf. | This Action Plan for COVID-19 is applicable to the proposed project as it is being launched during this pandemic. |

**Table 2-2: Main Legislation/Acts Related to Environment and Their Relevance to the Project**

| Sr. No. | Act | Brief Coverage | Relevance to Project |
|---|---|---|---|
| 1. | Gilgit - Baltistan Environmental Protection Act, 2014 | The GB Environmental Protection Act 2014 was enacted by Govt. of GB on May 06, 2016. The act has Eleven (11) Parts out of which part VI is related to environmental examination and assessments. This act is applicable to almost all environmental parameters such as air, water, soil, and noise | The provision of the act is applicable to proposed Project for conducting an EIA according to section 16 and to obtain environmental approval/NOC from the GB EPA. The proposed Project will also ensure the |


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| Sr. No. | Act | Brief Coverage | Relevance to Project |
|---|---|---|---|
| | | pollution, as well as to the handling of hazardous wastes. The Act provides the framework for protection and conservation of species, wildlife habitats and biodiversity, conservation of renewable resources, establishment of standards for the quality of the ambient air, water and land, establishment of Environmental Tribunals, appointment of Environmental Magistrates, IEE and EIA approval. Penalties have been prescribed for those contravene the Act. The key features of the Act have a direct bearing on the requirement for an Initial Environmental Examination and Environmental Impact Assessment for development projects. | compliance with all other relevant sections of this Act. |
| 2. | Pakistan Environmental Protection Agency Review of Initial Environmental Examination and Environmental Impact Assessment Regulations, 2000 | These regulations set out:<br>• Key policy and procedural requirements for filing an EIA;<br>• The purpose of environmental assessment;<br>• The goals of sustainable development;<br>• The requirement that environmental assessment be integrated with feasibility studies;<br>• The jurisdiction of the Provincial EPA and Planning & Development (P&D) Departments;<br>• The responsibilities of proponents;<br>• Duties of responsible authorities;<br>• Provides schedules of proposals that the project requires either IEE or an EIA;<br>• The environmental screening process of the projects under schedule I, II and III; and<br>• The procedure for the environmental approval for filing the case with the concerned EPA for the granting of the NOC. | The provisions of these regulations are applicable for environmental screening of the project, which implies that an EIA is required for the proposed project. After submission of EIA to GB EPA, the process for environmental approval/NOC will be initiated. |
| 3. | National Environmental Quality Standards, 2000 | The National Environmental Quality Standards (NEQS) were first promulgated in 1993 and have been amended in 1995 and 2000 which includes standards for liquid effluent, industrial gaseous emissions, ambient air, drinking water quality, noise levels and standards for motor vehicle exhaust, diesel vehicle, and petrol vehicles. | All projects to be implemented in GB must comply with NEQS during all the phases i.e. construction and operation. |


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| Sr. No. | Act | Brief Coverage | Relevance to Project |
|---|---|---|---|
| 4. | Guidelines for Environmental Assessment | EPA has published a set of environmental guidelines for conducting environmental assessments and the environmental management of different types of development Projects. The guidelines that are relevant to the proposed project are listed below.<br>• Guidelines for the Preparation and Review of Environmental Reports, Pakistan Environmental Protection Agency, 1997;<br>• Guidelines for Sensitive and Critical Areas, 1997;<br>• Guidelines for Public Consultation, Pakistan Environmental Protection Agency, May, 1997; and<br>• Sectoral Guidelines: Pakistan Environmental Assessment Procedures, Pakistan Environmental Protection Agency, October 1997. | These guidelines are applicable to the proposed project and have been considered during the preparation of the EIA. |
| 5. | Forest Act, 1927 | The Act reserve the areas having forest cover, or significant wildlife, to regulate movement and transit of forest produce, and duty leviable on timber and other forest produce. It also defines the procedure to be followed for declaring an area to be a Reserved Forest, a Protected Forest or a Village Forest. | Proposed project involves tree cutting so the relevant clauses of preservation of this act will be applicable, however, no forest area falling within the project boundary. |
| 6. | Northern Areas Wildlife Preservation Act, 1975 | This Act provides for the establishment of national parks, wildlife reserves and wildlife sanctuaries and the issuing of hunting licenses and certificates of lawful possession. It regulates hunting, prohibits the use of in humane methods and imposes certain other limitations, such as time of day, season and area in which hunting is permitted. The First Schedule to the Act contains a list of animals divided according to the categories of “small game” and “big game”. | All activities at the Project site will be carried out keeping in view the provisions of this act. Moreover, there is no notified protected site in and near the project area. |
| 7. | Northern Areas Fisheries Act, 1975 | This act is related to the fisheries in the GB. The act mainly describes the prohibition of destruction of fish by explosive and destruction of fish by poisoning water. The act also describes the fish size not to be kill and capture specified in the second column of the First Schedule. Moreover, the action also | The Act is directly applicable to the proposed project since it is planned on a potential fish habitat. |


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| Sr. No. | Act | Brief Coverage | Relevance to Project |
|---|---|---|---|
| | | describes the separate penalties for the violation of section 4, 5 or 9 and section 6, 7, 8 or 10. | |
| 8. | Land Acquisition Act (LAA), 1894 Including Later Amendments | The Land Acquisition Act, 1894, is a "law for the acquisition of land needed for public purposes and for companies and for determining the amount of compensation to be paid on account of such acquisition". The exercise of the power of acquisition has been limited to public purposes. The principles laid down for the determination of compensation, as clarified by judicial pronouncements made from time to time, reflect the anxiety of the lawgiver to compensate those who have been deprived of property, adequately. The land needed for the construction of development projects will be acquired under normal conditions based on prevailing market prices or negotiated prices between client and the owners of land. Section 17(4) of the LAA will not be used in the absence of an emergency. Instead, the land will be purchased under willing-seller willing-buyer deal at agreed upon market rates and the seller will have the option not to sell the land, in case an acceptable deal for both the parties is not reached. | This act is applicable as the proposed project involves the permanent acquisition of land. |
| 9. | Factories Act, 1934 | The Factories Act provides regulations for health, safety and welfare of workers, disposal of solid wastes and effluents, and damage to private and public property, handling and disposal of toxic and hazardous materials. | This act will be applicable during the construction phase of the proposed Project. The EPC Contractor will respect the provision of this act during the execution of the proposed Project. |
| 10. | Pakistan Antiquities Act, 1975 | The Antiquities Act, 1975 (amended in 1990) states the following:<br>• "Ancient" is any object that is at least 75 years old;<br>• All accidental discoveries of artefacts must be reported to the Federal Department of Archaeology;<br>• The Government is the owner of all buried antiquities discovered on any site, whether protected or otherwise; | No notified archaeological site has been identified within the proposed Study Area. However, the law will be applicable to the project mainly due to its two provisions:<br>▪ According to the law, any construction activity within 61 m or 200 ft. of protected antiquities, are prohibited.<br>▪ The provisions of this act would also be applicable, if any accidental archaeological discoveries may occur during the |


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| Sr. No. | Act | Brief Coverage | Relevance to Project |
|---|---|---|---|
| | | • All new construction within a distance of 200 feet from protected antiquities is forbidden;<br>• No changes or repairs can be made to a protected monument, even if it is owned privately, without approval of the responsible authorities; and<br>• The cultural heritage laws of Pakistan are uniformly applicable to all categories of sites regardless of their state of preservation and classification as monuments of national or world heritage. | excavation works for the construction of proposed Project. |
| 11. | Explosives Act, 1884 | It provides regulations for handling, transportation and use of explosives. | Under the Explosives Act, the EPC Contractor is bound by regulations on handling, transportation and using explosives during quarrying, blasting and other purposes. |
| 12. | The Protection against Harassment of Women at the Workplace (Amendment) Act, 2022 | The Protection Against Harassment of Women at the Workplace Act refers to sexual harassment at the workplace. | This Act will be applicable to the project if women are employed for the construction of the proposed Project. |
| 13. | Employment of Children Act, 1991 | Article 11(3) of the Constitution of Pakistan prohibits employment of children below the age of 14 years in any construction, or any other hazardous employment.<br>In accordance with this Article, the Employment of Child Act 1991 prohibits child labor (a child is under 14 years old). | The relevance of this act to the project will be to prohibit child employment for construction of the proposed project. |
| 14. | National Disaster Management Act, 2010 | National Disaster Management Act, 2010 was passed by Parliament of Pakistan in 2010. The Act applies to whole Pakistan. The Act was passed in backdrop of 2010 Floods in Pakistan and strengthens Disaster Management system. | For the proposed Project, GB Disaster Management Authority (GBDMA) is responsible. The EPC Contractor will follow the guidelines of updated Contingency Plan prepared by the GBDMA. |
| 15. | Hazardous Substances Rules, 2003 | The rule describes the procedure of handling, transportation and disposal of hazardous substances and hazardous waste. General safety precautions for handling hazardous substances as well as safety precautions for workers, and notification requirements in the event of | This rule is applicable to the proposed Project due to involvement of hazardous waste handling, use and disposal during different construction activities at the construction stage. |


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| Sr. No. | Act | Brief Coverage | Relevance to Project |
|---|---|---|---|
| | | an accident are also described in these rules. | |
| 16. | Building Code of Pakistan, 2007 | The provision of BCP shall apply for engineering design of building like structure and related components. The construction in violation of the Building code shall be deemed as violation of professional engineering work. Moreover, a certificate for the proposed action will be obtained from concerned Control Authority. | These codes shall be used in structural design of building area components constructed under this proposed project. |

## 2.3 COMPLIANCE PROCEDURE FOR OBTAINING NOC FROM GB EPA

Review of IEE and EIA Regulations, 2000 provide the necessary details on the preparation, submission, and review of the IEE and the EIA reports. Categorization of projects for IEE and EIA is one of the main components of these regulations. Projects have been classified on the basis of expected degree of adverse environmental impact.

The proposed project falls under Schedule II (category A Energy: Hydroelectric power generation over fifty megawatts), which requires an EIA to initiate the process of NOC from GB EPA.

The regulations stipulate that within ten working days of the IEE or EIA study having been submitted, GB EPA will confirm that the document submitted is complete for the purpose of review. During this time, should the agency require the proponent to submit additional information, it will return the IEE or EIA to the proponent for revision, clearly listing those aspects that need further discussion. Subsequently, GB EPA would make every effort to complete an IEE review within forty-five days and an EIA review within ninety days of filing (refer **Figure 2.1**).

The prescribed procedure for review of EIA by the GB EPA is described in Review of IEE and EIA Regulations, 2000. The agency will communicate its approval or otherwise within a period of two months from the date that the initial environmental examination is filed, and within a period of four months from the date that the EIA is filed complete in all respects in accordance with the regulations, failing which the initial environmental examination or, as the case may be, the EIA shall be deemed to have been approved, to the extent to which it does not contravene the provisions of this Act and the rules and regulations

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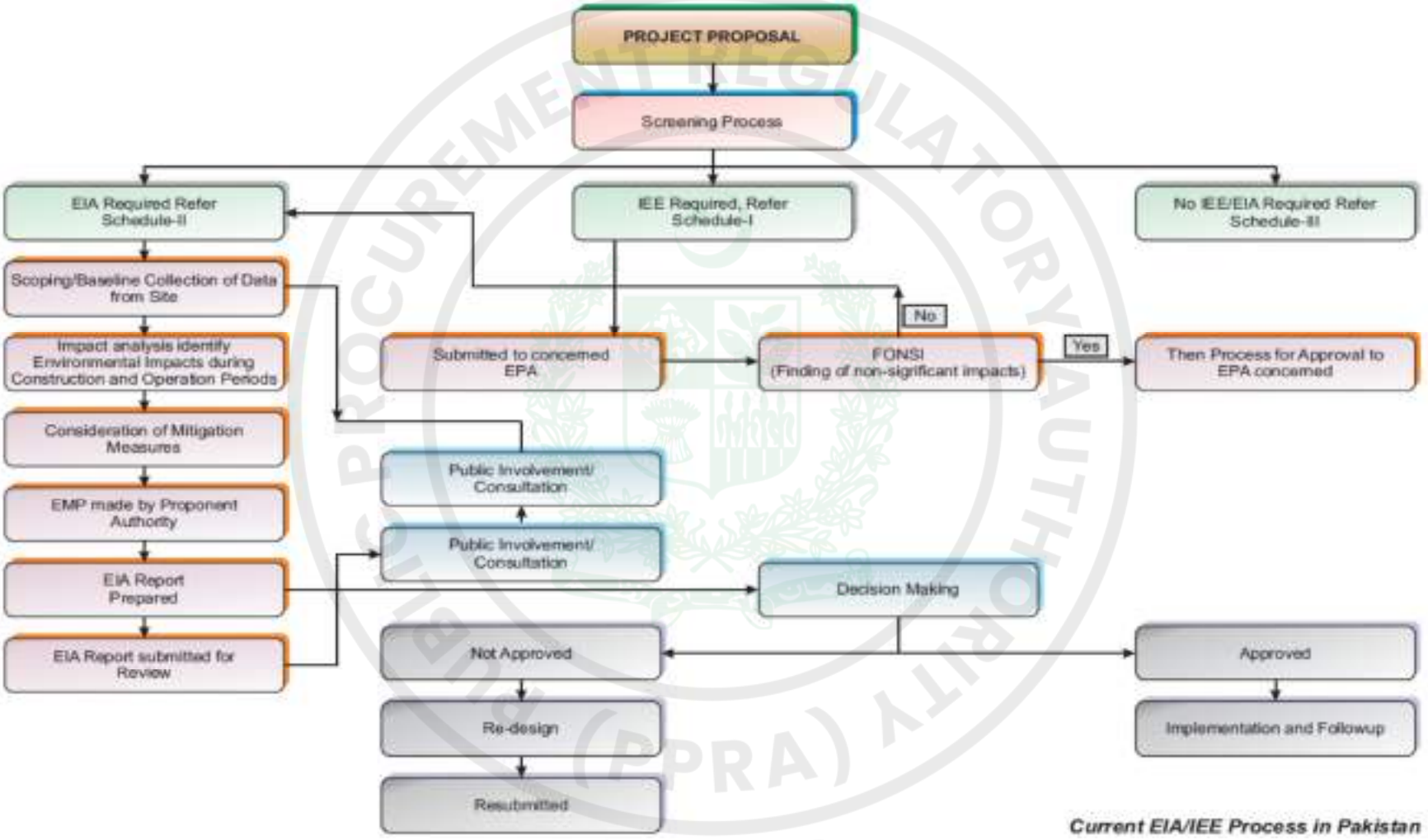


**Figure 2-1: EIA and IEE Procedure in Pakistan**



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## 2.4 INTERNATIONAL PROTOCOL/CONVENTIONS

As Pakistan is a member of a number of international organizations such as United Nations Organization (UNO), Organization of the Islamic Cooperation (OIC), South Asian Association for Regional Cooperation (SAARC), Economic Cooperation Organization (ECO) etc., so it has to follow the international protocols and obligations related to the environment. The major protocols, ratification dates by Pakistan and obligations related to the proposed project are provided in the **Table 2.3**.

**Table 2-3: International Agreements/Conventions Relevant to the Project**

| Sr. No. | Agreement/Convention | Ratification | Description/Relevance |
|---|---|---|---|
| 1 | Convention on Biological Diversity, 1994<br>**Web Link:** https://www.cbd.int/ | Signed in 1992 and ratified in 1994. | The Convention on Biological Diversity (CBD) has three main goals: conservation of biological diversity (or biodiversity); sustainable use of its components; and fair and equitable sharing of benefits arising from genetic resources.<br><br>This is applicable to the Project for conservation of biological diversity during the Project life. |
| 2 | The Rio Declaration, 1992<br>**Web Link:** http://www.unep.org/documents.multilingual/default.asp? documented =78 &articled = 1163 | Signed on 13th June 1992, and ratified on 1st June 1994 | The Rio Declaration comprises 27 principles which address important issues such as; sustainable development to integrate environmental protection into the development process; common but differentiated responsibilities to conserve, protect and restore the earth's ecosystems; public participation and information access at the national level, reduce and eliminate unsustainable patterns of production and consumption.<br><br>The provision of the declaration is applicable for environmental protection during the Project life. |
| 3 | Kyoto Protocol, 1992<br>**Web Link:** http://unfccc.int/kyoto_protocol/items/ 2830.php | Ratified in 2005 | The Kyoto Protocol is a protocol to reduce greenhouse gasses that cause climate change. It was agreed on 11th December, 1997 at the 3rd Conference of the countries to the treaty when they met in Kyoto, and entered into force on 16th February, 2005. As of November 2007, 175 countries have ratified the protocol.<br><br>One hundred and thirty seven (137) developing countries have ratified the protocol, including Brazil, China, India |


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| Sr. No. | Agreement/Convention | Ratification | Description/Relevance |
|---|---|---|---|
| | | | and Pakistan but have no obligation beyond monitoring and reporting emissions.<br><br>The protocol is applicable to reduce the emissions from Project construction activities. |
| **4** | The Basel Convention, 1989<br><br>**Web Link**: http://www.basel.int/theconvention / overview/tabid/1271/default.aspx | Ratified 26th July 1994 | Basel Convention on the control of trans-boundary movements of hazardous wastes and their disposal is an international treaty that was designed to reduce the movements of hazardous waste between nations, and specifically to prevent transfer of hazardous waste from developed to Less Developed Countries (LDCs). It does not, however, address the movement of radioactive waste. The Convention is also intended to minimize the amount and toxicity of wastes generated, for environmentally sound management as closely as possible to the source of generation, and to assist LDCs in environmentally sound management of the hazardous and other wastes they generate.<br><br>The provisions of this convention implies to minimize the amount of waste generated and its management during construction and O&M phases. |
| **5** | Convention on the International Trade of Endangered Species (CITES), 1975<br><br>**Web Link:** https://www.cites.org/ | Pakistan signed the Convention in 1973 and ratified it in April 1976. | The convention entered in to force on 1st July 1975. The principal obligations of contracting parties to the CITES are to safeguard the trade in rare or endangered species and it established a permit system to control imports and exports of wild fauna and flora. According to this convention species threatened with extinction whose movement between countries is prohibited except for conservation purposes such as captive breeding, species whose commercial trade is permitted but export permits are needed. The National Council for Conservation of Wildlife (NCCW) is the CITES Scientific and Management Authority in Pakistan.<br><br>The provision of this convention will be respected during the project |


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| Sr. No. | Agreement/Convention | Ratification | Description/Relevance |
|---|---|---|---|
| | | | implementation. |
| **6** | UNESCO Convention on the Protection of the World's Cultural and Natural Heritage, 1972<br><br>**Web Link:**<br>http://whc.unesco.org/en/ convention text/ | Pakistan ratified this convention on 23rd July 1976. | Convention concerning the Protection of the World Cultural and Natural Heritage - requires parties to adopt a general policy on the protection of the natural and cultural heritage, to set up services for such protection, to develop scientific and technical studies, to take appropriate legal, technical, scientific and administrative measures and to foster training and education for such protection.<br><br>The provision of this convention will be respected during the project implementation. However, there is no notified archaeological site within the Project Boundary. |
| **7** | The Rotterdam Convention on Chemicals, 1998<br><br>**Web Link:**<br>http://www.pic.int/ | Pakistan signed this convention on 9th September, 1999 and ratified on 14th July, 2005 | The convention promotes shared responsibilities in relation to importation of hazardous chemicals. The convention promotes open exchange of information and calls on exporters of hazardous chemicals to use proper labeling, include directions on safe handling, and inform purchasers of any unknown restrictions or bans. Signatory nations can decide whether to allow or ban the importation of chemicals listed in the treaty, and exporting countries are obliged to make sure that procedures within their jurisdiction are complied. |


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| Sr. No. | Agreement/Convention | Ratification | Description/Relevance |
|---|---|---|---|
| | | | The convention is applicable with reference to proper labeling and safe handling of hazardous chemical if used during the Project implementation. |

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# 3 PROJECT DESCRIPTION

## 3.1 GENERAL

This Chapter presents the technical details of proposed project including location, accessibility, components (such as Weir, Sediment Flushing Tunnel, Headrace Tunnel, Surge Tank, penstock, Powerhouse, Tailrace, Switchyard etc.), construction aspects, implementation schedule and project cost etc.

## 3.2 OBJECTIVES OF THE PROJECT

Following are the main objectives of the Project:

- The prime objective of the proposed Project is to develop the Power Potential, available in Attabad Lake on sustainable basis by providing cheaper, renewable, Environmental friendly and most needed power, keeping in view the present and future requirements of Region especially rural and remote areas;
- Transmit energy to Hunza Valley and its suburbs for meeting power and energy requirements; and
- Ensured availability of power will reduce reliance and consumption of diesel, timber and other fuels. This will overall reduce the Greenhouse Gases (GHGs) as cutting of trees will be reduced.

## 3.3 PROJECT LOCATION

ALHPP has been identified on Hunza River on Attabad Lake. Attabad Lake was formed on January 04, 2010, when a huge mass from the right bank of Hunza River slided down near Attabad Village and blocked Hunza River. The inflow filled upstream valley created a reservoir 22 km long till the end of May 2010.

The proposed Project is located at Hunza River/ Attabad Lake situated in Hunza-Nagar District, GB. The proposed project Site is located about 119 km from Gilgit Town and 27 km from Aliabad town in Hunza Valley. Project Location Map is shown in **Figure 1.1**.

## 3.4 PROJECT ACCESSIBILITY

The proposed Project site is accessible through Motorway from Islamabad to Thakot (M-15) and afterwards by Karakorum Highway (KKH) from Thakot to Project Area. Power house site is located on the left bank of Hunza River near Salmanabad Village. Access to the Project Site, along the Attabad Lake is quite convenient with steep slopes and moderate bends. No problems are expected to occur during the transportation of heavy construction and permanent equipment for the Project as well as the heavy construction materials. However, the road towards Power House Site needs improvement and widening of the track to cater for the transportation of the heavy construction material and machinery. The accessibility map of the proposed Project is shown in **Figure 3.1**.

## 3.5 CATCHMENT AREA

The catchment area of Hunza River upstream of the Project Site is about 8,900 km² which mostly consists of glaciers and snow deposits accumulated in the mountainous region usually during winter. Hunza River cuts through the Karakoram Range and flows approx. 250 km with an average slope of 0.90% from north to south before it merges into the Gilgit River. Many large size glaciers like Batura, Passu, Ghulkin, Gulmit, Bliglong, Minapin, Hasanabad and Muchlobel Glaciers drain in Hunza River. The water from main streams including Chaprot,


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Hasanabad and Molma Nullahs from large as well as small valleys also drains into the Hunza River. The discharge of Hunza River has its peak in months from May to September due to melting of snow/glaciers due to rise in temperature.

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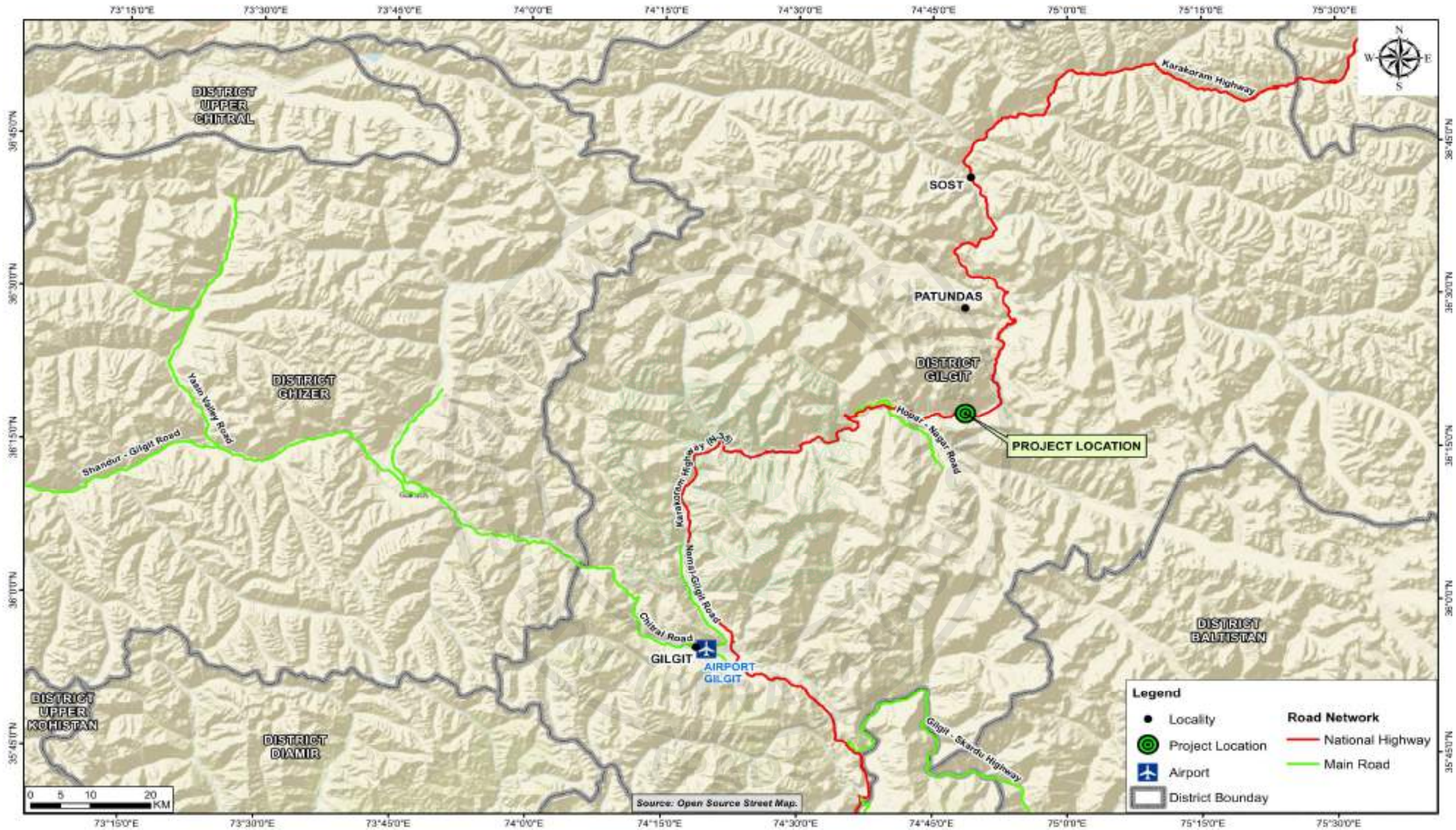


**Figure 3-1: Site Accessibility Map**


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## 3.6 PROJECT COMPONENTS

Following are the main components of the proposed Project and the salient features are provided in **Table 3.1**:

- Weir and its associate structures;
- Sediment Flushing Tunnel;
- Headrace Tunnel;
- Surge Tank;
- Penstock;
- Powerhouse;
- Tailrace; and
- Switchyard.

**Table 3-1: Salient Features of the Proposed Project**

| Sr. No. | Items | Description |
|---|---|---|
| 1 | Location | 27 km from Aliabad Town |
| 2 | River | Hunza River |
| 3 | Catchment Area | 8901 $km^2$ |
| 4 | River Mean Annual Flow | 209 $m^3/s$ |
| 5 | Purpose | Power Generation |
| 6 | Type of Development | High Head Run of River with Peaking |
| 7 | Type of Weir | Overflow |
| 8 | Weir Crest Elevation | 2414 m.a.s.l |
| 9 | Weir Crest Length | 60 m |
| 10 | Weir Height | 30 m |
| 11 | Design Flood | 3250 $m^3/s$ |
| 12 | Maximum Conservation Level including free Board | 2424 m.a.s.l |
| 13 | Maximum Flood Level | 2421 m.a.s.l |
| 14 | Minimum Operating Level | 2412 m.a.s.l |
| 15 | Gross Head | 112.0 m |
| 16 | Net Head | 106.0 m |
| 17 | Installed Capacity | 54 MW |
| 18 | Headrace Tunnel Length | 2320 m |


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| Sr. No. | Items | Description |
|---|---|---|
| 19 | Headrace Tunnel Diameter | 5.5 m |
| 20 | Penstock Length | 480 m |
| 21 | Penstock Diameter | 3.6 m |
| 22 | Type of Turbine | Francis (Vertical) |
| 23 | No. of Units | 03 |
| 24 | Design Discharge | 60.00 $m^3/s$ (20 $m^3/s$ to each unit) |
| 25 | Length of Weir | 55 m |
| 26 | Length of Power tunnel | 2320 m |
| 27 | Type of Powerhouse | External |
| 28 | Annual Energy | 374 GWh |
| 29 | Plant Factor | 76.5 % |
| 30 | Tailrace Length | 88 m |
| 31 | Design Life | 30 Years |

## 3.7 PROJECT DESIGN

An overflow structure will be constructed to divert the flow of Attabad Lake at Hunza River into power intake. Before construction of overflow structure, a deep sediment flushing tunnel will be constructed this will act as a diversion tunnel during construction of overflow structure. After the construction of the proposed Project at operational stage sluice tunnel will act as sediment flushing tunnel. The diverted water enters into the head race tunnel about 2320 m long. The tunnel is followed by surge shaft. Water will enter into 480 m long penstock pipe branching into three units at the end through manifold. These high-pressure penstock pipes and feed three turbines, 19.3 MW each. The proposed Project with design discharge 60 $m^3/s$ will generate the rated power round the year. The detailed components and cross sections are shown from **Figure 3.2** to **Figure 3.6**. The brief detail of each component is provided in the following sections.

### 3.7.1 Coffer Dams

Two temporary coffer dams will be constructed for the proposed Project if required i.e., Stage-I coffer dam and Stage-II coffer dam. Stage-I coffer dam will be constructed upstream of sediment flushing tunnel with crest level at El. 2380 m.a.s.l The construction of Stage-II coffer dam at upstream of overflow weir section with crest level at El. 2422 m.a.s.l., will be initiated after the completion of works of sediment flushing tunnel. On the completion of Stage-II coffer dam, the Hunza River / Attabad Lake water will be diverted through sediment flushing tunnel. The Stage-II coffer dam is envisaged to prevent entry of water into the working area for construction of overflow structure in dry portion.


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### 3.7.2 Sediment Flushing Tunnel

The suspended sediments transported by Hunza River and entering the power intake will unavoidably result in a certain wear and tear resulting in need for overhaul and replacement of runners. For this purpose, the sediment flushing tunnel will be constructed at the left side under the Power Tunnel section, consisting of low level outlets and during construction of overflow structure will be used as diversion tunnel. The invert level of sediment flushing tunnel is planned`` at El. 2380 m.a.s.l. The sediment flushing tunnel would be founded mostly on hard rock and with minor outlet on overburden / slided mass.

### 3.7.3 Power Intake

A two bay intake structure shall be constructed on left bank of Attabad Lake upstream of main weir for passing the design discharge. The Intake level will be 22 m above the invert level of sediment flushing tunnel section to keep the area upstream of the intake sediment free. It shall be equipped with a trash rack to prevent intrusion of debris (like timber, leaves, trees etc.) into the waterways and with a hydraulically operated gate for emergency closure and for isolating the waterways for inspection and maintenance.

### 3.7.4 Overflow Structure / Spillway

The overflow structure is a concrete gravity type, un-gated section (60 m wide) with downstream stilling basin. The overflow structure would be founded on overburden / slided mass. The overflow structure crest (El. 2414 m.a.s.l) will be of ogee type which will transfer the water from Attabad Lake reservoir in a smooth decline to the downstream. A stilling basin downstream of weir will dissipate the energy by creating a hydraulic jump and shall prevent downstream erosion.

### 3.7.5 Headrace Tunnel

From power intake, approximately 2320 m long low pressure headrace tunnel (horse shoe shape), having 5.5 m diameter would run along the left bank of Hunza River leading to surge tank. The upstream level of tunnel is El. 2402 m.a.s.l whereas downstream level is El. 2385 m.a.s.l.

### 3.7.6 Surge Tank

A circular surge tank having 10 m diameter and 45 m high will be constructed at the intersection of the headrace tunnel and penstock to prevent the adverse effect of water hammer pressure or flow variation due to turbine load fluctuation on the headrace and other structures.

### 3.7.7 Penstock

A Penstock of 3.6 m diameter will be laid under the left bank slopes for conveying water from headrace tunnel to 03 Vertical Shaft Francis Turbines to be housed in Powerhouse. At the end, the penstock shall be trifurcated into penstock manifolds with reduced dia. In the first section up to 80 m, the penstock will cross horizontally the rock starting from the bottom of surge tank. This section can be considered as an extension of headrace tunnel, lined with an embedded steel lining. The second section, 400 m long will be the embedded penstock descending towards the Powerhouse.


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### 3.7.8 Powerhouse

The Powerhouse is proposed 52 m long, 25 m wide and 25 m high with four floors at different levels. Machine Hall floor would be at El. 2313 m.a.s.l and powerhouse top shall be at El.2325 m.a.s.l. The main hall would accommodate three vertical Francis units, each of 19.3 MW, along with three generators, switchgear cabinets, trifurcation of penstock pipe and erection bay.

The three generating units will be housed in the Powerhouse, with the operating floor at El. 2306.2 m.a.s.l. A large erection bay is provided to maximize the ability to work on multiple units at a time to save time. Each turbine is connected via a main inlet valve to a steel penstock.

### 3.7.9 Tailrace Channel

The draft tube of each turbine unit will drain water in the 88 m long tailrace channel and it finally will be discharged into Hunza River. The tail water level is therefore maintained to retain the minimum setting for turbines.

### 3.7.10 Switchyard

A surface AIS 132 kV switchyard will be located near Powerhouse. The civil works of the switchyard area will be started after the construction of powerhouse superstructure. The switchyard equipment will be transported to its location through access road to Powerhouse. The erection of switchyard equipment will be done using the 5 ton mobile crane. Cabling for instrumentation, monitoring and controls along with cable terminations will be completed before the start of unit testing.

### 3.7.11 Residential Colony

An area of 2.5 Acres will be required for the construction of office, residential block for O&M Staff including Engineers, supervisory and lower staff, rest house, mosque, basic health unit, shops and other allied services including roads, water supply / sewage disposal system and the electricity arrangement etc. near Powerhouse Site. The Colony once completed will be utilized for the management personnel of the Employer and Consultant till the project construction completes, to facilitate the communication and management. After the completion of the project the colony will be utilized by Operation & Maintenance (O&M) staff.

### 3.7.12 Contractor Camp

The EPC Contractor will be responsible for the construction of adequate accommodation and temporary facilities for the workforce prior to start of main works. All utilities including electricity, water supply, sewerage system and approach roads will be provided by the EPC Contractor at construction camps & offices and in residential area. The EPC Contractor will ensure that all these facilities fulfill the requirements for residential camps, site offices, yards, construction sites etc.

Camp site will be selected keeping in view the availability of adequate area for establishing camp site, including parking areas for machinery, stores and workshops, access to communication and local markets, and an appropriate distance from sensitive areas in the vicinity. Keeping in view the following criteria guidelines, the EPC Contractor has to identify the construction camp sites before start of the construction activities:

- There should be no resettlement issue for the location of the camps;


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- Camp site should be away from the residential areas and sensitive receptors;
- Selection of sites for construction camps shall be near the project area having proper access to the nearby main/link road;
- The camps must be located in a place where the drainage from and through the camps will not threaten any domestic or public water supply;
- Camp site must be adequate in size to prevent overcrowding of necessary structures;
- The camp site should consider avoiding any damage of property, vegetation, irrigation, and drinking water supply systems;
- The camp site must not be subject to periodic flooding; and
- There should not be any ecological sensitive areas e.g. wildlife sanctuaries, game reserves, national parks, forest areas, etc. near to the construction camp site.

The Contractor Camp is planned near Powerhouse Site.

### 3.7.13 Other Site Facilities

The other site facilities that will be required by the EPC Contractor for the construction of Project are described below. Most of these facilities are planned near proposed Powerhouse site, where suitable wide land is available.

- ***Materials Laboratory*** equipped with the equipment for test on soil, rock, concrete, aggregates, bricks, embankment materials and filter materials;
- ***Temporary Facilities / Buildings*** such as steelwork and carpenter's workshops, mechanical equipment repairing workshop, fabrication workshop, storage yards for storing equipment, machinery, aggregate, sand, cement, steel reinforcement, scaffolding, bricks, chemicals, explosives to be used during blasting operations and fuel tanks etc.;
- ***Temporary Roads*** connecting camp & other temporary facilities with the sites of main structures in the project area, other than the access roads;
- ***Religious Facilities*** within the camp areas for performing religious activities;
- ***Health Facilities*** including portable First Aid Station equipped to provide primary care for emergencies relating to injuries, burns, broken bones etc. Arrangements shall be made with the closest major hospital to cater for accident and hospitalization cases;
- ***Emergency Fire Protection Facilities*** in all offices and buildings to cater for any fire hazard including hose, fire extinguishers, pails and shovels etc.;
- ***Wireless Communication System*** for communication between site personnel, site offices and the working areas;
- ***Security Facilities*** including security check posts at main entrance of camp/site. All the work areas, storage areas and such other area where construction activity is proceeding shall be guarded by the security guards and watchmen for security; and
- ***Spares and Standby Equipment*** to ensure continuity and proper completion of operations, including diesel power generating sets, earthwork plant, concrete mixing and transportation plant, grouting equipment, dewatering plant and other key plant and equipment required to ensure work progress.

### 3.7.14 Detailed Engineering Design

The proposed project will be implemented in EPC Contractor mode therefore, the EPC Contractor will be responsible for the Detailed Engineering Design and will be approved by


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Project Consultants engaged for construction supervision. The EPC Contractor will design all Permanent works and all necessary Temporary works.

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**Figure 3-2: Project Component Map**

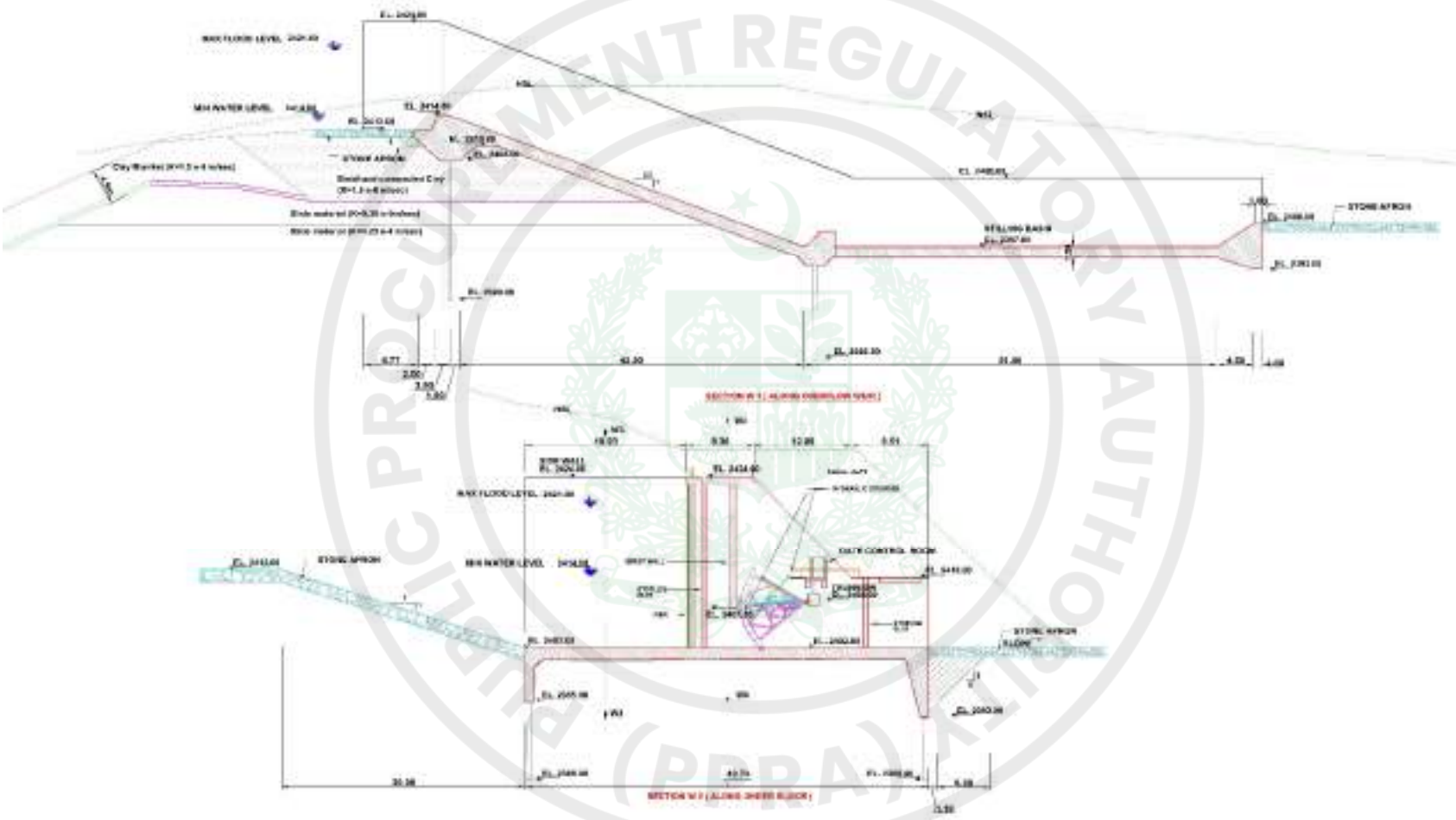

**Figure 3-3: Weir Longitudinal Section**




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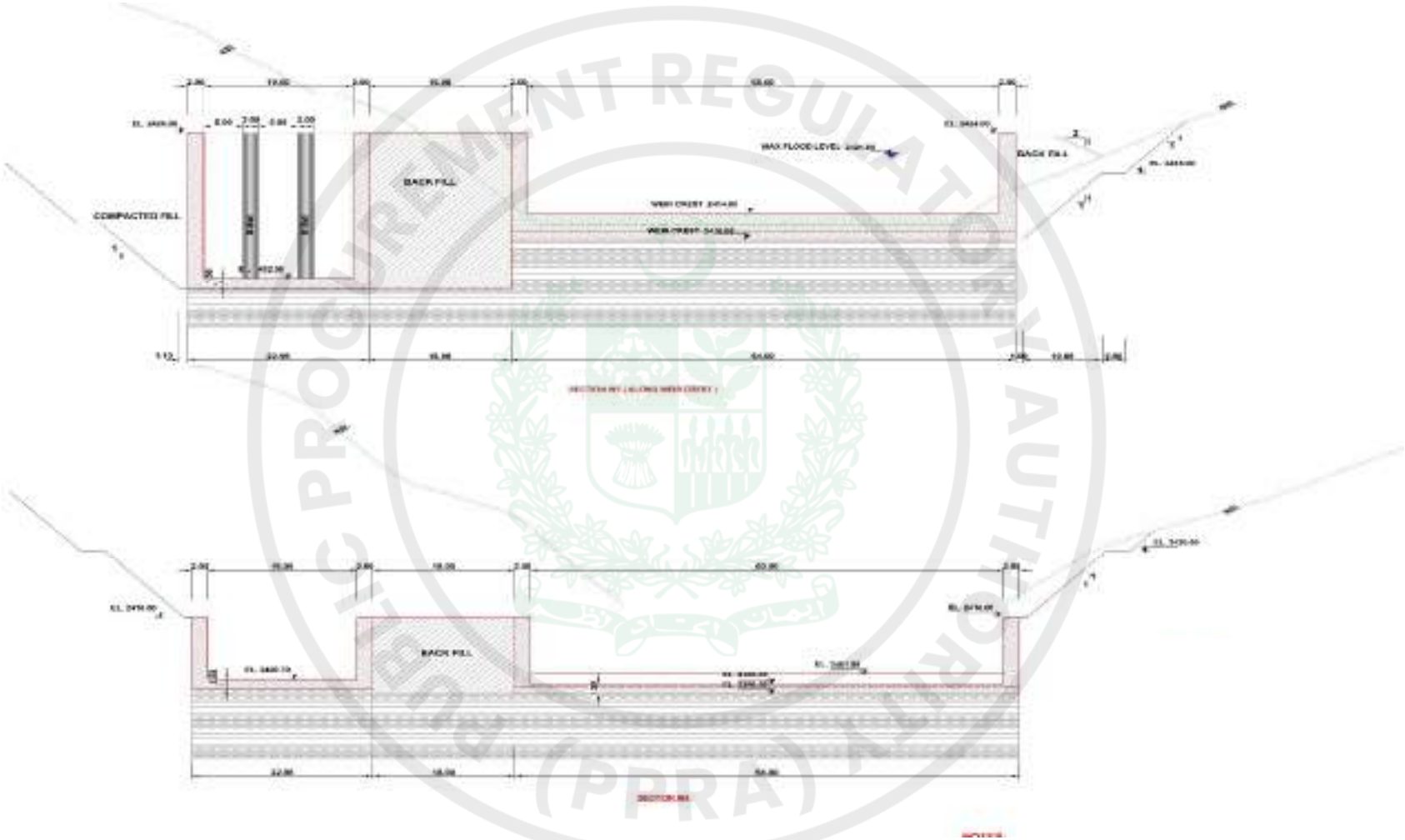


**Figure 3-4: Weir Cross Section**



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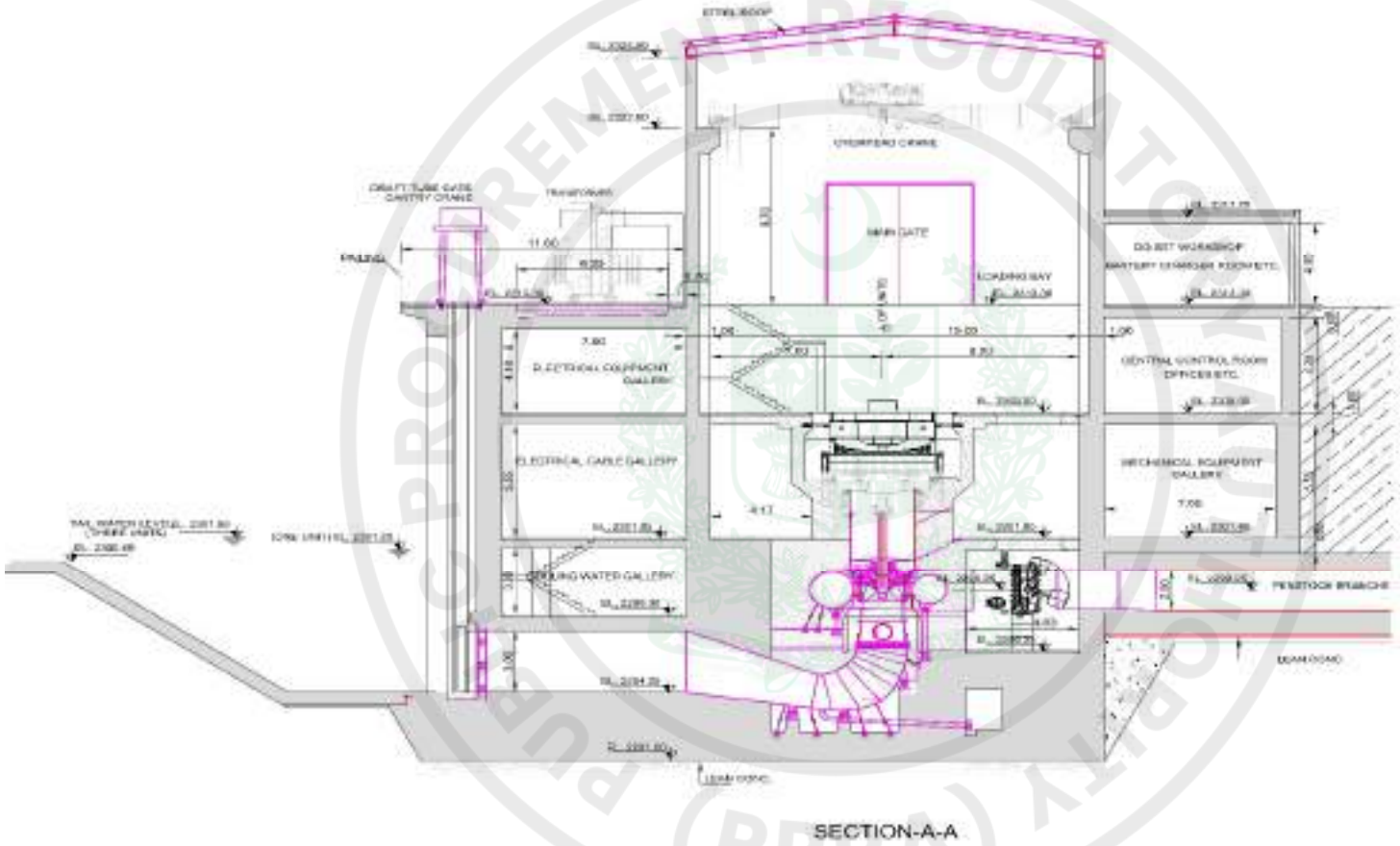


**Figure 3-5: Powerhouse Longitudinal Section**



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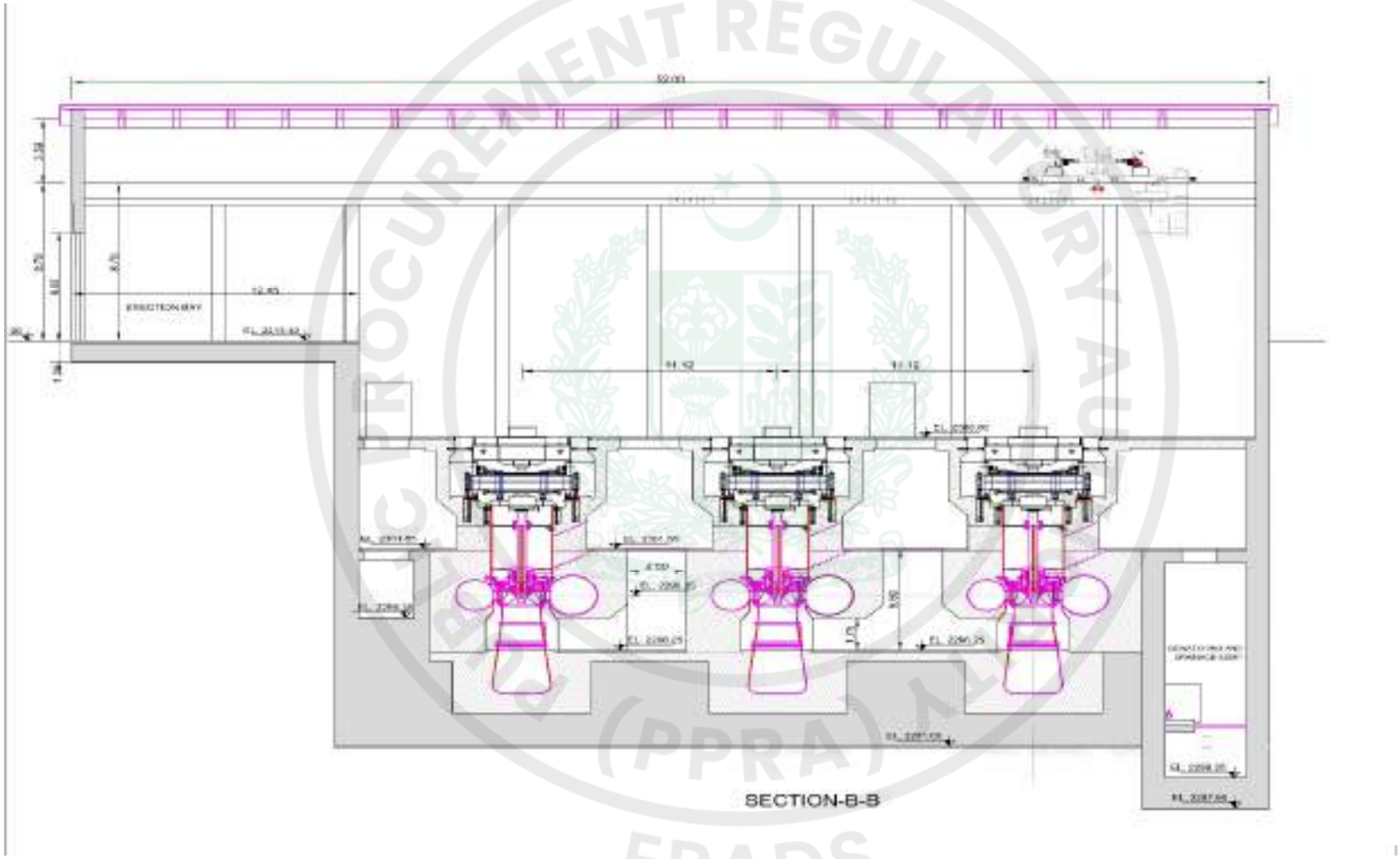


**Figure 3-6: Powerhouse Cross Section**



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## 3.8 LAND ACQUISITION

The land will be acquired for the Project components such as powerhouse, weir and associated structures, access roads and project colony. Total land to be acquired is approximately 183 acres (05 acres for Contractor's Camp, 60 acres for Project Colony and Powerhouse Area, 103 acres for Intake Area and Access Corridor and 15 acres for Spoil Area) for project components which includes both private and government land. The estimated total land to be acquired is 777.5 acres due to the impounding of reservoir up to maximum conservation level including free board, including river bed. Private land will be acquired by the Client as per Land Acquisition Act 1894 including later amendments.

The land required for the establishment of contractor camps, stores and workshops will be acquired on temporary basis by direct negotiation and agreement with the owners. Temporary acquisition will principally be the responsibility of the EPC Contractor.

## 3.9 PROJECT ADMINISTRATIVE JURISDICTION

The proposed project falls under administrative jurisdiction of Hunza Nagar District, GB.

## 3.10 CONSTRUCTION ASPECTS

### 3.10.1 Construction Materials

The materials used for construction purpose would include coarse aggregates (crush), fine aggregates (sand), steel, water, asphalt, reinforcement, cement etc. Water, stone of required quality is available in the project area. Coarse and fine aggregates for concrete can be obtained locally, subject to meeting ASTM gradation requirements. Asphalt, reinforcement and cement material will be transported from nearby factories.

The bulk of construction material can be gained by quarrying. The material balance counts for a surplus of excavated material from the weir site & associated structures, headrace Channel, powerhouse, tailrace, switchyard has to be deposited in the area or used for other construction sites. Required construction material for either cutoff wall or upstream impervious blanket shall be properly investigated by means of test pits for its required quantity and quality for detail/construction design by EPC Contractor.

### 3.10.2 Procurement of Construction Materials

#### a) Cement

It has been estimated that about 31,485 tons cement (ordinary Portland cement) would be required to meet the project construction activities. The nearest cement factories to the Project site are: Bestway Cement (Farooqia, 675 km), Askari Cement (Wah, 685 km), Fauji Cement (Fateh Jhang, 710 km), Askari Cement (Nizampur, 755 km) and Cherat Cement (Nowshera, 790).

#### b) Coarse Aggregate

The rock quarries have been identified at Passu and Powerhouse area. The marble present in Passu area and Rounded Boulder Gravel Silt (RBGM) at Powerhouse Area can be used as coarse aggregate by certain amount of processing.

#### c) Sand

High quality of large sand deposits are available in the tail end area of Attabad Lake near Shishkat Bridge for use in the proposed Project.


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**d) Reinforcing Steel**

The quantity of reinforcing steel required for the Project will be about 3,300 tons, with a monthly average consumption of about 155 tons. The nearest location from where the reinforcing steel bars of the desired specification are available is Islamabad (735 km from Project Site).

**e) Explosive Materials**

In the main weir and flushing tunnel areas, extensive volume of excavation is of slided materials having large size boulders, which may require blasting. There are certain areas, where rock excavation would also be involved like power intake, headrace tunnel and surge tank etc. The Wah - Bofors factory in Wah (near Rawalpindi) is capable of supplying all the explosives and blasting consumables required for the Project.

**f) Steel Plates and Steel Formwork**

Steel sheets of various thicknesses are produced at the Steel Mills at Karachi, which can be used to fabricate steel formwork. Alternatively, steel items can be imported from abroad. Most likely source of steel plate could be nearby countries such as China and Iran.

**g) Petroleum Products**

Petroleum products will be mainly diesel with comparatively minor quantity of gasoline and lubricants, which can be procured directly from the source i.e. the oil refineries, spread in the country, for the operation of machinery and vehicles. The storage tanks would be established at the Project site with total capacity of around 40,000 litres, sufficient for around one month of operation, to cope with extraordinary conditions like land sliding on the KKH or fuel shortages, etc.

**h) Water and Stone for Riprap and Fill Material**

The Hunza River water will be used in the making of concrete. The results of water samples taken from Hunza River indicate that water is suitable for mixing & curing of concrete. The large boulders with sufficient quantity present in the slided mass can be used as riprap material to control the erosion by water. Silty sand, sandy silt and gravelly sand available in the river bed and in slided mass (in ample quantities) can be used as fill material for the protection of slopes and construction of coffer dam etc.

### 3.10.3 Work Force

The construction of the proposed Project shall be carried out by WAPDA through EPC Contractor. Total workforce required for the proposed project including supervisory staff, skilled and unskilled labour is approximately 300-350 numbers during construction phase. The workforce will be originated from GB and different regions of Pakistan and from oversees.

### 3.10.4 Construction Activities and Required Machinery

Construction activities involve following:

- Earth work (clearing of vegetation/ trees and top soil);
- Access Road work; and
- Structure works.
- E&M Works


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The list of the machinery and the equipment required for the proposed Project is provided in **Table 3.3.**

**Table 3-2: Machinery and Equipment Requirement**

| Sr. No. | Type of Machinery/ Equipment | Sr. No. | Type of Machinery/ Equipment |
|---|---|---|---|
| 1 | Dump Truck | 12 | Self-Propelled Pneumatic Roller |
| 2 | Front End Loader | 13 | Asphalt Distributor |
| 3 | Dozer | 14 | Batching Plant |
| 4 | Grader | 15 | Concrete Transit Truck |
| 5 | Vibratory Roller | 16 | Concrete Pump |
| 6 | Water Tankers | 17 | Excavator |
| 7 | Aggregate Spreader | 18 | Water Pumps |
| 8 | Three Wheel Rollers | 19 | Cranes |
| 9 | Tandem Roller | 20 | Vibrators |
| 10 | Asphalt Plant | 21 | Generators |
| 11 | Paver | | |

### 3.10.5 Water Requirement

Water requirement during construction phase will be met from Hunza River. The water can be uplifted from the Hunza River through pumps to meet the domestic demand and requirement of project construction activities like concrete preparation and wet drilling during excavation for water carrying channel. The water consumption is estimated to be 35,000 liters /day[5] for 350 construction workers of the proposed Project.

Wastewater Generation

The wastewater generation is estimated to be 28,000 liters/day for 350 construction workers for the proposed Project[6]. The estimated wastewater generation will vary during the operational stage of the project.

### 3.10.6 Solid Waste Estimation

Due to construction activities waste will be generated at construction site and contractors camp. The EPC Contractor will provide the estimated quantity of excavation material during

[5] *Tentative Work Force Requirements Including Client and EPC Contractor Staff"*

*= (350) x (100) = 35,000 liters/day*

[6] *Design Criteria of Public Health Engineering for Water Supply, Sewerage and Storm Water Drain (Domestic sewage generation = 80% of water consumed/day*


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the construction phase. These wastes will be generated due to the construction activities and the up to the extent possible the excavated materials will be reused, where applicable, for construction purposed. Solid waste generated during construction and camp sites shall be safely disposed in demarcated waste disposal sites.

The solid waste generation is estimated to be 157.5 kg/day (as per 0.45 kg/capita/day waste generation)[7] for 350 construction workers.

### 3.10.7 Power Requirement/ Power Source

The main source of electricity/electric power during construction phase will be arranged by the EPC Contractor for construction camps and construction machinery. The main sources of energy required at the project are diesel, petrol, natural gas and electricity.

## 3.11 PROJECT IMPLEMENTATION SCHEDULE

The proposed project construction schedule spans over a period of 50 months, which include 36 months for construction activities and 14 months for pre-construction activities.

## 3.12 COST OF THE PROJECT

The estimated cost of the proposed Project is PKR 24.246 million[8].

[7] *The World Bank Report 2012 – What a Waste: A global review of solid waste management. Based on UNEP estimates for waste generation in the Asia Pacific. Average is 0.45 kg/capita/day*

*8 Source: Feasibility Report, 2021*


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# 4 PROJECT ALTERNATIVES

## 4.1 GENERAL

This Chapter presents the Analysis of Alternatives such as No Project Option, Project Layout, Headrace, Penstock and Powerhouse Location. The details provided in the following sections:

## 4.2 NO PROJECT OPTION

Electricity has become a basic need of human beings and is one of the most important ingredients of economic development. There exists a strong correlation between energy utilization and rate of economic expansion of any country. In Pakistan per capita energy consumption is very low. With the ever-increasing gap in the demand and supply in the national grid the short fall reached to an extent that an electricity crisis arises in the country which resulted in long hours of load shedding even in the main cities of the Pakistan as well as cities and towns of GB.

The Central Hunza is located on the right bank of Hunza River, extending from Murtazabad up to Attabad Village Central Hunza is the hub of tourism in Gilgit-Baltistan. National and international tourists flow remain at peak during summer season. As a result, hotel industry is booming, whereby, other small-scale businesses i.e. transport sector, cottage industry, local markets and automobile workshops are most likely to flourish in the near future. The increase in tourism industry has significantly enhanced the energy demand of the area. Furthermore, the area is having multiple business opportunities due to its location on the China Pakistan Economic Corridor (CPEC), which will result in fast growth of economic activities, thus increase in the energy demand being interlinked with each other.

The supply from the existing hydropower projects is currently not sufficient to meet the existing demand, therefore it is supplemented through standby diesel generators during peak hours, mostly in winter season. Due to abrupt surge of Shishper Glacier situated in the catchment of Hasanabad Nullah, the powerhouses on Hassanabad Nullah are under the threat of Glacier Lakes Outburst Flood (GLOF). The Govt. has limited resources to address the issue of sustainable electricity supply in the area. The private sector is reluctant to invest in Gilgit-Baltistan's energy sector, which is due to absence of a Power Policy and non-connectivity of the area with the National Grid. Therefore, it is necessary to develop projects on other water resources to facilitate central Hunza.

Presently, there is high supply and demand gap; therefore, load shedding is common in summer, while it becomes very acute in winter. The commercial and industrial demand is partly fulfilled from privately owned diesel generators. The diesel generators are mainly used by the hotels, small businesses, banks and other consumers which can afford the high running cost. Apart from the cost the use of these diesel generators is creating environmental pollution (i.e. noise and air), which is also affecting the tourism in the area.

Thermal power generation is more expensive, being dependent on the imported oil, and is less environmentally friendly due to high emission rate of Green House Gases (GHGs). The power shortfall situation is being tackled through load management by shedding and supplying the power to various areas and sectors alternatively.

Hydropower generation is very attractive for sustainable development of the country as it reduces the need for imports and can abate substantial amount of GHG emission by substituting for largely gas and oil based power generation. The no project option would


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therefore require the installation of more thermal units which will further aggravate the economy and will become a major source of environmental degradation.

Attabad Lake was formed on January 4, 2010, when a huge mass from the right bank of Hunza River slided down near Attabad Village and blocked Hunza River. The inflow filled upstream valley created a reservoir 12 km long till the end of May 2010. Attabad Lake is about 15 km upstream of Ganish Bridge and about 111 km upstream from Gilgit. Therefore, ALHHP will utilize the Attabad Lake water and head for the generation of the Hydel Electricity. Therefore, due to the implementation of Attabad Lake HPP, no major adverse impacts are anticipated.

Based on above, it is concluded that the Project of 54 MW is technically, economically and environmentally feasible. Therefore, NPO is not a feasible option.

## 4.3 PROJECT LAYOUT ALTERNATIVES

In order to optimize the location of the Project in terms of benefits and potential impacts on the environment, following project location alternatives were discussed:

### 4.3.1 Alternative-I: Project Layout on the Left Bank

The left bank has been examined in detail to propose Project Layout with power intake, 2.3 km low pressure headrace tunnel, surge tank, embedded penstock and surface powerhouse near Hunza river, 2.5 km downstream of Attabad Lake.

The main access road to Project Area from down country is KKH passes on the left bank in Project Area leading to Chinese Boarder through Khunjerab Pass. After landslide, about 7 km highways tunnel has been constructed on the left bank because about 19 km was submerged in the lake. The access to the area and for construction activities, the left bank is the suitable bank to propose the Project Layout. Since the slide did not initiate from left bank the slopes are more stable. The geological conditions favour intake, headrace tunnel and surface powerhouse. The slided area of about 500 m is to be stabilized by excavating material on the left bank.

The following observation have been made:

- An overflow structure is to be constructed to pass the 1000-year flood. The river diversion during construction is to be managed through a deep cut channel on the left bank. Later on, the same deep channel is to be used for sediment flushing by installing gates;
- For power intake, there is sound rock formation on the left bank just upstream of weir site. The access to the area can be made through adit and headrace tunnel. Steep slopes and weak geology have been observed for the headrace, penstock and powerhouse area;
- Headrace tunnel can be constructed at lower elevation of highways tunnel in same geological formation up to surge tank. The access to surge tank and headrace tunnel is available through old KKH;
- From surge tank to powerhouse area, embedded penstock can be laid down over mild slope terraces. The anchor block can be placed over rock/boulders; and
- At the proposed site, surface powerhouse can be constructed. Surface powerhouse, tailrace channel and bifurcated penstock can be placed at required elevation by excavating the alluvium.


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### 4.3.2 Alternative-II: Project Layout on the Right Bank

A Project Layout on the right bank have been studied with intake 1.6 km upstream and powerhouse 2.0 km downstream of overflow structure. A low pressure tunnel about 2.3 km length is to be constructed to utilize the available head at ALHPP.

The Project Layout on the right bank has geologically disturbed area and Attabad slide originated from the right bank and slided material fallen on the left bank. On the right bank of the River, there is excessive loose material present and it is considered susceptible to rock fall and minor slides due to its being fragmented. The accessibility to the right side is difficult and construction and operation of scheme on the right bank is technically unfeasible.

The right bank of the river is where the slide basically was initiated from, therefore, there is excessive loose material present and the mountain side is quite fragmented. Clearing the overburden to reach the rock face will not only require a lot of excavation, but also the site will remain susceptible to rock fall and minor slides due to its being fragmented. Operability of Project components on this bank will remain a challenge.

Considering the Project construction, operation and maintenance, environmental issues, stability of structures, the left bank layout has been preferred over that of the right bank and is selected for further studies.

For Feasibility Study, field investigations like topographic survey, geological mapping, borehole drilling, test pits, environmental survey, flows and sediment observations have been carried out. For the identified dam / weir and the powerhouse site on the left bank of Hunza River near Attabad, topographic survey has been carried out, which is duly connected with Survey of Pakistan (SOP) Grid. The long term flow data of Hunza at Danyor Station has been used to estimate the daily flows and flow duration curves at the weir site. All the field data helped to finalize the structure locations and sizes for a technically feasible and economical layout. Similarly, environmental and social constraints have been studied.

Considering topographic, geological and environmental conditions at the weir and upstream valley, an overflow structure at El. 2414 m.a.s.l has been proposed with normal operating pond level as 2414 m.a.s.l. The tailrace outlet of ALHPP has been planned at El. 2300 m.a.s.l.

Based on the above analysis, Project Layout on the Left Bank Option has been selected for the proposed Project.

## 4.4 HEADRACE ALTERNATIVES

Two (02) options have been studied on the left bank of Hunza River. i.e.:

- Alternative -I A Headrace Tunnel Option; and

### 4.4.1 Alternative-I A Headrace Tunnel Option

The proposed Project has been envisaged with a 14 m high weir on Hunza River identified, 4 km downstream of Attabad Lake confluence with Hunza River and the powerhouse near Batakundi Village. The Project Layout includes power intake, sand trap, headrace tunnel, surge shaft, in addition to ungated weir spillway and surface powerhouse on the right bank.

For the water ways from intake to surge shaft, two options have been considered; either headrace tunnel or pressure pipe. These two options have been studied with respect to powerhouse and preliminary cost estimates.


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The salient features with this option are as under:

| | |
|---|---|
| Overflow Height | 4.0 m |
| Normal Reservoir Level | 2414.0 m.a.s.l. |
| Minimum Operating Level | 2412.0 m.a.s.l. |
| Live Storage | 3.0 Million $m^3$ |
| Mean Annual Flow | 209.0 $m^3/s$ |
| Design Discharge | 60.0 $m^3/s$ |
| Turbine Level | 2300.0 m.a.s.l |
| Maximum Net-Gross Head | 112.0 m |
| Minimum Net-Gross Head | 108.0 m |
| Headrace Tunnel Length | 2320 m |
| Penstock Length | 480 m |
| Type of Turbine | Francis |
| Installed Capacity | 54.0 MW |
| Annual Energy Generated | 374.0 GWh |
| Plant Factor | 76.5 % |

## 4.5 PENSTOCK ALTERNATIVES

Both the embedded penstock and tunnel options are considered for the conveyance of lake water for power generation along the left bank of the Attabad Lake. On the basis of field observations, on topographic survey, geological & geotechnical investigations, the embedded penstock route passes through overburden and its construction/installation will be quite hazardous as observed during geotechnical investigation. The cost comparison of tunnel and embedded penstock has also been carried out to check the suitability of conveyance of lake water. Cost comparison also shows that power tunnel option is more appropriate in view of least cost with less operation and maintenance issues that may encounter in case of embedded penstock alternative. Necessary geological studies, mapping and geotechnical studies including topographic surveys of cross drains along tunnel route and embedded penstock have also been carried out.

## 4.6 POWERHOUSE LOCATION ALTERNATIVES

Powerhouse location is affected by factors primarily associated with availability of head, favorable geology, availability of land and accessibility besides impact of powerhouse construction on habitants in the area (locality). Issues relating to protection against land sliding and flooding have also been taken into account. Keeping the above in view, only one location has been considered for powerhouse for both the alternates.

A surface power house is being considered on the left bank of Hunza River about 300 m upstream of Sarat Bridge. The terrace is large enough space for powerhouse, switchyard, offices and/or staff residences in the close vicinity of the powerhouse. The river bed level at the site is 2306 m.a.s.l.


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# 5 DESCRIPTION OF THE ENVIRONMENT

## 5.1 GENERAL

An environmental baseline study is intended to establish a database against which potential project impacts can be predicted and managed later. This section covers a comprehensive description of the environment of project area, including the resources which are expected to be affected directly by the project, as well as, those indirectly affected by the construction and operation of the project. The existing environmental conditions of the proposed project have been considered with respect to physical, biological and socio-economic aspects within Study Area i.e. (Area of Influence) from boundary of the proposed Project, as shown in **Figure 1.2**.

The existing information to establish a database for the proposed project was collected from review of published literature and through the site visits/surveys carried out in the project area. To comprehend the existing environmental conditions, site survey was conducted and salient observations were duly noted. Situation of prevailing air quality, noise level, water and wastewater quality were also monitored through laboratory testing. The socio-economic baseline survey of the proposed project area was conducted through consultation with the community. People of the project area were interviewed to get their opinions and feedback regarding the construction of the proposed apartment buildings

## 5.2 PHYSICAL ENVIRONMENT

The following section provides an overview of the information on physical environment of the proposed Project study area collected from primary as well as secondary sources. The major parameters covered include topography, land use, soils, geology, seismicity, climate, water resources and other parameters as described in the following sub-sections.

### 5.2.1 Topography and Geomorphology

The Project Area is located on Hunza River at Attabad Lake which was formed in the year 2010 due to a huge slide from right bank mountain. The project site is about 15km upstream from Ganish Bridge of Hunza. Its distance is about 20 km from Hunza and 115 km from Gilgit. The project area is located in district Hunza. Topographically, Hunza valley has a varying relief.

The segment of Hunza valley wherein the various components of the proposed project are situated reflects very high relief conditions marked by relatively steeply inclined extensive mountain slopes along right side of the valley as compared to the left bank mountain slopes.

The mountain slopes are mostly marked by erratic slopes instabilities along with relatively less extensive segments of casuistic slopes. The mass wasting regimes active in the project area are drastically influenced by a broad spectra of variables such as geo-mechanical conditions, moisture distribution and dynamic loading. Most abundant slope hazards include but not limited to rock fall / debris flows, rolling slopes in unconsolidated loose overburden and mud/debris flows in sub-parallel rectilinear secondary drainage.

Tupopdan peaks 6,106 metres (20,033 ft) lies near the Project Area also known as 'Passu Cones' is the most photographed peak of the region. The other nearby high peaks are Pasu Sar, Shispare Sar, and Batura.


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The powerhouse location is on the left bank of river and easily accessible from Karakoram Highway. The intake weir/dam site is selected at current exit point of Attabad Lake.

The topography map of the project area is shown in **Figure 5.1**.

### 5.2.2 Regional Geology

Tectonically, project area lies in the Karakoram Block towards the north of the Karakoram Thrust (MKT) and Main Mantle Thrust (MMT) which are considered to be the manifestation of the tectonic collision between Indian Plate (Continent) with the Kohistan Island Arc and then with the Eurasian plate (Continent). The Himalaya, Karakorum and Hindokush are considered to be the highest mountainous ranges in the world.

#### 5.2.2.1 Site Geology

The Project Area lies in Karakorum Block, where rocks of meta igneous provenance are exposed. The rock units represent acidic igneous rocks including Granodiorite and Granitic Gneiss. Many local as well as regional faults are present in Project Area.

Soil units present in the Project Area are

- Angular Boulder Gravels with Sand and Appreciable Amount of Fines (ABGM): Most of the slopes are covered by material comprising of ABGM. This is colluvial material broken from the rock units, rolled down slope and settled at the foothill or along the slopes. ABGM material is present in the sediment flushing tunnel, surficial deposits in power tunnel alignment and in part of tailrace channel.
- Rounded Boulder Gravels with Sand and Appreciable Amount of Fines(RBGM)
- Terrace Deposits which consist mainly of unconsolidated mixtures of clay, silt, sand and gravels with occasional boulder sand. Terrace deposits are present at a relatively higher elevations in the project area.
- Morainic Deposits consists mainly of material ranging in size from large boulders to clay size particles, angular to sub-angular, poorly sorted, elongated and have flat surface, powerhouse area is covered by moraine deposits with clayey silt to silty clay.

Both fine and coarse aggregates for construction of overtopping concrete weir and other associated structures are present in the vicinity of Project Area in ample quantities. Clayey silt for blanketing/ impervious material, coarse aggregate and rip rap have been investigated and proposed as barrow area while sand and fill materials are proposed to be excavated from river bed.

**Figure 5.2** provides map for the location of the proposed Project in regional geological prospective.


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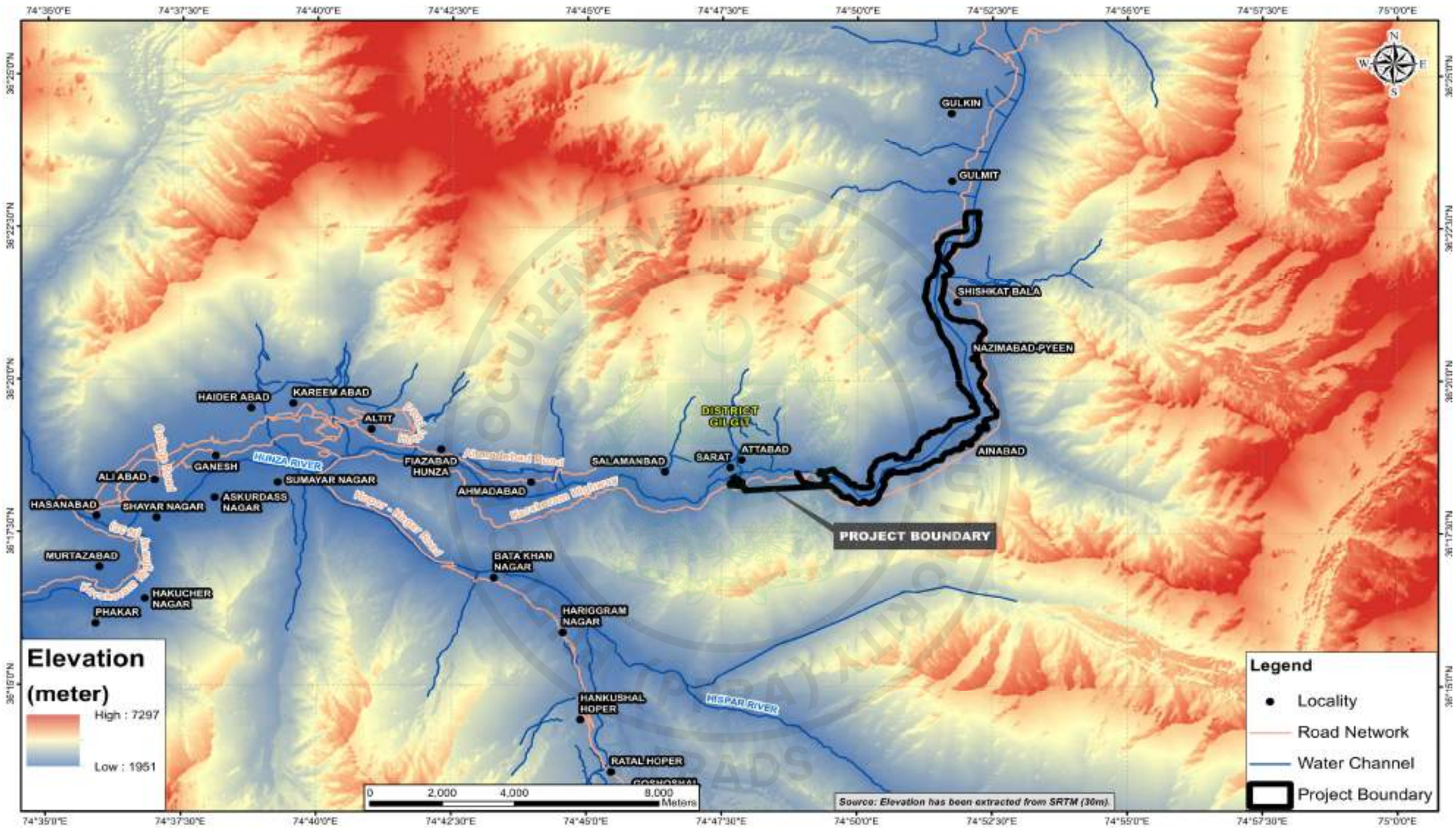


**Figure 5-1: Topography Map**


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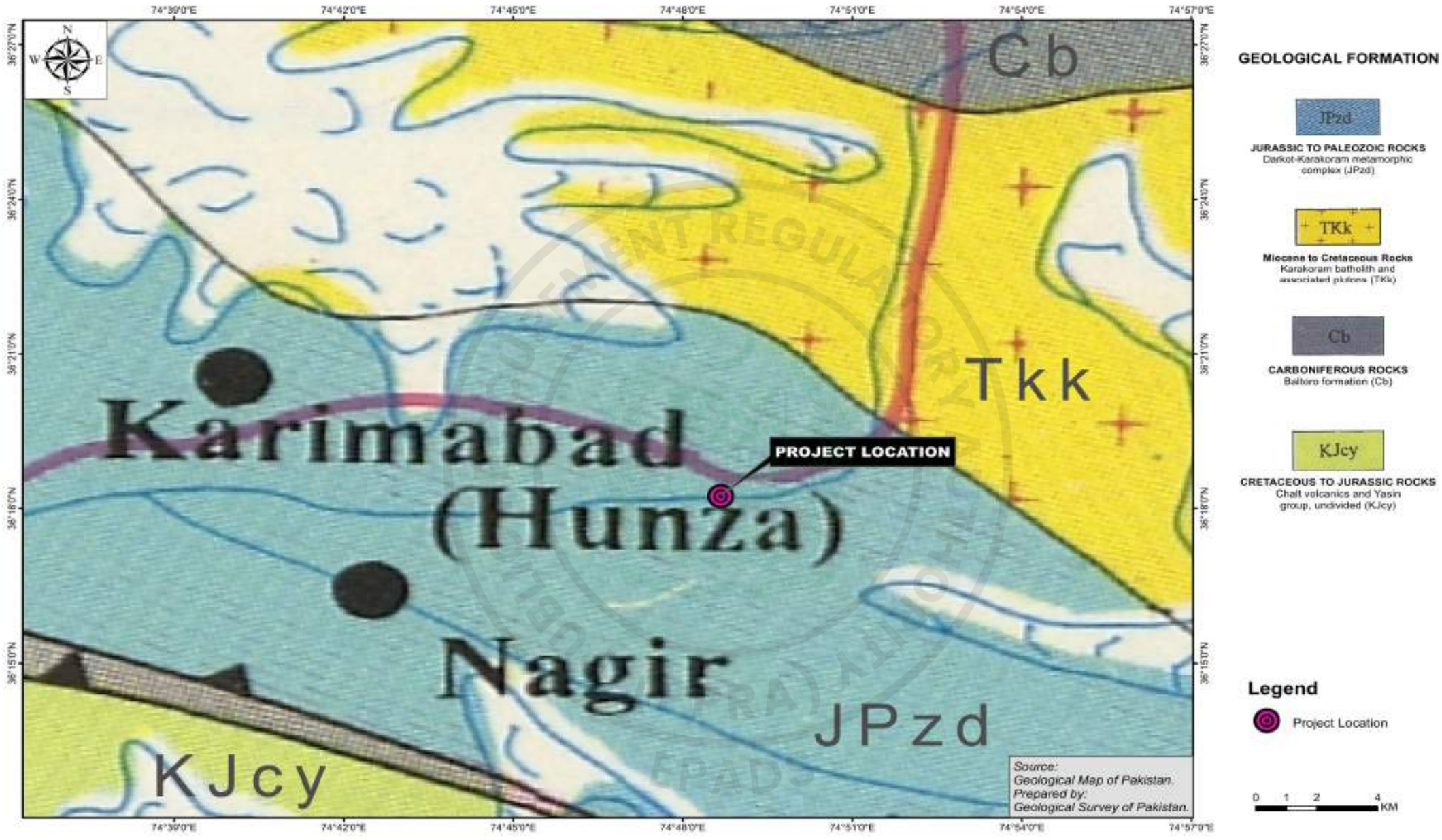


**Figure 5-2: Regional Geological Map**



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### 5.2.3 Seismicity

The project area lies in the region of Northern Pakistan which has high frequency of earthquakes especially in the Himalayan orogenic belt. This belt represents the contact between Indo-Pak and Eurasian plates, which has always been the source of moderate to large earthquakes including Kangra (1905), Bihar-Nepal (1934), Assam (1897) and 2005 Kashmir earthquakes with significance consequences. The presence of some of the active faults like Main Karakorum Thrust (MKT), Main Mantle Thrust (MMT), Raikot Fault, Riwat Fault, Panjal Khairabad Fault, Jhelum Fault and Main Boundary Thrust (MBT) etc make the GB region tectonically very active.

According to Seismic Provisions in the Pakistan Building Code 2007, the Project area falls in Seismic Zone 2B (moderate), which represents Peak ground acceleration from 0.16 to 0.24g, where g represents acceleration due to gravity. Seismic zoning map of the Project area is given in **Figure 5.3.**


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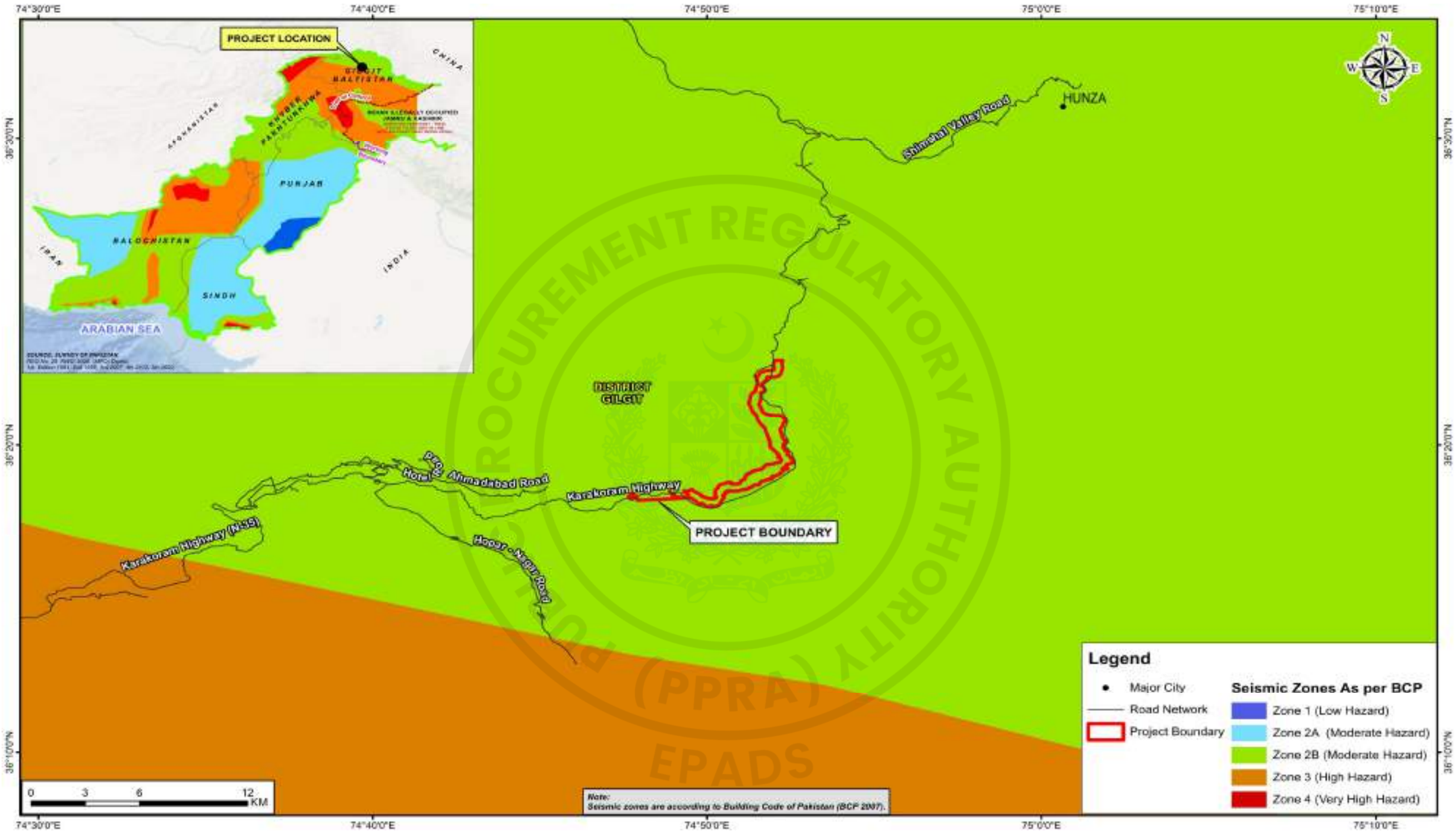


**Figure 5-3: Seismic Zoning Map of the Project Area**


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### 5.2.4 Land Erosion

The glaciers of the GB and KPK have very high “activity indices”, an index for the total amount of water passing through the glacier system per annum. As a result, they have high flow rates in terms of the glacier melt, ranging between 100 and 1,000 meters/year. As a result of these high rates of flow, these glaciers aggressively erode their beds and transport the eroded materials to the headwaters of rivers, which causes the transport of sediments into the major rivers of the region. The exact proportion of sediment due to glacial erosion is still not measured; however, it could be stated that these account for the huge load of the sediments passing through the upper Indus system especially Hunza River, Shyok River and Shiger River.

Landslides are very common features in the project area because of the high steep terrain. Erosion and sediment input to the river is a function of landslides and riparian erosion processes. There are frequent talus accumulations along the side slopes of the river. These are typically in a state of stable equilibrium at their current slope angle and environment but become unstable when the equilibrium is disturbed. Excess water and earthquakes often trigger landslides.

### 5.2.5 Hydrogeology

Glaciers and snow are the principal water source in Gilgit-Baltistan, located in the extreme north of the country, home to some of world’s highest mountain ranges and to three of the world’s largest glaciers, Biafo, Baltoro and Batura. The province, which has a population of two million, is also the place from where the country sources much of its water through its lifeline, the Indus River. The melted water from snow fields and glaciers enters streams, which feed manmade channels that take water to settlements for agriculture, livestock and domestic requirements, including drinking.

The water supply systems in GB are primarily based on the use of surface waters which include rivers, springs and streams. This means that people face moderate to acute water scarcity during the winter months when glacier melt is reduced. The use of ground water is uncommon, except for a few riverside villages, where people draw water from shallow wells. There are many sources of surface water in GB, some of the surface water sources situated near project area are mentioned as follows:

- Hunza River is the principal river of Hunza in Gilgit–Baltistan, Pakistan. It is formed by the confluence of the Shimshal River including Chapursan, and Khunjerab River which are fed by glaciers. It is joined by the Gilgit River and the Naltar River, before it flows into the Indus River. The river cuts through the Karakoram Range, flowing from north to south.
- Borith Lake lies approximately 2 km to the north of Gulmit, a saline body of water occupying a small hollow at an elevation of 2,500 meters (8,200 feet). The lake can be reached via a 2 km unpaved jeep route from Husseini village, which lies adjacent to Gulmit village. It is also accessible by a 2-3 hour trekking route directly from Gulmit, across the end of the Ghulkin glacier.
- Attabad Lake a part of the project area, is a lake located in the Gojal region of Hunza Valley in Gilgit−Baltistan, Pakistan. It was created in January 2010 as the result of a major landslide in Hunza River at Attabad. The Lake has become one of the biggest tourist attractions in Hunza, offering activities like boating, jet-skiing, fishing and other recreational activities.


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- Shimshal River is located very close to the Project Area. It is formed from three main sources such as Khurdopin Glacier, Shimshal Pass and Zardgorban. The river also receives water from other sources before flowing into the Khunjrab River and finally ending in Hunza River near the Project Area.
- Shiskat Nullah Gojal and Shishkat Spring Gojal are main streams present near the Project Area, which are being used for the drinking purpose by the people of Hunza. As per the study conducted by GB EPA in 2019, the water quality of both the streams is fit for drinking purposes as the water is free from heavy metals. The main surface water sources in the Study Area are shown in **Figure 4.9**.

### 5.2.6 Flooding

Flooding of the Hunza River at the weir site is not a common feature although some floods of high intensity have been recorded in the past at upstream site e.g. the Glacial Lake Outburst Floods (GLOF) at Shimshal River.

Flood has been estimated from the available record. The maximum peak daily discharges of Danyor Bridge station at Hunza Rivers for every year recorded. The instantaneous peaks will definitely be higher than the measured daily flows. Instantaneous peak flows of Danyor Bridge station for the period 1966 to 2024 have been calculated and generated one day maximum peak Instantaneous flow for every year at proposed weir site. The estimated instantaneous peak flow for the period of 1966-2024 at Attabad Lake is graphically represented in the **Figure 5.4**.[9]

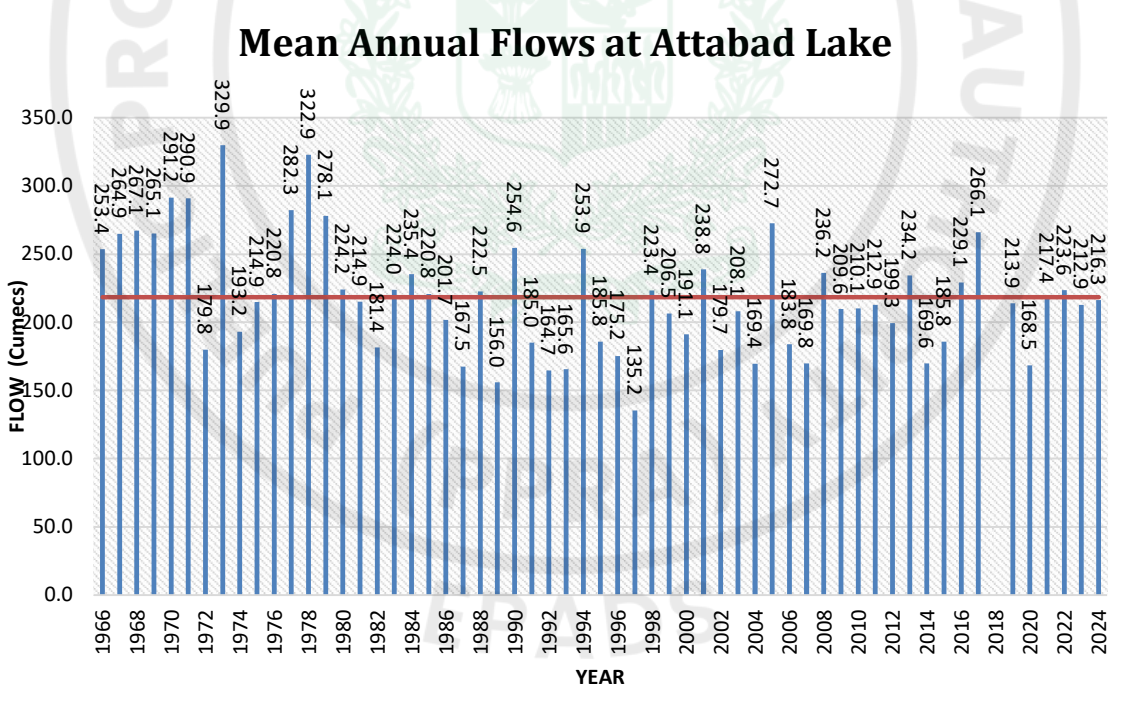


**Figure 5-4 Instantaneous Peak Flows at Attabad Lake HPP Site**

[9] *Source Feasibility Report, 2021*


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Flood has been estimated at the proposed weir site by using Peak Instantaneous flows of Attabad Lake for a period of 1966-2024. Flood Frequency Analysis (FFA) has been carried out by using different distributions (Gumble, Lognormal & Pearson type 3). Keeping in view the flood estimation against returns periods by using different distributions, it is recommended to adopt Gumble Distribution against 10,000 years of return period with flood outcomes of 3,250 m³/s for the selection of design flood at the proposed weir site. A design flood of 3,250 m³/s, corresponding to a 10,000-year return period, has been selected for the design of hydraulic structures at the weir site. [10]

The flow in Hunza River varies greatly at different times of the year, the discharge is at a minimum during the colder months when Attabad Lake is frozen, and there is a rise of water in spring and early summer season when glaciers melt.

Recently a massive GLOF occurred in Hunza district's Hassanabad village sweeping away the Hassanabad Bridge on the Karakoram Highway. The Shisper Glacier started discharging 5,000 cusecs of water owing to premature melting, leaving Hunza, Gilgit disconnected.

### 5.2.7 Climate

The climate of Hunza valley is characterized by mild summer and cold winters. Wide spread snow fall occurs in winter. During winter the northern winds blow constantly bringing the temperature down considerably. At Hunza, the mean temperature recorded from 2010-20 is 21.20 °C in July, the hottest month and the coldest month is January with an average temperature of -0.42 °C. The mean maximum temperature is 26.34 °C in July and mean minimum temperature are -3.8 °C in January respectively. Hunza receives maximum rainfall in spring i.e. in April. **Table 5.1** to **Table 5.3** provides climatic condition in project area. Graphical representation is given in **Figure 5.5 to Figure 5.7.** [11]

**Table 5-1: Average Minimum and Maximum Temperature in Hunza from 2010-20**

| Sr. No. | Month | Minimum Temperature °C | Maximum Temperature °C | Mean Temperature °C |
|---|---|---|---|---|
| 1 | January | -3.8 | 2.96 | -0.42 |
| 2 | February | -0.7 | 5.5 | 2.4 |
| 3 | March | 2.73 | 10.18 | 6.45 |
| 4 | April | 6.89 | 15.97 | 11.43 |
| 5 | May | 10.23 | 19.627 | 14.93 |
| 6 | June | 14.11 | 23.97 | 19.04 |
| 7 | July | 15.87 | 26.34 | 21.10 |
| 8 | August | 16.33 | 26.01 | 21.17 |

[10] *Using Hydrologic Engineering Center's (HEC) Statistical Software Package (HEC-SSP) Software.*

[11] *Source: Karimabad Meteorological Station*


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| Sr. No. | Month | Minimum Temperature °C | Maximum Temperature °C | Mean Temperature °C |
|---|---|---|---|---|
| 9 | September | 10.74 | 20.08 | 15.41 |
| 10 | October | 6.9 | 17.2 | 12.05 |
| 11 | November | 1.25 | 10.2 | 5.725 |
| 12 | December | -1.99 | 4.4 | 1.205 |

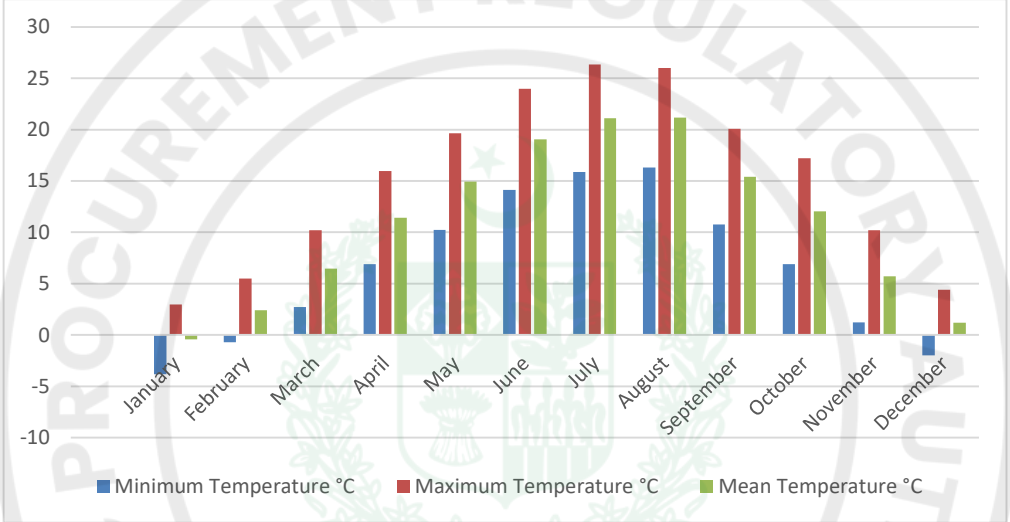


**Figure 5-5: Average Minimum and Maximum Temperature in Hunza from 2010-20**

**Table 5-2: Mean Monthly Precipitation (mm) 2010-2020**

| Sr. No. | Month | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | January | 0 | 4.8 | 0 | 6.6 | 3 | 0 | 3.8 | 0 | 0 | 13.5 | 13.2 | 4.1 |
| 2 | February | 0 | 1.8 | 0 | 8.1 | 0 | 2.5 | 0 | 6.6 | 1.8 | 10.4 | 0 | 2.8 |
| 3 | March | 2.8 | 0 | 0 | 0 | 11.4 | 11.7 | 8.9 | 3 | 14 | 6.9 | 0 | 5.3 |
| 4 | April | 25.4 | 3.8 | 19.8 | 12.7 | 8.1 | 13.5 | 70.6 | 36.8 | 13.2 | 2.5 | 3.6 | 19.1 |
| 5 | May | 28.7 | 5.3 | 17.3 | 16.3 | 4.6 | 10.9 | 21.8 | 7.6 | 22.4 | 17 | 8.6 | 14.6 |
| 6 | June | 10.2 | 7.9 | 11.7 | 1.8 | 1.3 | 19.1 | 4.8 | 11.4 | 3 | 30 | 2.8 | 9.5 |
| 7 | July | 52.1 | 15 | 5.1 | 9.7 | 31.8 | 0 | 37.4 | 6.6 | 8.9 | 10.2 | 15.7 | 17.5 |
| 8 | August | 13.2 | 16 | 19.6 | 24.1 | 17.3 | 6.6 | 12.6 | 20.3 | 0 | 4.3 | 20.1 | 14.0 |
| 9 | September | 14.5 | 35.1 | 42.3 | 19.1 | 36.3 | 1.3 | 4.1 | 2 | 1 | 0 | 8.6 | 14.9 |



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| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | October | 2.5 | 16 | 3 | 0 | 16 | 0 | 0 | 0 | 0 | 3 | 1 | 3.8 |
| 11 | November | 0 | 0 | 0 | 0 | 0 | 8.9 | 0 | 0 | 9.7 | 0 | 1 | 1.8 |
| 12 | December | 0 | 0 | 4.6 | 0 | 0 | 0 | 0 | 1.5 | 0 | 0 | 0.5 | 0.6 |

Source: Karimabad Meteorological Station

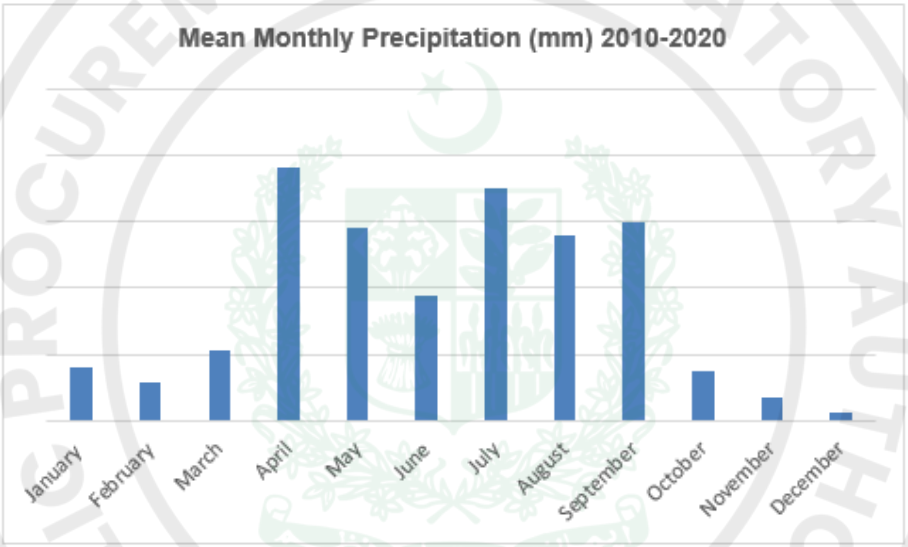


**Figure 5-6: Mean Monthly Precipitation (mm) 2010-2020**

**Table 5-3: Mean Monthly Relative Humidity (%) 2010-2020**

| Month | Average Relative Humidity % |
|---|---|
| January | 37.1 |
| February | 41.5 |
| March | 35.75 |
| April | 34.65 |
| May | 39.5 |
| June | 42.25 |
| July | 43.75 |
| August | 48 |



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| | |
|---|---|
| September | 50.35 |
| October | 42.5 |
| November | 41.6 |
| December | 45.5 |

Source: Karimabad Meteorological Station

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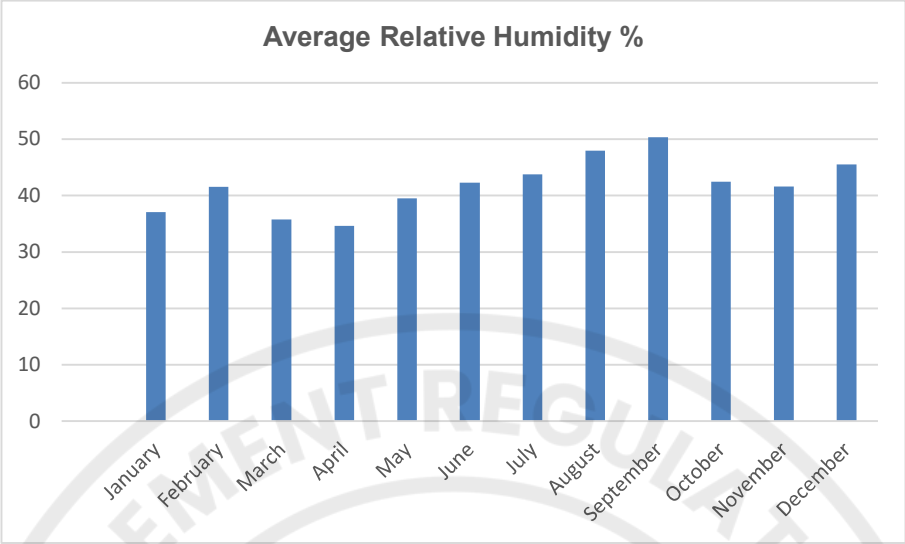


**Figure 5-7: Average Relative Humidity**

### 5.2.8 Solid Waste and Sewerage System

In the Study Area, no proper solid waste management system exists. Most of the solid waste is found to be stored in the form of small heaps at various locations near the villages and People use their solid waste in the vegetable field as fertilizer. Animal waste especially cow dung is used for farm manure or used for burning after drying (though rarely). Few waste bins have been observed along the Karakoram Highway and at popular tourist locations in Hunza to encourage waste management. The major constituents of solid waste in the area are paper, plastic, and organic waste (food waste, garden waste, animal waste). GB Waste Management Company (GBWMC) and Karakoram Area Development Organization (KADO) are the waste management companies in the Hunza district which focuses on waste management and recycling system by encouraging waste management practices.

The study area lacks proper sewerage system, only some open drains constructed in the vicinity for the discharge of wastewater. More than 50 percent of the houses have improvised pour flush pit latrines. The remaining 50 percent of the household use locally made toilets, dry pits or defecate in the fields. Wastewater (sludge) from kitchen, bathing and washing is discharged into small drains/ water courses leading to the nala or directly to small fields outside the houses.


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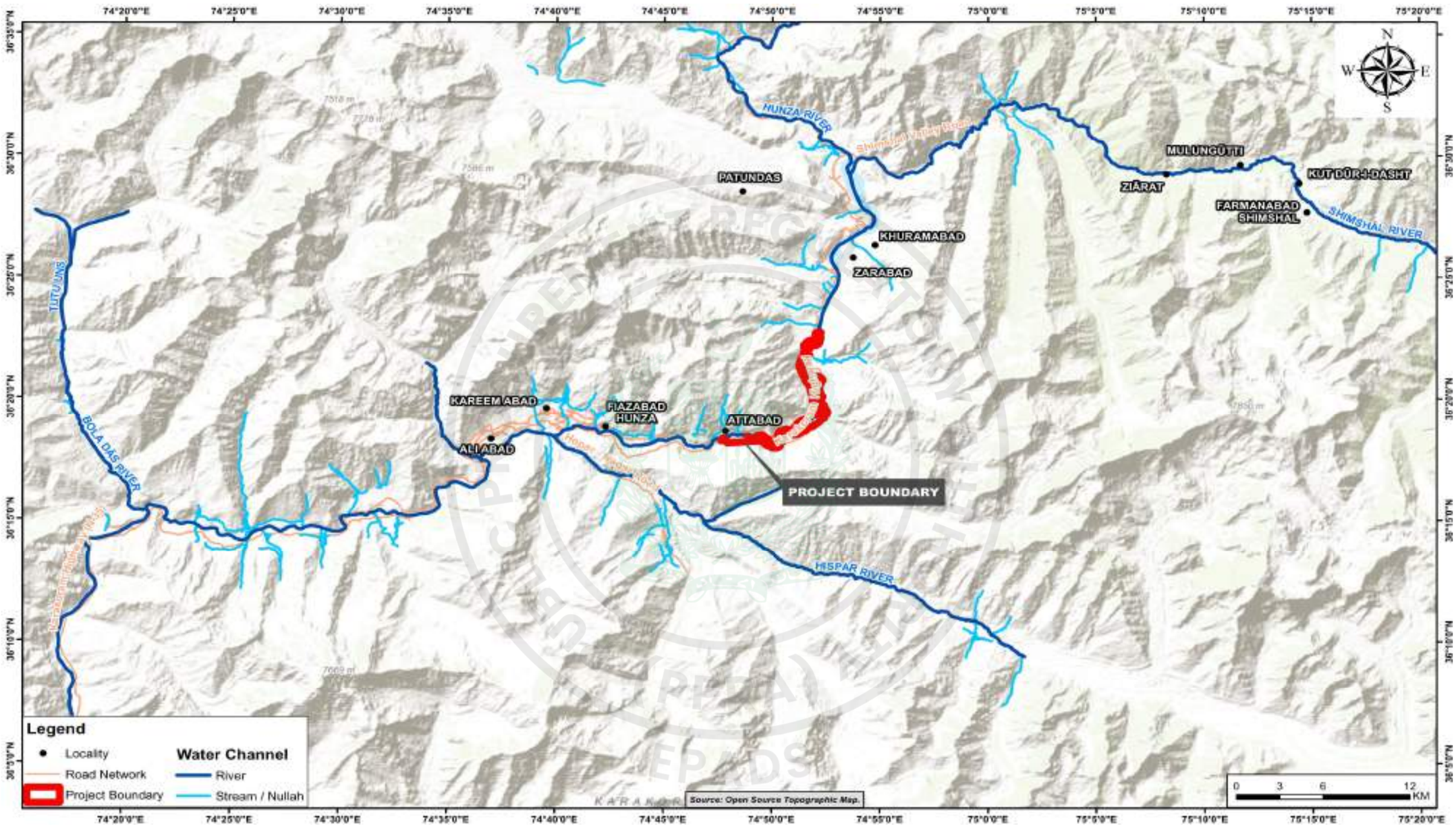


**Figure 5-8: Hydrological Map**

### 5.2.9 Land Use

The Project Area including reservoir comprises mostly of the barren/open area and cultivated area. However, graveyard and some built up area is also present in the Project Area. The land use of the proposed project boundary and reservoir are provided in the **Tables 5.4.** The land use of the Project Area is shown in the **Figure 5.9.**

**Table 5-4: Summary of Land Use within Study Area of Project**

| Sr. No. | Land use Type | Project Boundary | | Reservoir |
|---|---|---|---|---|
| | | Area (Acres) | Percentage | Area (Acres) |
| 1 | Agricultural Land | --- | --- | 14.276 |
| 2 | Built-up | 0.446 | 2.35% | 8.460 |
| 3 | Culvert | --- | --- | 0.008 |
| 4 | Distributary Channel | --- | --- | 0.640 |
| 5 | Drain | --- | --- | 0.162 |
| 6 | Graveyard | --- | --- | 0.334 |
| 7 | Landside Dabris | --- | --- | 0.188 |
| 8 | Open/Barren | 11.593 | 61.14% | 124.320 |
| 9 | Parapet Wall | --- | --- | 0.095 |
| 10 | Road | 0.024 | 0.13% | 5.320 |
| 11 | Track | 0.345 | 1.82% | 1.258 |
| 12 | River | 0.265 | 1.40% | --- |
| 13 | Slope | 6.176 | 32.57% | --- |
| 14 | Water Pond | 0.114 | 0.60% | --- |
| **Total** | | **18.96** | **100%** | **---** |

### 5.2.10 Environmental Sensitive Receptors

Sensitive receptors are mainly people or other organisms that may have a significantly increased sensitivity and exposure to the pollutants and social disturbance, due to the developmental projects. Thus, sensitive receptors are necessary to be identified, to evaluate the potential impacts of the proposed project on public health and the environment. The project area is situated in base of the mountain which is a barren land. There are no sensitive environmental receptors present in the Area of Influence of the project. However, the lake itself is a sensitive receptor. One graveyard is also present in the Reservoir Area.


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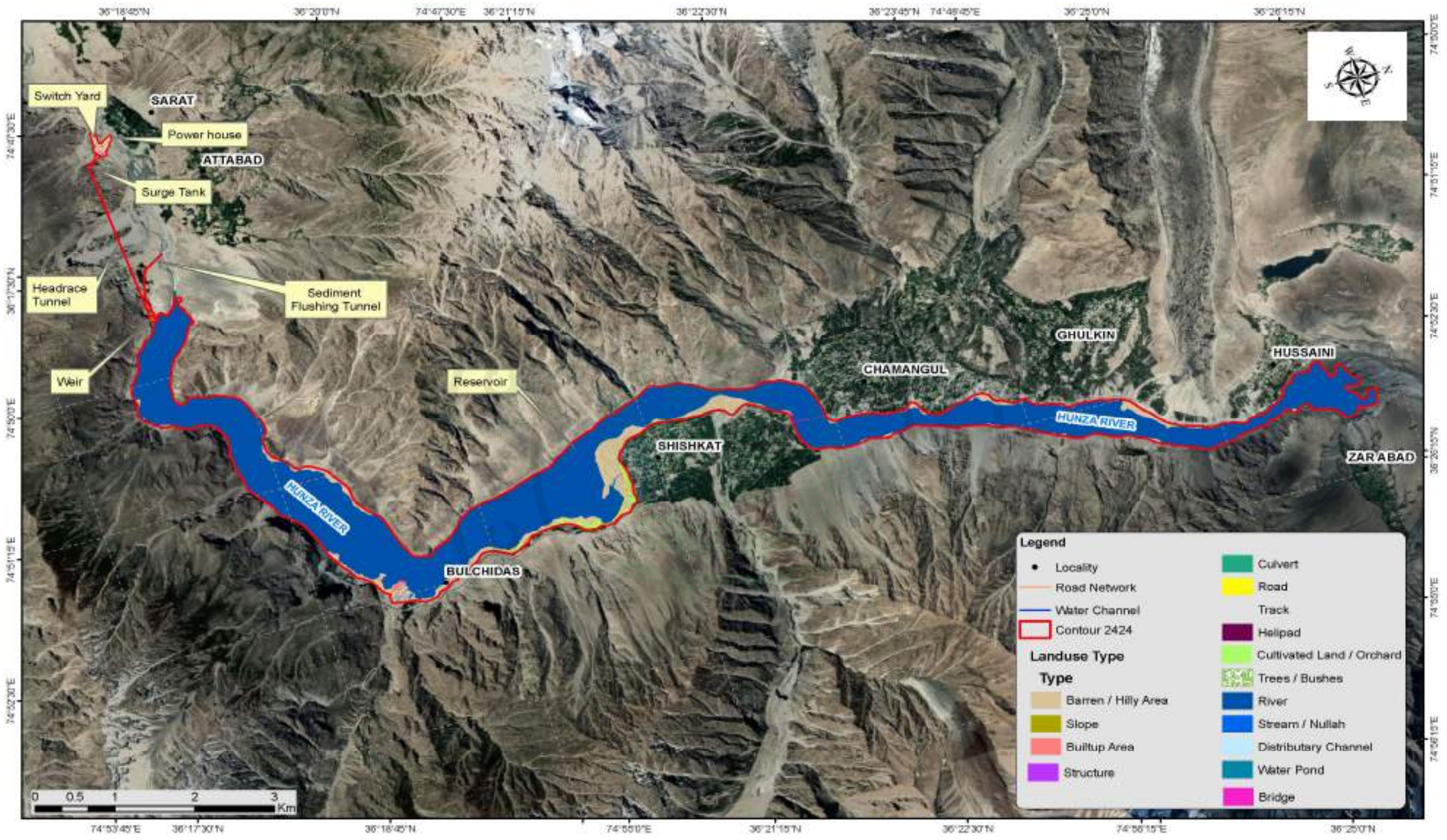


**Figure 5-9: Land use Map of the Study Area**

### 5.2.11 Environmental Parameters for Monitoring

The environmental monitoring of parameters like ambient air quality, noise level, surface water and groundwater help us to analyze the prevailing environment conditions in and around the study area, and to protect it from any adverse activities due to the proposed Project implementation.

The environmental parameters for ambient air, noise level, surface water and groundwater monitored during preparation of EIA of ALHPP in 2021 has been taken for the current EIA.

### 5.2.12 Air Quality and Noise Level

The ambient air quality monitoring for Carbon Monoxide (CO), Sulfur Dioxide ($SO_2$), Nitrogen Oxides ($NO_x$) and Suspended Particulate Matter (SPM was carried at near the proposed Project Site. Noise level was also measured near the project area. Based on the environmental monitoring, the following range of concentration of gaseous pollutants is estimated on the roadside at Gulmit (**Table 5.5**):[12]

**Table 5-5: Range of Gaseous Pollutant Concentration & Noise Emission Level**

| Range of Variation | CO ppm | SO2 ppb | NOx ppb | SPM g/m3 | Noise dB(A) |
|---|---|---|---|---|---|
| Minimum | 0.65 | 05 | 05 | 45 | 40 |
| Maximum | 0.9 | 10 | 12 | 90 | 70 |
| Average | 0.7 | 07 | 07 | 70 | 55 |

**$g/m^3$:** grams per cubic meter

The noise level near the river is fairly high and range between 50 to 65 dB without traffic, mainly due to the flowing water colliding against rocks and boulders.

### 5.2.13 Surface/Wastewater Quality

In the project area, the Hunza river carries water of various streams (nallahs)of snowmelt, and rainwater fall. The people use the water of these nallahs for drinking, household and agriculture purposes. Generally, there is no shortage of clean potable water in the project area as it is very difficult to fetch the water of river and nallahs due to the very steep slopes. People mostly use water from nallahs for drinking, washing and other domestic purposes. As these waters flow over land they pick up sediments, salts, toxic elements, pulverized organic matter and bacteria from the surface. Water samples were taken covering the complete affected area within the project area. The laboratory results of these samples summarized in **Table 5.6 & 5.7** reveal that all the parameters are within the permissible limits when compared with drinking water quality standards of WHO, except the presence of Escherichia coli pathogenic bacteria which causes gastroenteritis in human beings.[13]

[12] *Feasibility Study Report of Attabad Lake Hydropower Project-Volume-VI*

[13] *Feasibility Study Report of Attabad Lake Hydropower Project-Volume-VI*


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**Table 5-6: Chemical Parameters Results of the Samples (Surface Water)**

| National Standards for Drinking Water Quality of Pakistan (mg/l) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Nitrate** | **Nitrite** | **Cu** | **Al** | **Fe** | **Mn** | **Cr6** | **Zn** | **Ni** | **B** |
| ≤50 | ≤3 | 2.0 | ≤0.2 | ----- | ≤0.5 | ≤0.05 | 5.0 | ≤0.02 | 0.3 |

| Sr. No | Location from Sample Collected | Test Results (mg/l) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Nitrate** | **Nitrite** | **Cu** | **Al** | **Fe** | **Mn** | **Cr6** | **Zn** | **Ni** | **B** |
| 1 | Hunza River Side before Confluence of Shamshal Nullah | ND | ND | 0.4 | ND | ND | ND | 0.03 | ND | 0.01 | ND |
| 2 | Shamshal Nullah before entering Hunza River | ND | ND | 0.07 | ND | 0.04 | ND | 0.02 | ND | 0.02 | ND |
| 3 | Hunza River Side Near Power House | ND | ND | 0.2 | ND | 0.3 | ND | ND | ND | 0.01 | ND |
| 4 | Attabad Lake Boating Area | 1.3 | ND | ND | ND | ND | ND | 0.03 | ND | 0.02 | ND |
| 5 | Gulmit Tap Water | ND | ND | 0.02 | ND | ND | ND | ND | ND | 0.01 | ND |
| | Gulmit Glacier Near Hunza River | | | | | | | | | | |



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| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | | ND | ND | ND | ND | ND | ND | 0.14 | ND | 0.2 | ND |

| | |
|---|---|
| **Conclusion**: | The concentrations of nitrate, copper, iron. Chromium 6 and nickel are within National Standards for Drinking Water Quality of Pakistan for first four areas. |

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**Table 5-7: Bacteriological and Physical Parameters Results of the Samples (Surface Water)**

| Bacteriological Parameter | National Standards for Drinking Water Quality of Pakistan (Physical Parameters) | | | | | | |
|---|---|---|---|---|---|---|---|
| **E.coli** | **pH** | **Turbidity** | **Total Dissolved Solids** | **Electrical Conductivity** | **Color** | **Odor** | **Taste** |
| 0/100 ml | 6.5-8.5 | <5 NTU | <1000 ppm | 2000 µs | Un Objectionable | Un Objectionable | Un Objectionable |

| Sr. No | Location from Sample Collected | Test Results | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Bacteriological | Physical Parameters | | | | | | | |
| | | E.coli | pH | Turbidity | Total Dissolved | Electrical Conductivity | Temp. | Color | Odor | Taste |
| 1 | Hunza River Side before Confluence of Shamshal | 0 col/100ml | 8.4 | <5 NTU | 67.8 ppm | 130.4 µs | 7ºC | Clear | Odorless | Tasteless |
| 2 | Shamshal Nullah by entering Hunza | 0 col/100ml | 8.4 | 15 NTU | 98.1 ppm | 186.8µs | 7ºC | Clear | Odorless | Tasteless |
| 3 | Hunza River Side Near Power House | 0 col/100ml | 8.0 | <5 NTU | 62.7 ppm | 125.4µs | 7ºC | Clear | Odorless | Tasteless |
| 4 | Attabad Lake Boating Area | 0 col/100ml | 8.5 | <5 NTU | 65.4 ppm | 129.7µs | 7ºC | Clear | Odorless | Tasteless |
| 5 | Gulmit Tap Water | 0 col/100ml | 7.4 | <5 NTU | 23.5 ppm | 47.2µs | 7ºC | Clear | Odorless | Tasteless |



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| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 6 | Gulmit Glacier Near Hunza River | 0 col/100ml | 8.0 | <5 NTU | 29.7 ppm | 59.4µs | 7ºC | Clear | Odorless | Tasteless |
| **Conclusion**: | | Results show that the turbidity in Shamshal Nullah by entering Hunza water sample exceed the National Standards for Drinking Water Quality of Pakistan. | | | | | | | | |



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The laboratory results of these samples reveal that all the parameters are within the permissible limits when compared with drinking water quality standards of WHO, except the presence of Escherichia coli pathogenic bacteria which causes gastroenteritis in human beings.

### 5.2.14 Mining

Mining is one of the common professions in small parts in Hunza. Locals have developed mining at their own level with their own resources. People use to explorers the Mines by their own resources without any support of Government. However, in project area, no mining activity was observed.

### 5.2.15 Natural Disaster

The project area and its surrounding valleys are highly susceptible to natural disasters such as landslides, flash floods and avalanches, which affect civic life of areas within project vicinity. Atta Abad Lake, itself is an example of a massive landslide in 2010 and dammed the Hunza River. Attabad village was completely devasted and six small villages and 25km of KKH was completely submerged in Attabad Lake . GLOF events are becoming common in the project area as the areas is surrounded by some very large glaciers which can

### 5.2.16 Tourism

Attabad Lake has now become a spot of tourist attraction. A large number of tourist visits the area every year. The local communities get employment as tourist guides and transporters.

## 5.3 ECOLOGICAL ENVIRONMENT

### 5.3.1 Methodology

The available literature was thoroughly reviewed to have a better understanding of the project area and its surroundings including habitat, flora and fauna. The route alignment was thoroughly examined based on the primary and secondary data (Flora of Pakistan - M.I.Sheikh, Birds of Pakistan -Z.B.Mirza, Mammals of Pakistan-T.J. Roberts, previous EIAs of the proposed area, Manual of silviculture for Pakistan [1965] Champion, Sir H.G.; Pakistan Forest Institute, Peshawar, Seth, S.K. Khattak, G.M.). The data from primary and secondary sources was collected and adopted as such giving reference to the source. The stakeholder Forest, Wildlife, Agriculture, Fisheries and EPA departments were also consulted and relevant data was acquired from them. This survey broadly covers ecosystem sensitivities (If any), vegetation, other flora and fauna. Only the trees and vegetation in the vicinity of Power House, around the Lake and Communities were also consulted during the process of EIA and their view point and suggestions were incorporated in the Plan. The Project area comprises of Hydro Power station and Transmission Lines from Attabad to Sost and Attabad to Karimabad which linearly stretch over major part of the District. However the impacts of Transmission Line component of the project were not tangibly quantified at this stage. The Biological component of the Project area represents almost entire district in terms of flora, fauna aquatic life and agriculture sectors. The specific information related to aquatic life in the Attabad Lake was collected along with the information of other parts of the Project area.

### 5.3.2 Introduction and General Information Related to Biological Component of the Project Area

Biological Environment study includes the study of all those factors such as wild animals, plants or aquatic life, bacteria that affect human life as in a particular place or period.


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Biodiversity is the core component of Biological Environment. Habitat loss is considered as the leading cause of loss of world's biodiversity. Most species need undisturbed habitat to find food, water, shelter, and mates. But people are altering habitats all over the world. In such areas, the activities causing habitat loss include commercial logging (not based on technical and sustainable basis), land development, over-grazing, fuel wood collection, construction of roads, and building new settlements. All these actions change landscapes, natural water flows, and the species composition in the area. Moreover, changes in climate and land use patterns is also reducing the amount of snowfall and rain upon which the habitat depends.

As far as the Biological Environment of the project area is concerned, the high altitudes, rugged mountains and sweeping glaciers make much of the region of Gilgit -Baltistan uninhabitable. Only two per cent of the Northern Areas (NAs) estimated to be suitable for agriculture through irrigation by diverting stream water. However, so far only one percent of the total area is being cropped. Approximately nine per cent of the areas are covered by natural forests and open scrub, 22 per cent area constitutes alpine pasture, and remaining 68% is mostly bare rock, under permanent snow and glaciers.

### 5.3.3 Flora

A study was carried out on the Biodiversity of Hunza District including Khunjerab National Park (KNP) to establish baseline information about existing plant wealth and wildlife including flora, reptiles, birds and mammals in order to make some vantage points for future monitoring of key wildlife species. Using different direct and indirect investigation techniques, 14 different valleys and Nullahs of Hunza and KNP were surveyed and observations on various habitats were recorded.

The wide variety of climatic conditions in the region, coupled with the extreme variations in altitude and aspect, has created a wide array of vegetation and ecological zones. Five distinct zones can be identified including Dry Alpine Scrub, Moist Alpine Pastures, Dry Alpine Plateau Pastures and Sub Alpine Scrub and Birch Forests. So far, 62 plant species belonging to 45 genera and 25 families were identified. Of them, 4 grasses and one species of Liliaceae were determined. This represent the Project area and finding of the study were verified during field visit of the Project area. The detail of ecological zones is as follow:

**a. The Dry Alpine Zones and Permanent Snowfields**

This ecological zone is characterized by vast glaciers, boulder fields and sheer cliffs. This zone predominates at high altitudes, around the major peaks of the Karakoram Mountains. It covers most of upper Hunza and the northern parts of Baltistan.

**b. Alpine Meadows and Alpine Scrub**

This zone covers the areas between the high valleys and the permanent snowfields, between 3,500 and 3,800 meters. It is characterized by lush, green and well-watered alpine meadows, located on valley bottoms or high plateau surrounding the main watercourses. Alpine meadows occur in almost all the higher regions of Gilgit, Baltistan, Ghizar and Diamir and Hunza particularly where mountains extend above the tree line. The meadows support a wide variety of wildflowers, grasses, sedges and other plants.

**c. Sub-Alpine Scrub**

The sub-alpine scrub zone occurs throughout the higher mountains of the Himalaya, Hindu Kush and Karakoram, and is found in Gilgit, Skardu, Ghizar, Astore and Hunza. However, it is often confined to small ravines on the upper slopes. The vegetation consists of small deciduous species such as Betula utilis, and evergreens such as Juniperus communis and


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Rhododendron hypenanthemum.

**d. Dry Temperate Coniferous Forest**

These forests are usually found on the inner or northerly slopes of the Himalaya, between 1,500 and 3,400 meters. They occur in parts of Gilgit, Diamir and Baltistan Districts, and are characterized by single species stands of conifers. Typical tree species include Picea smithiana, Cedrus deodara and Pinus wallichiana, with an understory of Quercus ilex and Junglus regia and scattered shrubs of Artemisia maritima and other species.

**e. Dry Temperate Evergreen Oak Scrub**

This is an intermediate zone, lying between 1,500 and 2,500 meters. The vegetation is dominated by dry oak forest (Quercus ilex). Occasionally individual stands of evergreen species are also found, including Pinus gerardiana, Pinus wallichiana, Cedrus deodara and Juniperus spp.

**f. Medicinal Plants**

A large number of medicinal plants grow in the natural forests of Gilgit-Baltistan, especially Astore Valley and Hunza Valley. The following is a list of important medicinal plants found in the project area (**Table 5.8**).

**Table 5-8: Important medicinal plants report in GB Forests**

| Sr. No. | Botanical Name | Local Name | | Botanical Name | Local Name |
|---|---|---|---|---|---|
| 1 | Aconitum Chasmanthum | Mohri | 12 | Onasin echioides | Laljari |
| 2 | Aconitum Hetrophyllum | Partis | 13 | Orchus-latifolia | Salib misri |
| 3 | Aconitum lavae | | 14 | Picrohiza-kurrva | karroo |
| 4 | Angelioa glauca | Chora | 15 | Podophyllum-emodi | Ban kakri |
| 5 | Arterrisia bravifolia | Rund | 16 | Rheun emodi | Rhewand chini |
| 6 | Carum spp. | Kala | 17 | Sausuria-lappa | Kuth |
| 7 | Ephedra spp. | Oman | 18 | Saxifraga ciliate | Zakhmay hayat |
| 8 | Ferula feotida | Heeng | 19 | Shymus serpyllum | Bannanajwainu |
| 9 | Ferula narthex | Heeng | 20 | Swertia chiretha | Chiretta |
| 10 | Lavatria | Resha | 21 | Valeriana wallichii | Mushak bala |
| 11 | Macrotomia- | Gao | 22 | Viola serpans | Banafsha |

**g. Forestry**

Forests in GB cover an area of 281,600 hectares. Majority of these are found in the districts of Diamer, Baltistan, Gilgit and Ghizer. However the Hunza District including the project area has 0.75% of the area under forest. The forests provide timber, firewood, torchwood, grazing land and medicinal plants.eg. kuth (*sassuria, lappa*) black cumin, and other non-timber forest products (NTFP) including pine nuts (chilghoza), mushrooms, honey, berries of sea buckthorn, and animal products. The forests are important watersheds for the downstream population. Many species of wild animals and plants depend on these forests for survival. Fuel wood is the main resource harvested from the forests, followed by timber. The young branches of trees provide an important fodder source from March to May, when other fodder sources are scarce. Fuel wood is collected from low and high pastures, private land, fruit trees, and purchased from local markets. Generally, fuel wood is collected in spring and autumn and is stored for


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use during winters. Wood is also harvested to make agricultural and household tools and utensils while some types of bark, leaves, and berries are widely used for medicinal purposes.

Forestry is important for fuel, timber, in addition to control of the soil erosion and reduction in silt load in lakes and rivers. In the Gilgit-Baltistan only Diamer district is rich in forest while the other five districts including Hunza have nominal forest of Juniper. The forests consist of blue pine, spruce; willows and shrub consist of rosa species.

A new program of planting trees over private land by AKRSP and 10 Billion Trees Tsunami in the valley is operational. The forest areas including uncultivated wasteland are State Forests owned by the government. Wood is used for timber, fire and fuel wood throughout the year. Firewood is used during winter season. Based on data used by AKRSP each house on average use 100 monds of fire and fuel wood during a year. On the other hand, fire and fuel wood collected from common property is 63 mounds per annum. Forest trees are rich source of fodder. It was noted that 12 mounds of fodder are also collected by each household from the forest. The natural forest although has been extensively exploited. In the Hunza valley more forest plants are planted to reduce the pressure on existing forest. For this purpose, an average 130 trees of Poplar by each household and 90 plants of willow per household are planted under this Program.

In Ten Billion Tree Tsunami 4.4 Million trees were planted in 2019-20 year through Gilgit forest circle, Diamer Astore Forest Circle, Baltistan Forest Circle, Wildlife Divisions, AKRSP and through Agriculture Department in Gilgit Baltistan. The detail of planting in the year 2021 is given in **Table 5.9** as under.

Part of activities already has been undertaken in the Project Area.

**Table 5-9: Plantation Plan in Hunza District for the year 2021**[14]

| Sr. No | Activities | Sites | Area /KM | Total nos. of plants to be planted |
|---|---|---|---|---|
| 1 | Avenue Plantation | Nasirabad to Aliabad | 45 km | 30,000 |
| 2 | Slope plantation | Attabad lake | 700 Kanal | 25,000 (first Phase) |
| 3 | Block Plantation | Hussaini | 1680 | 50,000 (first Phase) |
| 4 | Block Plantation | Gulkin Shahabad | 948 Kanal | 25,000 (first Phase) |
| 5 | Block Plantation | Khuramabad | 1500 k | 50,000 (first Phase) |
| 6 | Free Distribution of | Across Hunza | - | 150,000 |
| 7 | Urban Planation | District Head Quarter | - | 15,000 |
| Total | | | - | 345,000 |

With action plan of 10 TBTTP, it will improve the production and procurement of forest and fruit plants, rehabilitation program of natural forest and awareness campaign for forestry will help in plantation of trees in the region.

### 5.3.4 Agriculture

The Hunza district spread over an area of 10,109 sq.km (1,010,900 ha) which is 14% of the total area of Gilgit-Baltistan. Hunza District is bounded on the south by the Nagar District and Shigar District and on the west by the Ghizer District. The district headquarter is the town of

[14] *Source: Forestry & Wildlife Department GB) Plantation site Khuramand & Zarabad, Hunza*


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Karimabad. Administratively, Hunza district is composed of two tehsils namely Ali Abad and Gojal. The number of villages are 46, the population in 2017 was 50,000, dwelling in about 6,494 households with average household size of 7.7 persons. With a growth rate of 2.74, the estimated population of the district is 57,236 persons in 2022. Overall literacy rate is 71% - male 80% and female 65%

According to Agriculture Department Gilgit-Baltistan, total agricultural land of the district is 6,453 ha out of which 2,114 ha is cultivated while 4,339 ha is cultivable waste. The land use statistics of district Hunza is given in **Table 5.10.**

**Table 5-10: Land Use Statistics of District Hunza**

| Sr. No. | Type of Land | Area (Ha) | Percentage |
|---|---|---|---|
| 1. | Agricultural Land | 6,453 | 1% |
| 2. | Forest Land | 5,003 | 0.75% |
| 3. | Range Land & Pastures | 194,498 | 19% |
| 4. | Rivers/Lakes | 32,480 | 3% |
| 5. | Settlements | 46,016 | 5% |
| 6. | Snow/Glaciers | 313,896 | 31% |
| 7. | Rocks/Barren Land | 412,555 | 41% |
| 8. | Total | **1,010,901** | **100%** |

### a. Current Features of Agriculture in District Hunza

The crops grown and cropping pattern in Hunza is influenced by the elevation which ranges from about 8,000ft to above 10,000ft. From 8,000ft to 8,500ft transitional double cropping system is practiced while above 8,500ft single cropping pattern is followed in the district. The major cereal crops of the districts are wheat, barley, maize and buckwheat. The vegetables grown are potato, tomato, peas, cabbage, cucumber, carrot, radish and beans. The fruits of the districts are apricot, apple, cherry, grapes, pear, peaches, pomegranate, mulberry, walnut and almond. Fodder is also produced in sufficient quantity. It is important to note that farmers grow mix of crops for subsistence. Therefore, the land is used for growing multiple crops in the same season. A typical cropping pattern followed in district Hunza is given in the **Table 5-11** below.

**Table 5-11: Cropping Pattern of Hunza District**

| Elevation | Cropping Pattern |
|---|---|
| 2438 m (8,000ft) to below 2591 m (8,500ft) | Wheat followed by maize or peas, and vegetables and fodder - OR |
| Cropping season Feb - Oct | Potato followed by peas, and vegetables and fodder - OR |
| Transitional double cropping | Wheat followed by buck wheat, and vegetables and fodder |


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| Elevation | Cropping Pattern |
|---|---|
| | Fruits are grown |
| 2591 m (8,500ft) to below 2743 m (9,000ft)<br>Cropping season Mar–Oct<br>single cropping | Potato, and vegetables and fodder – OR<br>Wheat, and vegetables and fodder - OR<br>Barley followed by buckwheat, and vegetables and fodder OR<br>Maize, and vegetables and fodder |
| | Fruits are grown |
| above 2743 m (9000ft)<br>Cropping season late Apr–September<br>single cropping | Potato, and vegetables and fodder - OR<br>Wheat, and vegetables and fodder - OR<br>Barley, and vegetables and |
| | Fruit in limited quantities in relatively lower altitudes and no fruits on higher altitudes |

### b. Future agricultural potential in Hunza

The following potential has been identified after analysis of the consultations with Agriculture Department and farming community as well as assessing the market potential pertaining to various agro-ecological zones of the district including the Project area (refer **Table 5.12**)

**Table 5-12: Potential of crops in various agro-ecological zones of Hunza**

| Type | Potential crops | Remarks |
|---|---|---|
| **Potential in Warm & Cold Temperate zone** | | |
| **Cereals** | Wheat (winter sowing),<br>Maize. Quinoa and buckwheat may be high potential | Among cereals, wheat in winter and maize as a second cereal crop are priority. Quinoa has been proposed as a high potential super food crop in Nagar during summer at the peripheries. Buckwheat may also be a future potential. It used to be cultivated earlier and this trend may be regenerated. |
| **Vegetables** | Potato, capsicum, peas | Potato and Capsicum are in high demand from the market from this zone. This zone in Hunza also specializes in Peas, sown in February / March and harvested in May /June which is early harvest having advantage in the market. Tomato vertical cultivation is cultivated in May and fruits in July over a long stretch. Cucumber and bottle gourd are also suitable to be cultivated in vertical formation. |

### c. Fruit Culture in GB and Hunza District including Project area

The main strength of the economy of Gilgit-Baltistan (GB) depends largely on dry fruits and agriculture. This area is famous for its almond, apricot, cherry and other dry fruits production in the world, but the most popular fruit is almond; a huge variety of almond is found in all


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districts of GB. Each type has its own specific characteristics. Gilgit-Baltistan produces about 120,650 tons of almonds per year[1]. Farmers of GB could earn billions of rupees through almonds export. The fresh and dried almonds in Gilgit-Baltistan are famous for its rich taste and organic nature. Pollution free environment and abundant water resources make it ideally suitable for natural growth of fruits and vegetables.

Gilgit-Baltistan faces problems with advantages in respect of fruit sector like long and difficult road journey, lack of storage facilities, non-availability of export quality packing material, quality control for grading and facilities for disinfection decrease the worth of fruits and cannot be dispatched to various markets of the country. Gilgit-Baltistan could be a business hub between Pakistan and China in the wake of China Pakistan Economic Corridor (CPEC) and Hunza District can be used as a gateway between both the countries. In this scenario people of GB could get huge benefits by exporting its finest quality of almonds and other dry fruits to China. The irony is the lack of infrastructural facilities and efficient road network to reach timely to market network.

People of GB have more opportunities in the agriculture sector and organic farming. Climate and abundant water resources make it ideally suitable for marvelous growth of this sector in Gilgit Baltistan, where immense potential is yet to be exploited. The nearest large city from GB is Rawalpindi/Islamabad. Under these conditions one of the options available is to process the fruits at location to increase its shelf life and to add to its value, so that it may be transported economically.

**d. Fruit Crops[1]**

Gilgit-Baltistan including district Hunza (Project area) has a very favorable climate for producing diverse fruits, particularly apricots. For centuries, the farmers of the region have been practicing horticulture as part of their livelihoods management strategy. Horticulture contributes about 83 percent of the entire income generated from agriculture. Similarly, within the horticulture, fruits contribute 60 percent. There are about 5.749 million fruit trees (3.653 million fruit bearing and 2.096 million non-fruit bearing).production volume of 169,373 tons produced over an area of 25,012 hectares. Major fruits produced in the area include apricot, apple, grapes, pears, peaches, pomegranate, cherry, mulberry, walnut and almond.

**i. Livestock Rearing[1]**

Livestock in GB (including Hunza) plays a central role in the rural economy as rural farmers use livestock for both dairy and meat production. They also use the manure, skins, and hides for income generation. Livestock contributes 35-40 percent to the overall agriculture income[15]. The production potential of livestock is too low to meet the demand of meat and dairy products. This gap is filled from importing meat from other parts of the country. As a part of subsistence farming, every household rears some kind of livestock.

Many different breeds of sheep, goats and cattle are found in Gilgit-Baltistan. Sheep breeds include the Baltistani, Gojali and Kohai Ghizar varieties. Goat breeds include Baltistani, Pamiri, Gojali, Kohai-Ghizar, Jarakheil, Gaddi and Kaghani. Farmers also keep cattle, yaks and various cross breeds of the two known as zo/zomo. Yaks are typically kept in the high regions

[1] *(Source: Rangelands and their Interfaces in the Hindu Kush Himalayas, 2013, ICIMOD)*


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such as Gojal, Baltistan and parts of Ghizar and Hunza Districts. Preferred animals are yaks *(Bos grunniens), Zo* (cross infertile breeds of yaks and domestic cow), and *Zomo* (female fertile breed). Zo are used as source of meat or sold to meet domestic requirements. In addition, each household maintains local breeds of cows for subsistence milk production.

These are highly valued animals and very important to the local economy as they provide milk, wool, draught power and manure. Yaks are physically well-adapted to high altitudes. Their heavy wool and other thermo regulatory mechanisms enable them to tolerate extreme weather conditions.

**g - Problem in Agriculture Sector**

Gilgit-Baltistan is a remote mountainous region of smallholders with comparatively higher incidence of poverty. Agriculture productivity is generally low due to poor access to quality inputs, huge postharvest losses (45% for apricot and 10% for potato), lack of local processing and value addition and poor access to markets. Production is scattered and fragmented over large areas and of variable quality with difficult access and there are no aggregation platforms. Varietal selection is inappropriate and most farmers produce fruits and vegetables of multiple varieties; many of which are not in demand in the market or have poor shelf life. There is a poor connectivity among the actors and stake holders along the value chains of key products. Supportive policies and incentives are often weak or entirely missing. In view of these challenges, there is need to undertake research and studies on the following aspects of Agriculture sector.

1. To determine the potential of agriculture in areas of Gilgit-Baltistan;
2. To identify investment opportunities in Gilgit-Baltistan; and
3. To determine challenges of farming community in this area and to provide recommendations/suggestions.

### 5.3.5 Fauna

This diverse range of vegetation and ecological zones also supports a rich faunal diversity, including an estimated 54 species of mammals and 230 species of birds. About 23 species of reptiles and 6 of amphibians have been reported from GB. Among reptiles 9 species are of lizards and 14 of snakes, while among amphibians 2 species of frogs and 4 of toads. Very little information is available on insect diversity in GB; however, about100 species of butterflies have been reported from GB. The project area does not support any habitat of endangered wildlife species.

Occurrence of some rare species has been reported in Hunza District including KNP. These include species like Lammergeyer and Golden eagle. Few sightings of Lesser Kestrel have also been reported in lower Hunza near Hunza River. The main diverse group of birds is the Passeriformes species. These are mostly Warblers, Tits, Flycatchers, and Buntings. Some of the restricted range species like Snow Partridge and Himalayan Monal pheasant are extremely rare and may be at the verge of extinction from many of their earlier strongholds. According to Birdlife International (2001) report there are 27 species of Pakistan, which are threatened internationally out of which 7 species are found in GB.

Hunza has very scattered settlements with meager population. Considering its wildlife resources to be protected and preserved, shooting, trapping of wild animals is not allowed except with a special permit. The number of animals or birds killed or captured is also restricted and specified in the permit. Snow leopard and Ibex are already declared as endangered and


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other species of mammal are also scarce. But trophy hunting is allowed which is beneficial to the local community as the 70% of the funds go to local community which is used for the development of the local area. The detail of fauna in the Project area is given in **Table 5.13**.

**Table 5-13: Fauna available in Project area of Hunza District**

| English Name | Urdu Name | Scientific Name |
|---|---|---|
| Red fox | Lombrei | Vulpesvulpes |
| Lynx | Seaa gosh | Felis lynx |
| Wolf | Bharia or Bahdia | Canis lupus |
| Maramot | Barfani choh Tershoon | MaramotaCandata |
| Alpine weasel | Gilhari | Mustelaaltacia |
| Musk rat | Chachondar | Mustelaaltacia |
| Himalayan snowcock | Ramchakur | Mustelaaltacia Tetraogallushimalayencis |
| Chukor | Chukor | AlectorisChukor |
| Eagle | Shaheen | Aquila Chrysaetos |
| Hawk | Gid | - |
| Falcon | Ooqaabor Ooqabaa | - |
| Pie | Jample | UrocissaEryphrohyncha |
| Hopoe | Hodhodh | Upepaepaps |
| Pigeon | Kabutar | - |

**a. Insects**

The Project Areas is rich in biodiversity of insects including butterflies found in the project area, particularly during the humid months of July and August. In addition, caterpillars, bugs, beetles, black bees, weevils, mosquitoes, ants, green aphids, codling moths, leaf miners, mitts, fruit flies, woody aphids, stray grass hoppers, leaf hoppers, mealy and woolly bugs, peach leaf curling aphids, scale insects, walnut weevils, blister mites, and dusky veined aphides are all found in the NA including the project sites.

**b. Endangered, Threatened or Vulnerable Species of Fauna**

There are no endangered species of fauna found in the Project Area.

**c. Community Controlled Hunting Areas**

The concept of biodiversity conservation through community development was piloted in a few selected valleys by International Union for Conservation of Nature -IUCN under a Global Environment Facility (GEF)/ United Nations Development Programme (UNDP) project in Gilgit, Baltistan and Chitral during the period 1995-1998. The success of the project resulted in expanding the concept to a larger canvass and today there are 53 communities-controlled hunting areas CCHAs. Out which 12 CCHAs fall in Hunza District. The participating communities are required to write a management plan for conservation and sustainable use and monitor the population of species targeted for trophy hunt. The major species being managed for trophy hunt are Markhor, Ibex, and Urial. The communities are issued permits by government for the number of animals that can be safely hunted. Communities sell permits nationally and internationally through outfitters. Eighty percent of the income from successful hunt goes to local community while 20% goes to government to cover administrative costs.

There are no Community Controlled Hunting Areas falling in the Project Area.


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### d. Protected Area

In order to safeguard the biodiversity of key ecological systems, Government of Gilgit-Baltistan has declared 7 National Parks to protect and conserve bio-diversity of Gilgit Baltistan. These include Handarb National Park, Khunjerab National Park, Deosai National Park, Central Karakorum National Park, Qurumber National Park, Himalaya National Park and Nanga Parbat national Park. Out of these National Parks the Khunjerab National Park is situated in Hunza District. In the protected forest, the forest owned by Government as per Forest Act-1927, all activities are prohibited until and unless permitted by the government. Usually, removal of fallen, dying, and dead trees is not banned, however, grazing, sometimes, is regulated to ensure regeneration. In Gilgit Baltistan, designated protected forests cover an area of 445,712 ha and are mostly found in Ghizer, Astore, Skardu, Hunza and Gilgit Districts. Out of that 64,512 ha is conifer forests while 3, 81,200 ha are scrub forests (IUCN, 2003).

Aga Khan Rural Support Programme (AKRSP), International Union for Conservation of Nature (IUCN), Wildlife Conservation Society (WCS) and World Wide Fund (WWF) are the main international organizations who over the last two decades have played a crucial role in creating awareness among communities for sustainable management of biodiversity resources. The then Ministry of Environment also implemented a Program for Mountain Areas Conservation (PMAC) to promote biodiversity conservation in Gilgit Baltistan through community participation. This program was completed in 2011. As a result of these efforts the Gilgit Baltistan offers a model for community based management of forestry resources.

Despite of all these conservation initiatives and efforts by government and international organization, fast depletion of forest ecosystems has been observed in the last two decades. The following strategies and actions are being taken to achieve the objectives of conservation, sustainable use and equitable sharing of benefits.

There are no Protected Areas falling in the Project Area.

### e. Game Reserves

The Game Reserves areas set aside for conservation of key game species, however, hunting and shooting is allowed except under a special permit. There are 8 Game Reserves in GB out of which 1 Game Reserve is located in District Hunza. The detail of these Game Reserves is given as follow (**Table 5.14**):

**Table 5-14: Game Reserves Areas**

| Game Reserve | Area (km2) | Key Species |
|---|---|---|
| Danyore (Gilgit) | 443 | Markhor, ibex, Urial, snow leopard, lynx, wolf, fox, etc and bird species |
| Kilikmintika (Hunza Gojal) | 650 | Ibex, Marco polo sheep, snow leopard, brown bear, fox, marmot, etc and bird species |
| Nazbar Nallah (Ghizer Yasin) | 334 | Ibex, snow leopard, brown bear, wolf, fox, etc and bird species |
| Chassi Bowster (Ghizer Phander) | 370 | Ibex, snow leopard, wolf, brown bear, fox, etc and bird species |
| Pakora (Ghizer Ishkoman) | 75 | Ibex, snow leopard, wolf, fox, etc and bird species |


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| Game Reserve | Area (km2) | Key Species |
|---|---|---|
| Askore Nullah Skardu | 129 | Ibex, snow leopard, wolf, fox, etc and bird species |

There is no game reserve, wild sanctuaries and National Park present in the Project Area.

### 5.3.6 Aquatic Ecology

Gilgit-Baltistan is blessed with highest potential of cold and clean water resources in shape of lakes, canal, reservoirs, rivers, and water logged areas that offer ideal habitat for trout and other cold water fish species. There is dire need to get maximum benefit from these resources through technological advancement in production, processing and marketing. Both the public and private sector are fully involved in order to judicially exploit this potential both in natural waters as well as its development in culture conditions.

Hunza Valley is blessed with great water resources comprised of streams and alpine lakes fed by the snowmelt and glacier waters. The fish fauna in Hunza Valley is relatively poor due to high turbidity, low water temperature and high water speed.

**a. Fisheries**

Fisheries department Hunza was established in the year 2012 with the core aim to develop and promote Fisheries and aquaculture activities in newly created district. District Hunza has rich aquatic resources of aquaculture and fisheries in forms of bluish lakes, gashing rivers, torrential streams, seasonal and perennial springs etc.

District Hunza being gate way to the CPEC and hub for tourist has great potential in terms of natural resources and well aware educated man power can contribute and play vital role in the development of the area. The scenic beauty and natural water resources of Hunza attracts a great influx of national and international tourist every year, which may directly or indirectly contribute to the economy of local people and the region.

Fisheries department Hunza has come up with novel approach and ideas to get maximum benefit from wise use and sustainable exploitation of natural resources in multiple ways with special focus on introduction and installation of cage culture system in Attabad Lake under controlled environment to enhance production with stocking and multiplication of fine varieties of fish in nature. At the same time, it has also been planned to promote sport fishery providing enabling environment and other related facilities for tourists and fish anglers.

For this the Attabad Lake having crystal clear water offers as natural gene pool reserve, ideal for excessive multiplication and better growth of many indigenous and exotic fish species.

**b. EXOTIC FISH SPECIES OF HUNZA**

i. Salmo Trutta Fario (Brown Trout)
ii. Onchorynchus Mykiss (Rainbow T rout)

**c. INDEGENOUS FISH SPECIES**

Among the 15 identified indigenous fish species in GB the following six fish species found in Project Area:

- Shizothorax plagiostomus
- Shizothorax Nasus
- Ptychobarbus Conirostris


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- T riplophysa T erwasae
- Triplophysa Yasinensis
- Diptychus Maculatus

## 5.4 SOCIO-ECONOMIC ENVIRONMENT

The socio-economic aspects were studied with respect to human and economic development and quality of life values of the population in the Project Area. The human and economic development mainly focuses on population and communities, infrastructure availability, institutions, transportation network, prevailing land use, power sources and agricultural pattern. Quality of life includes socio-cultural values, public health situation, recreational resources & development and archaeological/historical and cultural sites etc. Baseline information was gathered from literature, study reports, districts census reports and through field surveys comprising interviews and meetings by the Consultants' social team, using survey tools. During the field survey interviews and meetings with the different categories of respondents were conducted and observations were also recorded after giving due consideration during survey.

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### 5.4.1 APPROACH AND METHODOLOGY FOR THE STUDY

The methodology was developed after thorough review of the Terms of References (TORs), the quantum of work/expected outputs and the prescribed period of study. The survey mainly used quantitative methods and included supplementary qualitative information and analysis, wherever possible. The design of the assessment was limited to measuring the overall socioeconomic condition of the population living in the proposed project area. **Table 5.15** presents a summary of the objectives, key indicators, tools, and survey methods used for data collection.

**Table 5-15: Survey Objectives, Key Indicators, and Methods**

| Sr. No. | Objectives | Key Indicators | Method | Tools |
|---|---|---|---|---|
| 1. | • Demographic Profile<br>• Occupation<br>• Income of the respondents<br>• Source of income<br>• Expenditures<br>• Asset ownership | • Demographic information (age, education status, health status, work status of household members)<br>• Income levels and sources<br>• Expenditure level<br>• Assets – quantity, value, and ownership<br>• Liabilities-loan amount and sources<br>• Available social amenities (electricity, sewerage, telephone, Sui gas, etc.) | • Sample household interviews | • Socioeconomic Proforma |
| 2. | • Availability of Social Amenities (access to and use of public services, such as access to water and sanitation, education, health, etc.)<br>• Perception about the proposed project. | • Availability, use, and sources of household facilities (water, sanitation, fuel)<br>• Availability, access, and use of public facilities (education, health, sanitation, civil acts registration, etc.) | • Sample household interviews<br>• Community Discussions | • Sample household interviews, and<br>• General Discussions with local community members |

### 5.4.2 Literature Review

Immediately after the mobilization, the consultant reviewed all the available information/data, reports and studies related to project, the detail is as followed;

- Foot Prints of the project,
- District census report for the Hunza district, and
- Project area location maps


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### 5.4.3 Field Reconnaissance Visit

The reconnaissance site visit was conducted to develop an understanding of the proposed project. The visit helped to prepare key milestones detailing socio-economic and poverty issues as well as possible project impacts.

### 5.4.4 Sampling Technique

In order to achieve the target of the study, random sampling technique was adopted to select adequate and representative sample from proposed project area to make the survey findings more compatible with the highest level of statistical confidence and thus get meaningful sociological facts/findings. Accordingly, 58 respondents were selected from the project area and detail is provided in **Table 5.16.**

**Table 5-16: Number of Respondents**

| Sr. No. | Settlements/Villages | Number of Respondents |
|---|---|---|
| 1. | Sarat | 06 |
| 2. | Ganish | 08 |
| 3. | Attabad | 06 |
| 4. | Ayeenabad | 05 |
| 5. | Shishkat | 07 |
| 6. | Gulmit | 07 |
| 7. | Gulkin | 09 |
| 8. | Passu | 10 |
| | **Total** | **58** |

### 5.4.5 Developing Survey Instruments

The TORs of the Consultant highlight the importance of collecting primary data; hence the consultants designed the questionnaires covering the various types of information regarding socioeconomic aspects, poverty indicators and availability of the social amenities.

### 5.4.6 Implementation of Data Collection Survey

The field methodology was prepared for data collection, used by the field teams during the execution of the study. A map of the proposed project area was obtained prior to the survey to facilitate the identification of sample respondents in the project area. Nonetheless, following techniques were applied in data collection.

### 5.4.7 Rapid Appraisal Methods

Rapid appraisal method was used which is quick way to gather the views and feedback of beneficiaries and other stakeholders. Rapid appraisal methods include (i) Key informant interview, (ii) Community group interview and consultations, and (iii) Direct observation.


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### 5.4.8 Participative Approach

- A two-ways approach was adopted and respondents were given the opportunity to express their concerns and views freely about the project;
- Community groups were the target of the study;
- The participatory tool like group meeting was applied to identify and listing of the beneficiaries;

### 5.4.9 Data Processing and Analysis

The following steps were undertaken to ensure proper data processing and analysis.

- The collected data/information from the field was computerized;
- A tabulation plan was prepared;
- Data was processed according to separate category of the indicators for analysis; and,
- All analyzed data was tabulated for interpretation and deriving conclusions and recommendations.

### 5.4.10 FINDINGS OF SOCIO–ECONOMIC SURVEY

The main objective of the socio economic survey was to analyze socioeconomic and cultural characteristics of the intended project beneficiaries in order to understand their interrelationships, dynamics, and inequalities and to identify opportunities and constraints in accessing the project benefits by all beneficiaries or a segment of them (based on gender, ethnicity, level of income, geographical remoteness etc.)

#### h) District Hunza at a Glance

The Hunza District is one of the 14 districts of the Pakistani territory of Gilgit-Baltistan. It was established in 2015 by the division of Hunza-Nagar District in accordance with a government decision to establish more administrative units in Gilgit-Baltistan. The district headquarter is the town of Karimabad. Hunza Valley is also hosting the ancient watchtowers in Ganish, Baltit Fort, and Altit Fort. Watchtowers are located in the heart of Ganish Village. Baltit Fort stands on top of Karimabad, whereas Altit Fort lies at the bottom of the valley. The local languages spoken include Burushaski, Wakhi and Shina.

#### i) Must Know Facts of Hunza

- First ever district to ban the use plastic and polythene bags. (First ever in Pakistan & South Asia).
- First ever district to ban on use of tobacco –smoking is strictly prohibits at public places, hotels and restaurants.
- Hunza is known for its rich culture, traditions and customs, therefore, known for hospitality, politeness and generosity.
- People are highly civilized & cultured since the literacy rate is 98%.
- Hunza is known for its longevity meaty organic food and clean environment.

#### j) Geography of District Hunza

The Hunza District is bounded on the north and east by the Kashgar prefecture of Chin's Xinjianj Uyghur Autonomous Region, on the south by the Nagar District and Shigar District, on the west by the Ghizer District and on the north-west by the Wakhan District of Afghanistan's Badakhshan province. The Hunza District represents the northernmost region of the Indian subcontinent. It is home to the historic passes through the Karakoram Mountains (the Killik, Mintaka, Khunjerab and Shimshal Passes) through which trade and religion passed


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between Central Asia, China and India for centuries. The present day Karakoram Highway passes through the Khunjrab Pass to enter China's Xinjiang Uyghur Autonomous Region.

**k) Tourist Attractions in Hunza Valley**

Hunza boasts great biodiversity and natural beauty, the valley has dramatic natural beauty and there are many places which have attractions for the tourists. Hunza is one of the most exotic places in Pakistan. Several high peaks rise above 7,000 m in the surroundings of Hunza Valley. The valley provides views of several mountains, including:

Rakaposhi 7,788 m (25,551 ft), Ultar Sar 7,388 m (24,239 ft), Bojahagur Duanasir II 7,329 m (24,045 ft), Diran peak (7,266), Spantik (7027m), Ghenta Peak 7,090 m (15,631 ft), Hunza Peak 6,270 m (20,571 ft), Darmyani Peak 6,090 m (19,980 ft), and Bublimating (Ladyfinger Peak) 6,000 m (19,685 ft).

Some lakes like Attabad Lake, Borith Lake, Shimshal Lake, and Hassanabad Lake are located in Hunza.

Khunjerab Pass is a 4,693-meter-high mountain pass in the Karakoram Mountains. It is in a strategic position on the northern border of Pakistan and on the southwest border of China and is also located in Hunza. Eco-friendly hiking treks like Ondra, Poygah, Gulmit, and Leopard Trek Shiskhat are also known for their views.

**l) Administrative Setup of District Hunza**

Administratively, the Hunza District comprises two tehsils, the Aliabad Tehsil and Gojal Tehsil. The villages of lower Hunza and central Hunza are located in the Aliabad Tehsil, whereas the villages from the Attabad Lake up to the Khunjrab Pass are located in the Gojal Tehsil. In lower Hunza, Shina is the main language, whereas in central Hunza, the dominant language is Burushashki and in upper Hunza, Wakhi is the main language.

District administration is exercised by the Deputy Commissioner (DC) with the assistance of Assistant Commissioners. The Hunza police force is command by the Superintendent of Police (SP).

**m) Attabad Lake at a Glance**

Attabad Lake is located in the Gojal region of Hunza Valley in Gilgit−Baltistan, Pakistan. It was created in January 2010 as the result of a major landslide in Attabad. The lake has become one of the biggest tourist attractions in Gilgit−Baltistan, offering activities like boating, jet-skiing, fishing and other recreational activities.

**n) Demography and Population**

Total area of Hunza district is 11,660 km2 (4,500 sq mi). Total population of hunza district according to census survey report 1998 is 243,324.

**o) Ethnic Groups and Religions**

Most of the people of Hunza are Ismaili Shia Muslims who are the followers of Prince Karim Aga Khan IV, while in the area of Ganish Village over 90% are Asna Ashri Shia Muslims.

**p) Culture**

The culture of the Hunza district is unique to its people**.** They eat simple and healthy foods like Hunza bread, apricot products, dry fruits, and meat. They don't eat oily and spicy foods.


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**q) Languages**

The local languages spoken include Burushaski, Wakhi and Shina, while Urdu and English are the official languages spoken.

**r) Education**

Education plays a pivotal role in changing social and economic condition of the individuals. The literacy rate here is 98%. The female education ratio matches the males in Hunza district. Education has always been a top priority for the residents. New public and personal sector educational establishments are growing wide to impart schooling to the younger people.

**s) Aga Khan Development Network (AKDN)**

After the annexation of Hunza and the abolition of the principal state a space concerning rule, law, administration and organization was created. It took a long time for the government institutions to fill this gap. AKDN is an international network and as part of Aga Khan Foundation (AKF) deals with issues such as education, rural development, culture, health services, housing programs and quite a few others. With its headquarters in Geneva and having been founded in 1967, The AKF is an international agency for development co-operation. Within the sub-branches of the AKDN, the Aga Khan Rural Support Program (AKRSP) is for rural development. The activities of the AKDN have shaped the development of the valley extraordinarily. Its various offices provide jobs for higher qualified Hunza cuts when they return from their studies in down country. Employment is also provided in the public sector in the rural areas. The AKDN extends its activities to establishing healthcare facilities and educational institutions. The AKRSP was established in Gilgit and covers 84% of the household in Gilgit-Baltistan. The AKRSP started supporting institutional development on the local level in 1982 by establishing community-based organizations (CBOs) like Village Organizations (VO) and Women Organizations (WO). These associations were established all over Hunza within a few years. It initiated developmental projects in this area aiming at improvement of the condition of the rural population and providing basic facilities to the masses, with special emphasis on infrastructure.

**t) Health Facilities**

The villages in the Hunza Valley have somewhat better healthcare facilities than rest of the GB except Gilgit and Skardu. Aga Khan Health Service (AKHS) and Government health workers are providing health facilities in the area. They provide first aid facilities and also give family planning guidance to the people.

### 5.4.11 Demography of Sampled households

**a) Gender Composition**

The socio-economic survey was carried out to understand the demographic and socio-economic characteristics of the population in the project area. According to the survey of sampled households, the male population was high as compared to the female population in the project area. On average the male population was 53% compared to the 47% female population among the sampled families. As per the survey, the household size was 6.2 persons per household. The detail of the population of sampled households is given in **Table 5.17**.


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**Table 5-17: Gender Composition of Households' Population**

| Total Respondents | Population and Family Size | | | | Total Population | Average HH Size |
|---|---|---|---|---|---|---|
| | Male | Percentage | Female | Percentage | | |
| 58 | 191 | 53 | 169 | 47 | 360 | 6.2 |

**b) Age Group**

Age is another important demographic characteristic which has a bearing on employment and mobility. The findings of the survey revealed that 24% of the respondent were between 21 to 30 years of age & 45% were between 31 to 45 years of age group and 31% of the were above 45 years of age group respectively. The data regarding the distribution of respondents by age is categorized and depicted in **Table 5.18.**

**Table 5-18: Age Group of Respondents**

| Sr. No. | Frequency Distribution | Number | Percentage |
|---|---|---|---|
| 1. | 21-30 | 14 | 24 |
| 2. | 31-45 | 26 | 45 |
| 3. | Above 45 | 18 | 31 |
| **Total** | | **58** | **100** |

**c) Education Level**

A person if he could read a newspaper or a journal of the same standard and could write the simple letter in any language defined as a literate in the Census of 1998. Education is one of the key factors in assessing the socio-economic condition of any area and is a more contributing factor than income for uplifting the living standards in society. The literacy rate is barrier with limited educational infrastructures.

Based on sample survey (**Table 5.19**), 100% respondent population was literate. In term of education distribution, 12% of the respondents got the education till primary level (five years of schooling), 9% of the respondents have the education up to middle level (8 years of schoolings), and 26% & 21% of the respondents were matriculates and intermediate respectively. However, 33% of the respondents had the education till graduation level and above.

**Table 5-19: Educational Level**

| Sr. No. | Educational Status | Number | Percentage |
|---|---|---|---|
| 1. | Primary | 7 | 12 |
| 2. | Middle | 5 | 09 |
| 3. | Metric | 15 | 26 |
| 4. | Intermediate | 12 | 21 |


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| | | | |
|---|---|---|---|
| 5. | Graduation & Above | 19 | 33 |
| **Total** | | **58** | **100** |

**d) Source of Income**

Household income could be the best indicator to assess the actual socio economic situation of the target communities. The majority of the respondents living nearby project area was engaged in agriculture, running restaurants and tourism business and some of them were doing private jobs to earn their livelihood.

The occupations have been categorized based on primary source of income. The sample survey revealed that the majority of the respondents 55% were associated with different kind of businesses including boating, jet-skiing, tourism, honey farming, dry fruits, restaurants, hotels and shop keeping etc. followed by 9% engaged in agriculture and 14% were doing private jobs, while 12% and 10% of the respondents were engaged in the field of driving and daily wages labor respectively. **Table 5.20** shows the occupation of the respondents.

**Table 5-20: Source of Income**

| Sr. No. | Professional Status | Number | Percentage |
|---|---|---|---|
| 1. | Business/shop | 32 | 55 |
| 2. | Agriculture | 5 | 09 |
| 3. | Private Job | 8 | 14 |
| 4. | Driver | 7 | 12 |
| 5. | Labor | 6 | 10 |
| **Total** | | **58** | **100** |

**e) Monthly Household Income**

During the socioeconomic survey, it was observed that monthly household income of the 12% respondents was up to Rs. 25,000 per month. Whereas, 10% households were earning between the range of Rs. 25,001 to 35,000 per month. However, 28% were earning between the ranges of Rs. 35,001 to 45,000. The majority of the households (50%) were earning above Rs. 45,000 per month. **Table 5.21** below shows the average monthly household income of the respondents.

**Table 5-21: Monthly Household Income**

| Sr. No. | Distribution | Number | Percentage |
|---|---|---|---|
| 1. | Up to 25,000 | 7 | 12 |
| 2. | 25,001 to 35,000 | 6 | 10 |
| 3. | 35,001 to 45,000 | 16 | 28 |
| 4. | Above 45,000 | 29 | 50 |
| **Total** | | **58** | **100** |


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### f) Monthly Household Expenditures

Household expenditure depends on the earning of the households. 24% respondents reported their monthly household expenditure up to 25,000 due to their low income. However, 16% respondents reported their expenses within the range of 25,001 to 35,000 per month. Whereas, 38% respondents reported their monthly expenditures between the ranges of 35,001 to 45,000 in order to fulfill their family needs, while 22% of the respondents reported their monthly expenditures above Rs. 45,000 in order to fulfill their family prerequisites. The information relating to the household expenditure in respect of sample population is shown in **Table 5.22.**

**Table 5-22: Monthly Household Expenditures**

| Sr. No. | Distribution | Number | Percentage |
|---|---|---|---|
| 1. | Up to 25,000 | 14 | 24 |
| 2. | 25,001 to 35,000 | 9 | 16 |
| 3. | 35,001 to 45,000 | 22 | 38 |
| 4. | Above 45,000 | 13 | 22 |
| **Total** | | **58** | **100** |

### g) House Ownership Status

Housing is a major element of people's material living standards. It is essential to meet basic needs, such as shelter from harsh weather conditions, and to offer a sense of personal security, privacy and personal space. Good housing conditions are also essential for people's health and affect childhood development. Further, housing costs make up a large share of the household budget and constitute the main component of household wealth.

Regarding the ownership of the houses, findings of the study indicated that 100% of the sampled respondents owned their houses.

### h) Type of the Houses

The Housing conditions of the respondents have been analyzed according to the type of houses in which they were residing. Majority of people use rock stones, concrete blocks, sand with cement for walls and floors whereas use wood for roofs.

### i) Source of Drinking Water

Drinking water, also known as potable water or improved drinking water is water safe enough for drinking and food preparation. Access to safe drinking water is not only a basic need and a precondition for healthy life, but is also a basic human right. The quality of water is directly linked to the quality of health.

Springs are the only source of drinking water for the local communities. According to the local people the water is clean and safe for drinking purpose. People fetch spring water for drinking and cooking. Most of the people have access to water supplies but these water supplies also carries the water of springs which is managed through pipelines to make an easy access.

### j) Satisfaction about Water Quality


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During the survey, local people were asked about the quality of the drinking water. The data revealed that 100% respondents were satisfied with the quality of water. According to the respondents that the water of springs is very good for health because it carries minerals and extract of natural herbs.

### k) Source of Energy for Cooking and Heating

Source of energy for cooking and heating purpose was also inquired during the survey from the respondents. In winters, 100% households uses wood for cooking and heating of the houses due to severe cold weather conditions. However, during the summer season almost 85% of the households use wood for cooking and heating whereas, rest of the 15% percent uses LPG as source of cooking. Hence, Sebagton Shrub wood is used for cooking and heating purpose while the wood of old Apricot, Apple, Popular and local trees is also used for cooking and heating. **Tables 5.23 & 5.24** indicates the sources which are being used by the respondents for cooking and heating purpose.

**Table 5-23: Source of Energy in Winter Season**

| Sr. No. | Source of Energy | Number | Percentage |
|---|---|---|---|
| 1. | Wood | 58 | 100 |
| **Total** | | **58** | **100** |

**Table 5-24: Source of Energy in Summer Season**

| Sr. No. | Source of Energy | Number | Percentage |
|---|---|---|---|
| 1. | Wood | 45 | 78 |
| 2. | LPG | 13 | 22 |
| **Total** | | **58** | **100** |

### l) Basic Social Amenities in the Proposed Project Area

Social infrastructure and amenities are key to creating sustainable communities. This assessment sets spaciousness of a household's dwelling, household amenities like availability of electricity and modern appliances, nature of access to water, fuel for cooking and type of sanitation facilities available as primary indicators for assessing standard of living.

The result of the survey revealed that 100% of the households had electricity facility while the facility of water supply was available to 79% of the respondents, basic health unit facility was available to 100% of the respondents. Facility of schooling was available to 100% of the respondents. Moreover, facility of mobile service was also available to 100% of the respondents. Providing proper sewerage system to the communities is the responsibility of the government, and this particular facility was not available in the area. The information in respect of access to social amenities and their quality of services is given in **Table 5.25**.

**Table 5-25: Basic Social Amenities in the Proposed Project Area**

| Sr. No. | Social Amenities | Available (%) | Satisfactory (%) |
|---|---|---|---|
| 1. | Electricity | 100 | 50 |


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| | | | |
|---|---|---|---|
| 2. | Water Supply | 79 | 100 |
| 3. | BHU | 100 | 90 |
| 4. | School | 100 | 100 |
| 5. | Mobile Service | 100 | 100 |

*Source: field survey*

**m) Mode of Transport**

It was observed that most of the respondents travelled by foot when traveling between nearest villages in the valley in the absence of proper road infrastructures. Whereas, in order to move to other cities or villages where road infrastructure exists, most of the respondents use their own transports either in shape of bike or car. **Table 5.26** describes mode of transport being used by the respondents asked during sampled household survey. About 38% of respondents were using their own transport and 21% reported the usage of public transport. While, 41% of the respondents were using both means of transport (private & public).

**Table 5-26: Mode of Transport**

| Sr. No. | Mode of Transport | Number | Percentage |
|---|---|---|---|
| 1. | Own Transport | 22 | 38 |
| 2. | Public Transport | 12 | 21 |
| 3. | Both (private & public) | 24 | 41 |
| **Total** | | **58** | **100** |

## 5.4.12 GENDER ASPECTS / ROLES AND RESPONSIBILITIES

The importance of gender equality, women's empowerment and the realization of women's rights in achieving sustainable development has been increasingly recognized in recent decades. This recognition is evident in a number of international norms and agreements, including principle 20 of the Rio Declaration on Environment and Development, adopted in 1992, in its statement regarding the full participation of women being essential to achieving sustainable development. The women of the proposed project area are hardworking, they have a vital role in maintaining domestic functions. During the field survey, the questions were asked from the respondents about the female participation in different activities of daily life. The survey revealed that participation of women in various household activities in the proposed project area is generally high (100%) in the case of household activities to take care and maintenance work of the household and take part in outdoor activities with their family members such as honey farming, fast food restaurant, help out in agricultural activities, fetching water, collecting fuel wood, cooking, washing, cleaning, looking after children etc. The **Table 5.27** depicts the routine activities and participation level of the female household members.


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**Table 5-27: Women Participation in the Various Activities**

| Sr. No. | Activities | Participation Level |
|---|---|---|
| 1. | Household | 100% |
| 2. | Child caring | 100% |
| 3. | Employment / Business | 50% |
| 4. | Farming | 80% |
| 5. | Social obligations (marriage, birthday& other functions) | 100% |
| 6. | Local representation (counselor /political gathering) | 30% |

*Source: Field Survey*


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# 6 PUBLIC CONSULTATION

## 6.1 GENERAL

Timely and broad-based stakeholder involvement is an essential element for an effective environmental assessment, as it is linked with Project Planning, appraisal and development in general. Public involvement during Environmental Impact Assessment (EIA**)** has a tendency to improve project design environmental soundness and social acceptability.

This section describes the outcome of the stakeholders' consultation sessions held with different stakeholders that may be directly or indirectly affected by the proposed project. Public consultations are also mandatory for development projects. The adequacy of the public consultation and information disclosure is one of the basic criteria used to determine the project compliance with the national / international safeguard policies.

Under the proposed project, stakeholder consultations were carried out in the Study Area with the locals, Government Departments and general public. These consultations were carried out from 05$^{th}$ October to 06$^{th}$ October, 2022. The major categories of the people who participated in the public consultations were the local population and community groups. The Project management and implementation authorities are committed for undertaking public consultation at local levels as a part of Project planning/design for getting necessary environmental permissions.

This Chapter presents the objectives, process, and outcome of the consultations carried out with the key stakeholders of the Project during the present EIA study. A consultation framework, describing the consultations to be carried out during the subsequent phases of the Project implementation ensuring ongoing and inclusive dialogues with key stakeholder is also provided in this chapter.

## 6.2 OBJECTIVES

The objectives of stakeholder consultation were to contribute to the openness, transparency and dialogue. Special efforts were made to ensure that the communication with the public should be efficient and well balanced. The concerned stakeholder groups were identified to participate in the assessment process. Specific tasks and purposes of consultations with stakeholders have been given in the **Table 6.1.**

**Table 6-1: Tasks and Purposes of Consultations**

| Task | Purpose of Consultation with Stakeholders |
|---|---|
| Why consultation with the stakeholders? | • To build trust to ensure sustained support for the proposed project and build resilience for times of crisis.<br>• To learn about public concerns that need to be addressed and taken into account in designing of the Project concept and preparation mitigation measures and programs.<br>• To learn about the strengths, skills and organizations that the stakeholders can bring to support Project planning and implementation. |
| Modes and benefits of consultation | • Listening and dialogue with stakeholders to keep the Project at tuned to public concerns early, to pre-empt breakdowns in public confidence.<br>• Engaging the public as advocates for the Project construction and to support the implementation of social, resettlement, and environment and health programs. |

Other objectives of public involvement include:


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- Informing the stakeholders about the proposed Project;
- Providing an opportunity to those who remained unable to present their views and values, therefore allowing more sensitive consideration of mitigation measures and trade-offs;
- Providing those involved with planning the proposal with an opportunity to ensure that the benefits of the proposal are maximized and that no major impacts have been overlooked;
- Providing an opportunity for the public to influence the Project design in a positive manner;
- Increasing public confidence in front of proponent, reviewers and decision makers;
- Providing better transparency and accountability in decision making;
- Reducing conflict through the early identification of contentious issues, and working through these to find acceptable solutions;
- Creating a sense of ownership of the proposal in the minds of the stakeholders; and
- Developing the Project which is truly sustainable.

More intangible benefits flow from the public involvement as the participants realize that their ideas can help to improve the Project. People gain confidence and self-esteem through taking part in the decision-making process and perceptions are expanded by meeting and exchanging views with people who have different values and ideas.

## 6.3 STAKEHOLDER IDENTIFICATION

The first step for the stakeholder consultation is the identification of the stakeholders. WAPDA is the Project Proponent for the proposed Project. As per definition, stakeholder is an entity which is concerned with the proposed Project in any way. Direct stakeholders are those entities which are directly concerned with the Project. The Project has both primary as well as secondary stakeholders.

The primary stakeholders include all the PAP's according to their loss of assets and living conditions, Provincial and District Level Government Departments of GB such as Environmental Protection Department (EPD), Irrigation Department, Agriculture Department, Wildlife Department, etc. However, the secondary stakeholders include the public and private agencies involved in the implementation of the Project.

Following is a list of major stakeholders consulted for the proposed Project:

### 6.3.1 District Level Stakeholders

- Gilgit-Baltistan EPA
- WAPDA GB;
- Forest Department, Hunza;
- District Administration;
- Wildlife Department, Hunza;
- Fisheries Department, Hunza;
- Agriculture Department, Hunza;
- District Health Department, Hunza;
- District Education Department, Hunza;
- Karakoram International University, Hunza

### 6.3.2 Village Level Consultations

- Project Affected Persons (PAPs)-Individual Interviews;


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- Community Consultations;
- NGOs;
- Local Ismaili Council Gulmit

Details regarding roles and responsibilities of the concerned agencies and departments are given below **Table 6.2.**

**Table 6-2: Roles of Concerned Agencies/Departments**

| Sr. No. | Name | Roles |
|---|---|---|
| 1. | Environmental Protection Agency | • EPA is the regulatory authorities and mainly responsible for the development and implementation of the environmental policies and strategies in order to integrate the environmental issues and sustainable development approaches into the legal and regulatory frameworks as per GB Environmental Protection Act 2014;<br>• EPAs are responsible for the issuance of Environmental Approval of the proposed Project; and<br>• EPA-Punjab is responsible for the compliance of EMP and Environmental Approval provision during the construction and operation phases of the Project. |
| 2. | WAPDA | • WAPDA is an autonomous and statutory body under the administrative control of the Federal Government and divided into three sectors Water, Power and Finance.<br>• Water Wing of WAPDA is responsible for planning, designing and execution of Water Resources Development Projects in the sector of irrigation, drainage and hydropower. Inter-provincial major surface water Projects including large dams are also operated and maintained by Water Wing, WAPDA.<br>• Roles of Power wing were redefined as Hydel Power Generation and O&M of power houses.<br>• The Charter of Duties of WAPDA is to investigate, plan and execute schemes for the following fields:<br>o Generation, Transmission and Distribution of Power;<br>o Irrigation, Water Supply and Drainage;<br>o Prevention of Water logging and Reclamation of Waterlogged and Saline Lands;<br>o Flood Management; and<br>o Inland Navigation. |
| 3. | Agriculture Department | • Ensuring food security;<br>• Enhancing productivity through better varieties and improved management practices;<br>• Promoting high value crops, fruits and vegetables;<br>• Promoting export of high value agricultural products;<br>• Promoting efficient use of water and other inputs;<br>• Improving soil health;<br>• Development of culturable waste lands; and<br>• Ensuring fair returns for the growers in marketing of their produce. |


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| Sr. No. | Name | Roles |
|---|---|---|
| 4. | Forest Department | • Protection, improvement and maintenance of existing forests;<br>• Increase forests by planting new trees; and<br>• Extension and advisory services to the general public about tree plantation. |
| 5. | Wildlife Department | • To save and protect wildlife. |
| 6. | Fisheries Department | • Responsible for the Conservation, Management and Development of Natural Fisheries resources through the enforcement of Punjab Fisheries Ordinance and Rules;<br>• Promote aquaculture practices in private sector to bridge gap of protein deficiency in the diet of common man; and<br>• Provide white meat to improve the health of people, utilize the untapped Fisheries resources to obtain maximum production, increase our share in the national economy. |
| 7. | Revenue Department | • Provide land ownership data of the project affected parties (PAPs) which include but not limited to the ownership record, land categorization and price details.<br>• Responsible for implementation of all relevant Sections of LAA, 1894. |

Consultations with district level departments were carried out through meetings while consultations with locals, village people, directly affected people etc. were undertaken during the baseline survey of the Study Area. The consultation is an on-going process which should be continued during the project life cycle i.e. even after submission of EIA.

## 6.4 DEPARTMENTAL CONSULTATIONS

The stakeholder consultations were held with relevant departments. The details of the departmental officials contacted are given in **Table 6.3.**

**Table 6-3: List of Government Officials Consulted**

| Sr. No. | Designation | Name of Department/ Office |
|---|---|---|
| 1. | Director -EPA | EPA Gilgit |
| 2. | Assistant Commissioner Gojal | Revenue Department |
| 3. | Project Director, Attabad Hydro Power Project ,Hunza | Water & Power Dept. GB |
| 4. | District Health Officer | District Health Department Hunza |
| 5. | Agriculture officer Hunza | District Agriculture Department Hunza |
| 6. | District Education Officer | District Education Department |
| 7. | Conservator of Parks and Wildlife | Parks and Wildlife, GB |


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| Sr. No. | Designation | Name of Department/ Office |
|---|---|---|
| 8. | DFO-Wildlife | District Wildlife Department Hunza |
| 9. | District Forest Officer | District Forest Department Hunza |
| 10. | Assistant Director Fisheries | District Fisheries Department Hunza |
| 11. | Director-KIU | Karakoram International University, Hunza |

### 6.4.1 Views & Suggestions of the Officials of Departments

The responses of the government officials about the construction of the Dam were recorded during the discussions. Generally, the officials were of the view, that the construction of the proposed project will have a positive impact on the economy of the area in term of availability of water for the irrigation purpose. The **Table 6.4** indicates the detail of issues raised/discussed and suggestions given during the consultation:

**Table 6-4: Detail of Issues/Points Raised/Discussed during Departmental Consultations**

| Sr. No | Agency / Department / Stakeholder | Representative's Details | Date | Apprehensions and Suggestions |
|---|---|---|---|---|
| 1 | Water and Power Development Authority (WAPDA) | Mr. Iqtadar Hussain,<br>Project Director, Attabad Hydro Power Project ,Hunza<br>0333-4481116 | 04-10-2022 | Project Director was briefed about the activities for the update/review of the EIA report. He commented that all the stakeholders should be properly appraised about the project and the relevant communities should be consulted. |
| 2 | Forest and Wildlife Department GB | Mr. Jilal Ahmed,<br>Conservator of Parks and Wildlife, GB<br>0355556999 | 06-10-2022 | The official was briefed about the advantages and present scenario of the proposed project. Mr. Jilal appreciated the proposed project and commented that this project will bring socio economic benefits to the communities and will solve the problem of shortage of electricity of in the area. He further suggested that the transmission line from Attabad to Sost and Attabad to Aliabad (Hunza) would be passing through some of the Community Controlled Hunting Areas (CCHAs). During the implementation of the project, the wildlife of the area should be protected and due care should be taken to create least disturbance for the wildlife. |
| 3 | | Mr. Muhammad Jaffar,<br>DFO, Hunza | 04-10-2022 | Mr. Jaffar was briefed about the project. He suggested that the project will go long way for the betterment of the area. The fruit and forest plants |


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| Sr. No | Agency / Department / Stakeholder | Representative's Details | Date | Apprehensions and Suggestions |
|---|---|---|---|---|
| | | 0355553086, 0346-9701825 | | will be affected due to construction of transmission line for which the PWD has schedule of compensation. The stakeholders must be paid well in time for compensation of the effected trees. |
| 4 | | Mr. Muhammad Akram, DFO Wildlife, Hunza 03129753399 | 06-07-2022 | NESPAK team briefed about the project. He was appreciative of the forth-coming project. He appreciated and commented that the proposed Project will be a game changer for the area as shortage of energy and load shedding has tremendous impact on the economy and social life of the area. He further apprised the team that the transmission line from the Attabad to Sost will trail through Community Controlled Hunting Areas (CCHAs). Therefore, during the execution of the project the necessary safeguards must be taken to avoid any disturbance and damage to the wildlife of the area. |
| 5 | Agriculture Department | Ms. Farhana Shah, Agriculture officer, Hunza 0349-5024259 | 04-10-2022 | The official was briefed about the advantages and present scenario of the project. She was appreciative of the proposed project and commented that the project will involve the cutting of fruit trees for the construction of transmission lines therefore the compensation to the effected land owners for the cutting of trees should be paid as per prevailing schedule of rates of PWD. |
| 6 | Fisheries Department | Mr. Shahbuddin, Assistant Director Fisheries, Hunza 0355-555251 | 04-10-2022 | The official was briefed about the advantages and present scenario of the project. He was highly appreciative of the project and apprised the team that the Attabad lake is rich in Fisheries resources and Cage fishing is introduced in the Attabad lake. It will help the communities to get extra income for their livelihood. He further suggested that during the construction phase of the project due care should be taken to avoid any damage to the aquatic life and fisheries. |


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## 6.5 COMMUNITY CONSULTATIONS

For ascertaining the perceptions of different stakeholders about the project (during/ after construction) meetings were held with local communities and anticipated project PAPs within the project area of influence. These meetings were held in an open atmosphere, in which participants expressed their views freely. Informal group discussions were also held as an additional tool for the assessment of the perceptions of the stakeholders about the project and potential impacts both positive and adverse likely to occur due to its implementation. The views of the local residents and general public were formally recorded and effort was made to make those beneficial for the Project.

## 6.6 APPROACH FOR THE CONSULTATION AND INFORMATION DISSEMINATION

A series of public consultations were required to get the feedback/concerns of the different category of stakeholders including local communities and other general public residing in and near about the project area.

Consultation process included meetings with specific proposed project area residents, community meetings/consultations and semi-structured interviews with the local community members. During the consultation process, the stakeholders were briefed about the project objectives and scope. Their fears and suggestions were recorded.

These Consultations were conducted at following two levels:

- Community/Public Consultations
- Individual meetings with PAPs

Public Consultation was carried out in order to establish stakeholder's opinion regarding project implementation. The following methods were used for public consultation with project stakeholders:

- Scoping Sessions
- Formal Meetings
- Informal Meetings
- Individual Interview

### 6.6.1 Locations of the Public Consultations and Participation

The detail of the locations with number of participants is provided in the **Table 6.5**

**Table 6-5: Consultation Locations and Number of Participants**

| Sr. No. | Village | Number of Participants |
|---|---|---|
| 1. | Ganish | 07 |
| 2. | Gulmit | 06 |
| 3. | Attabad | 11 |
| 4. | Passu | 18 |
| **Total Participants:** | | **42** |

### 6.6.2 Findings of Community Consultations

Extensive consultations were conducted with the local communities and anticipated PAPs in the proposed project area to record their views and incorporating in the project planning. Four (04) consultative meetings were held with locals in the proposed project area. The major categories participated in these meetings were local population, community groups,


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landowners, and particular project affected persons. All participants were briefed about the importance of the project and its impacts.

During the consultations, it was assessed that mostly people were aware about the project, its benefits and adverse impacts. During discussions, participants showed keen interest in discussion, gave valuable suggestions and also raised various questions. The local people expressed their willingness and cooperation with the project staff during survey and implementation of the project.

The question raised and response given are provided in **Table 6.6** whereas, list of participants has been provided in the **Annex-I.** Moreover, pictorial view of the community consultations, data collection and other filed activities is depicted as **Photo log.**

**Table 6-6: Consultation Meetings**

| Sr. No. | Questions/Concerns Raised By Participants | Responses of Team Consultant |
|---|---|---|
| **1.** | What will be the exact location of the reservoir and where the Dam will be constructed? | The participants were briefed about the tentative location of the proposed reservoir area and location of dam axis through projects' maps and drawings. However, the final location of dam and its allied structures will be finalized after detailed Geotechnical and seismic studies. |
| **2.** | How compensation for the land to be acquired will be paid and who will pay compensation? | Compensation will be given to all PAPs including the land owners.<br>Land evaluation will be completed by Revenue Department after the demarcation of RoW of the proposed project and compensation package will be prepared for all land affected PAPs. For land compensation land amount will be transferred to the District Revenue Department which will be responsible to pay the amount to the PAP's. |
| **3.** | Various surveys were conducted for the propose Dam but, there is no visible progress on the ground. | Feasibility and detailed engineering designing of the mega projects involves various studies which takes time. After completion of the respective studies, it is assessed that either the respective project is feasible or not. After approval of feasibility and detailed engineering design, projects are commenced and civil work is initiated on the ground. Respective project will also commence very soon in future once the necessary studies and field investigations are carried out/completed. |
| **4.** | When construction of the proposed project will get start? | After completion of the feasibility study and final approval of the detailed design, the construction work will be started. |
| **5.** | Due to construction activities as well as influx of labor, movement of the citizens particularly of females, residing in the local area will be restricted. | In order to tackle this situation, construction will be carried out in scheduled hours. So that after construction hours, local community, particularly females can easily move in the area. People would be aware about complete construction |


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| Sr. No. | Questions/Concerns Raised By Participants | Responses of Team Consultant |
|---|---|---|
| | | activity plans so that they can move in the area freely and safely. |
| **6.** | Dust and noise will disturb the nearby residential and commercial structures during construction. | All protective measures will be taken to keep safe the local community from noise and dust. Contractor will be bound to take all protective and precautionary measures to keep safe the health and properties of the local people. Internationally approved practices will be adopted in this regard. |
| **7.** | Skilled and unskilled work force should be hired from local community. It will enhance the acceptability of the proposed project among local people. | Contractor will be bound to hire the skilled and unskilled work force from the local community at priority. It will enhance the acceptability of the project among the masses as well as provide proper livelihood to the deprived and marginalized community. |

## 6.7 STAKEHOLDER CONSULTATIONS FRAMEWORK FOR CONSTRUCTION AND OPERATION PHASE

Key stakeholders of the Project include provincial and district level government departments such as EPD-GB, Agriculture Department, Forest Department, Wildlife Department, Fisheries Department, Project directly affected people, land owners and local people. The community members will be compensated by project proponent and they will be encouraged to participate in project activities during construction and operation phases. The consultations are recommended be made in future to facilitate the community at the local level.

The consultations should be carried out during the construction and operation phases of the Project. Efforts are recommended to maximize the consultations during the project implementation. The consultations will be carried out with the objectives to develop and maintain communication linkages between the project promoters and stakeholders, provide key project information to the stakeholders, and to solicit their views on the project and its potential or perceived impacts, and ensure that views and concerns of the stakeholders are incorporated during the implementation with the objectives of reducing or offsetting negative impacts and enhancing benefits of the proposed Project. The framework for the future consultations is elaborated in **Table 6.7.**

**Table 6-7: Future Consultations Framework**

| Sr. No. | Stakeholders | Project Phase | Frequency of Consultation |
|---|---|---|---|
| 1 | Provincial Government Departments | • Pre-Implementation<br>• During the Project Implementation | • One round of consultation before start of implementation of project.<br>• Monthly during construction phase and bi-annually during operation phase of the project. |
| 2 | District Level Government Officials | • Pre-Implementation<br>• During Project Implementation | • One round of consultations before start of implementation of project.<br>• Monthly during construction stage and bi-annually during operation phase of the project. |


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| Sr. No. | Stakeholders | Project Phase | Frequency of Consultation |
|---|---|---|---|
| 3 | PAPs | • Pre-Implementation<br>• During the Project Implementation | • One rounds of consultations before start of implementation.<br>• Fortnightly during construction stage and bi-annually during operation phase of the project. |
| 4 | Surrounding Villages | • Pre-Implementation<br>• During Project Implementation | • One round of consultation before start of implementation.<br>• Quarterly during construction stage and bi-annually during operation phase of the project. |
| 5 | Local Elders | • Pre-Implementation<br>• During Project Implementation | • One round of consultations before start of implementation of project.<br>• Monthly during construction stage and bi-annually during operation phase of the project. |
| 6 | Women | • Pre-Implementation<br>• During Project Implementation | • One rounds of consultations before start of implementation.<br>• Fortnightly during construction stage and bi-annually during operation phase of the project. |


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# 7 GRIEVANCE REDRESS MECHANISM

The grievance redress mechanism (GRM) is important for developmental projects where ongoing risks or adverse impacts are anticipated. This mechanism serves as a way to meet requirements, prevent and address community concerns, reduce risks, and assist larger processes that create positive social change. The major objective of GRM is to implement and maintain a procedure for handling the environmental and social concerns of the project stakeholders. This procedure will include a redress mechanism scaled to the project's identified risks and adverse impacts, focusing on stakeholders.

WAPDA will establish a Grievance Redress Committee (GRC) to facilitate the resolution of complaints by Project Affected People (PAPs) and grievances about the project's environmental performance. The GRC will be coordinated by the Chief Resident Engineer and Environment Head. The GRC will address affected people's concerns and complaints promptly, using an understandable and transparent process.

## 7.1 COMPOSITION OF GRC

The GRC will work directly under the supervision of the Chief Resident Engineer. The following members are recommended to form a GRC to look into environmental matters.

- WAPDA Environment Cell
- Environment and Social Head of E&ST
- Representatives from PAPs
- Environmental Engineer of Management Consultant
- Environmental Engineer of Construction Contractor

The Environment and Social Head of E&ST will nominate one member of GRC and shall act as Project's Environmental Grievance Officer (PEGO). He will review the case on merit and address the problem in accordance with prevailing rules/ procedures applicable to such grievances as per EMP. The PEGO will then refer the case to GRC for the final decision, whether to update and make necessary amendments in EMP. The GRC will deliver its decision within thirty (30) days of registration of the case. If the affected person does not receive a response from GRC within thirty (30) days of the registry of the complaint, he/she can appeal to the Environment and Social Head of E&ST, who should act on the complaint/ grievance within two weeks of the day of its filing. If the affected person is not satisfied with the decision of the Environment and Social Head of E&ST, then it can be referred to higher authorities / relevant government departments for its resolution. As a last resort, he/she may submit the complaint to GB-EPA.

## 7.2 RESPONSIBILITIES OF GRC

The responsibilities of GRC will include the following;

- The GRC shall review, consider and resolve grievances related to environmental issues during implementation received by the PD office of the Project.
- Environmental Specialist of MC is responsible for conducting investigations on these grievances.

Any grievances presented to the GRC should ideally be resolved on the first day of the hearing or within a period of one week, in case of complicated issues requiring additional investigations.


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GRC is empowered to take the decision which is binding on WAPDA and considered final.

GRC meeting will be held in the PD office or other locations agreed upon by the committee. If needed GRC members will conduct field visits to verify and review the issues in dispute.

### 7.3 PROCEDURES FOR FILING THE COMPLAINTS

Any affected person can register his complaint through an application at the PD office. The PD will direct the Environment and Social Head of E&ST to address the complainant on the same day. The Environment and Social Head of E&ST will have a maximum of one week to resolve the complaint. If the complaint is not addressed within a week's time, then the complainant can raise a grievance with the GRC.

There are several ways one can report a grievance:

- Contact the PEGO of GRC over the phone. The contact details will be provided in the PD office.
- Send an email to the address provided in the PD- office.

The grievance will be reviewed and will be decided by the GRC. If the grievance is not concerned with the project-related activity or the project authority finds that they are working within the applicable GB-EPA standards, the grievance will not be further processed. In these cases, this will be explained in writing to the grievant.

In all the other cases the GRC will investigate whether they have failed to work to the intended standard and if they have identified measures that might be taken to protect against the incident occurring again.

The grievance mechanism will be made public through public consultations and information leaflets during implementation.

### 7.4 TYPE OF GRIEVANCE

The following are some environmental issues that could be subject to the grievance from the affected people, concerned public, and NGOs.

- Dust, noise, and air pollution from construction activities
- Nuisance
- Intensive schedule of construction activities
- Inappropriate timing of construction vehicle flow
- Traffic Movement
- Water Pollution
- Waste disposal
- Disturbances to flora and fauna
- Health and safety
- Criminal activities
- Failure to comply with standards or legal obligations
- Non Compliance of EMP
- Social and Cultural Issues.


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# 8 ANTICIPATED ENVIRONMENTAL IMPACTS & MITIGATION MEASURES

## 8.1 GENERAL

This chapter identifies the potentially significant beneficial as well as adverse impacts of the pre-construction, construction and operational phases of the proposed Project on the physical, ecological and socio-economic domains of the environment. Moreover, appropriate, technically viable and economically feasible mitigation measures have been suggested for each potentially adverse impact.

Attabad Lake was formed on January 4, 2010, when a huge mass from the right bank of Hunza River slided down near Attabad Village and blocked Hunza River. The inflow filled upstream valley created a reservoir 22 km long till the end of May 2010. Attabad Lake is about 15 km upstream of Ganish Bridge and about 111 km upstream from Gilgit. Therefore, ALHHP will utilize the Attabad Lake water and head for the generation of the Hydel Electricity. Therefore, due to the implementation of ALHPP, no major adverse impacts are anticipated.

## 8.2 METHODOLOGY FOR IMPACT IDENTIFICATION

Selection of an appropriate and customized methodology for the impact assessment is critical for the whole outcome of an EIA study. The identification, categorization and evaluation of impacts were carried out by using various tools such as impact screening checklist, impact assessment matrices and overlay. Based on the notion of significance criteria each impact was classified. Based on the vast experience of the experts in the field of impact assessment, identification of the potentially significant and non-significant environmental impacts different tools has been utilized as detailed below:

### 8.2.1 Screening Checklist

Based on the findings of desk studies, processed satellite imageries, previous studies, screening checklist was prepared to screen out the potentially significant adverse environmental impacts during the construction and operation phases of the proposed Project. The objective of the impact screening is to assess the significance of the issues related to the atmosphere, climate, water resources, land resources, ecological environment, socio-economic environment, transport, infrastructure and communication, natural risks, hazards and external constraints of the Project for the proposed development. After the compilation of baseline information, processing of acquired satellite imagery, the screening checklist was filled to screen out the positive and adverse impacts of the proposed Project during the construction and operational phases.

### 8.2.2 Impact Matrices

Various EIA methodologies are available for identification of impacts including the checklist and project impact matrix. Among these methods, project impact matrix was used as impact identification methodology for the identification of temporal based impacts.

The Impact Evaluation Matrix was developed by placing project activities along one axis (i.e. Y-axis), and on the other axis (i.e. X-axis) the different environmental parameters likely to be affected by the proposed project actions grouped into categories i.e. physical, ecological and socio-economic environment. For the impact assessment, project impact evaluation matrix is used by dividing the project action into different phases (design/pre-construction, construction and operational phases).


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### 8.2.3 Overlays

In order to identify spatial based impacts, overlays were used. An overlay is based on a set of transparent maps, each of which represents the spatial distribution of an environmental characteristic. Information for an array of variables such as land use, infrastructure, vegetation etc. is collected for the standard geographical units within the Study Area are recorded on a series of maps, typically one for each variable. These maps are overlaid to produce a composite map. The resulting composite maps characterize the area's physical, social, ecological, land use and other relevant parameters related to the location of the proposed project interventions (such as construction of Coffer Dams, Sediment Flushing Tunnel/Under sluice, Weir, Headrace Tunnel, Surge Tank, Penstock, Powerhouse, Tailrace Channel, Switchyard and Project colony).

### 8.2.4 Notion of Significance

The "notion of significance" was based on the following criteria:

- **Extent:** The scale of impact, i.e., limited to the immediate areas of development activity (the site); limited to within a distance reach of the development; affecting the region as a whole; or occurring at a national or international scale;
- **Duration and Frequency**: A prediction/forecasting of the lifetime of the impact: i.e., short-term; medium term; long term with the impact ceasing after the operational life of the development; or considered permanent and how many times the event will occur during that period;
- **Intensity:** A description of the intensity (magnitude/size) of the impact: i.e., high, medium, low, or negligible (no impact). The specialist studies must attempt to quantify the magnitude of impacts and outline the rationale used. Where appropriate, national standards are to be used as a measure of the level of impact;
- **Reversible/Irreversible:** Changes considered irreversible, for example, the loss of biodiversity within a river due to a change in water quality;
- **Probability:** The likelihood that the event will actually occur; and
- **Legal Restriction:** If the action is likely to affect, or be affected by a legal restriction.

Taking into account these criteria, potential significance was classified as either:

- **Low:** an impact for which no mitigation is necessary;
- **Medium:** an impact that requires effective mitigation; and
- **High:** an impact, which, if not mitigated, could stop the Project from proceeding.

The potentially significant impacts were then further investigated in detail to carry out a comprehensive assessment of the significant impacts.


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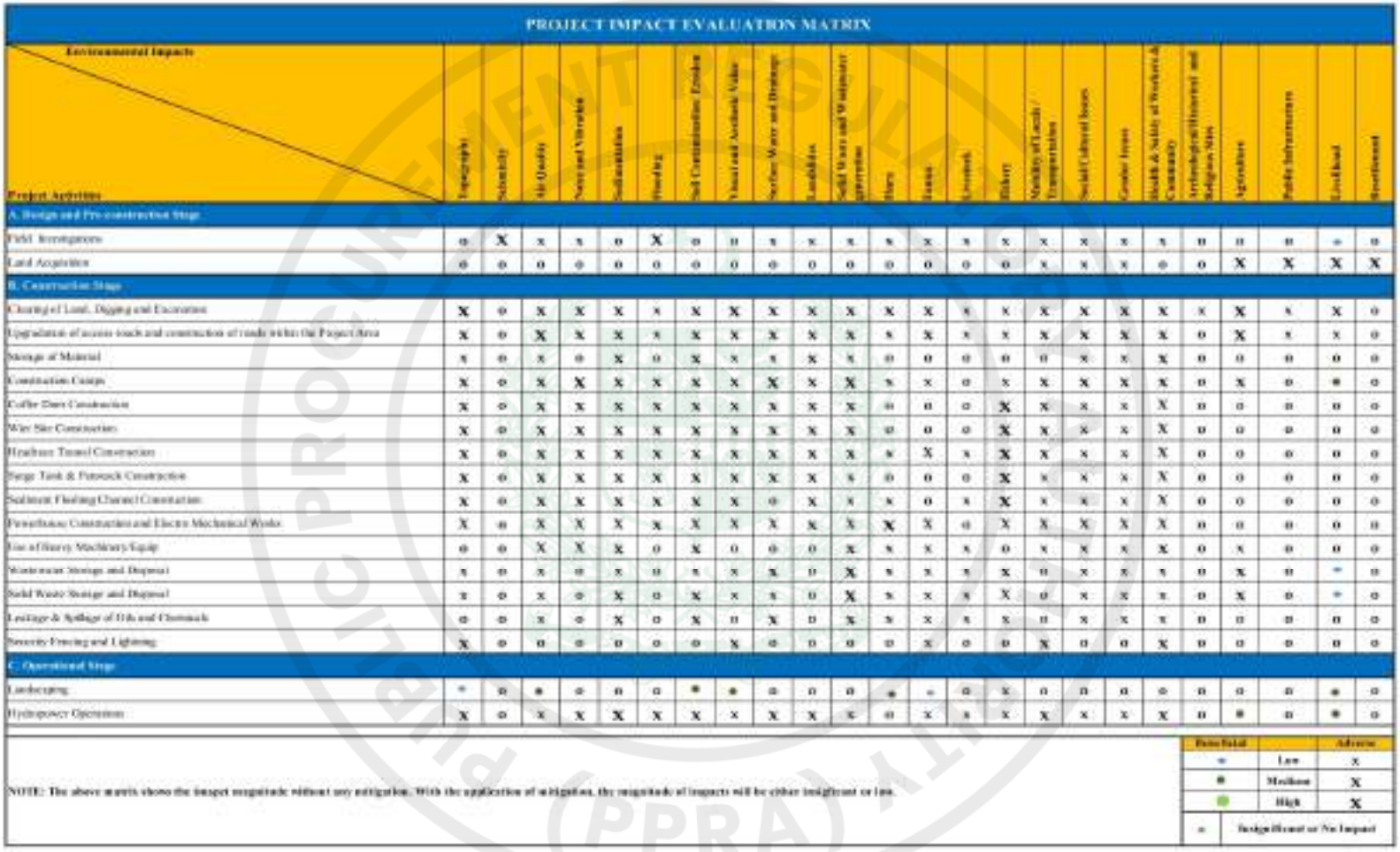

PROJECT IMPACT EVALUATION MATRIX

| Environmental Impacts / Project Activities | Topography | Seismicity | Air Quality | Natural Vibration | Sedimentation | Flooding | Soil Contamination/ Erosion | Unusual Aesthetic Value | Surface Water and Drainage | Landslides | Solid Waste and Wastewater generation | Flora | Fauna | Livestock | Fishery | Mobility of Locals / Transportation | Social Cultural Issues | Gender Issues | Health & Safety of Workers & Community | Archaeological/Historical and Religious Sites | Agriculture | Public Infrastructure | Livelihood | Resettlement |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **A. Design and Pre-construction Stage** | | | | | | | | | | | | | | | | | | | | | | | | |
| Field Investigations | o | X | x | x | o | X | o | o | x | x | x | x | x | x | x | x | x | x | x | o | o | o | + | o |
| Land Acquisition | o | o | o | o | o | o | o | o | o | o | o | o | o | o | o | x | x | x | o | o | X | X | X | X |
| **B. Construction Stage** | | | | | | | | | | | | | | | | | | | | | | | | |
| Clearing of Land, Digging and Excavation | X | o | X | X | X | x | X | X | X | X | X | X | X | x | x | X | X | X | X | x | X | x | X | o |
| Upgradation of access roads and construction of roads within the Project Area | X | o | X | X | X | x | X | X | X | X | X | x | X | x | x | X | X | X | X | o | X | x | x | o |
| Storage of Material | x | o | x | o | X | o | X | x | x | X | x | o | o | o | o | o | x | x | X | o | o | o | o | o |
| Construction Camps | X | o | X | X | X | X | X | X | X | X | X | x | x | o | x | X | X | X | X | o | X | o | * | o |
| Coffer Dam Construction | X | o | X | X | X | X | X | X | X | X | X | o | o | o | X | X | x | x | X | o | o | o | o | o |
| Weir Site Construction | X | o | X | X | X | X | X | X | X | X | X | o | o | o | X | X | X | x | X | o | o | o | o | o |
| Headrace Tunnel Construction | X | o | X | X | X | X | X | X | X | X | X | x | X | x | X | X | x | x | X | o | o | o | o | o |
| Surge Tank & Penstock Construction | X | o | X | X | X | X | X | X | X | X | x | o | o | o | X | x | x | x | X | o | o | o | o | o |
| Sediment Flushing Channel Construction | X | o | X | X | X | X | X | X | o | X | x | x | o | x | X | x | x | x | X | o | o | o | o | o |
| Powerhouse Construction and Electro Mechanical Works | X | o | X | X | X | X | X | X | X | X | X | X | X | o | X | X | X | X | X | o | o | o | o | o |
| Use of Heavy Machinery/Equip | o | o | X | X | X | o | X | o | o | o | X | x | x | x | o | x | x | x | X | o | x | o | o | o |
| Wastewater Storage and Disposal | x | o | x | o | x | o | x | x | X | o | X | x | x | x | X | o | x | x | x | o | X | o | + | o |
| Solid Waste Storage and Disposal | x | o | x | o | X | o | X | x | x | o | X | x | x | x | X | o | x | x | x | o | X | o | + | o |
| Leakage & Spillage of Oils and Chemicals | o | o | x | o | X | o | X | o | X | o | X | x | x | x | x | o | x | x | x | o | o | o | o | o |
| Security Fencing and Lighting | X | o | o | o | o | o | o | X | o | o | o | o | X | o | o | X | o | o | X | o | o | o | o | o |
| **C. Operational Stage** | | | | | | | | | | | | | | | | | | | | | | | | |
| Landscaping | + | o | * | o | o | o | * | * | o | o | o | * | + | o | x | o | o | o | o | o | o | o | * | o |
| Hydropower Operations | X | o | x | x | X | x | x | x | x | x | x | o | x | x | x | x | x | x | x | o | * | o | * | o |

NOTE: The above matrix shows the impact magnitude without any mitigation. With the application of mitigation, the magnitude of impacts will be either insignificant or low.

| Beneficial | | Adverse |
|---|---|---|
| + | Low | x |
| * | Medium | X |
| @ | High | X |
| o | Insignificant or No Impact | |

**Figure 8-1: Project Impact Evaluation Matrix**



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## 8.3 ANTICIPATED POSITIVE IMPACTS OF THE PROJECT

### 8.3.1 Environmental Benefits

The GB is known for their outstanding natural beauty, high peaks and landscape and it is a popular destination among tourists from both Pakistan and abroad. The GB offers tourists opportunities for outdoor activities such as hiking, fishing and trophy hunting. During construction phase of the project, the related equipment and influx of people will temporarily affect the visual and landscape values of this area. However, during operation phase the existence of the weir, headrace channel, powerhouse and other structures will change the visual amenity of the Project area impacting on the surrounding landscape and views.

The Project not only reduces or replaces equivalent electricity generation sources with all the associated environmental benefits but it will also help to avoid all associated pollution caused through extraction, processing, storage and transportation of conventional fuels required for fossil fuel power generation plants. The Project will avoid annual releases of about 149,476 tons of $CO^2$ from an equivalent thermal plant which have a corresponding reduction in atmospheric pollution.

The sustainable power supply with the development of the proposed Project is likely to attract more tourists in the Project area and will increase the local business and recreational activities. Impact relating to recreation activities is considered to be moderately positive.

### 8.3.2 Employment

Electric power is a prerequisite to any other investments. Without electricity both human and physical resources will remain unutilized for increasing welfare of the masses for providing income opportunities at or near the level being available to people in the developed part of the country.

The proposed Project will also provide skilled and unskilled jobs during the implementation phase and a limited number of jobs during operation and maintenance. This will be a bonus for the locals of the area; those are migrating to down country for employment. Considering the other planned hydropower projects in the region, a highly skilled human resource will be developed which can be used in hydropower projects planned in the near future.

### 8.3.3 Impact on the Local Economy

Increased incomes in the area will encourage the formation and growth of local businesses, which will result in new indirect employment opportunities. In combination with programs for assistance and advice, opportunities will arise both to improve agricultural productivity and to develop new businesses.

During the operation phase, the main economic benefits of the Project will be those resulting from increased power availability locally. The lack of reliable and economic power supplies is considered a key constraint in the development of the entire Project area.

### 8.3.4 Exploitation of Natural Resources

The non-availability of electricity is a major constraint to undertake farm cultivation program on a large scale. There are no cold storage facilities to preserve fruits which can earn substantial income to the orchard growers. Hunza and Nagar valleys have precious mineral resources which have remained unexploited. The availability of electricity will certainly develop a set up on large scale to preserve fruits and for exploration of minerals.


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### 8.3.5 Tourism

The Gilgit-Baltistan region and its valleys are tourist's paradises for tracking and mountaineering. At present a few opportunities under Govt.'s social and infrastructure development programs are available for the educated and skilled workforce in various trades. The reliable energy sources and transmission network are key factors for the development tourism and mountaineering.

### 8.3.6 Trade Route to China

The opening up of Gilgit-Baltistan region to China has provided an incentive to the local entrepreneurs for self-employment and outlets for income generation. Hunza is developing into a central city for economic activities for tourism. With the provision of the basic infrastructural facility of electricity, Hunza and its surrounding towns have the potential for development in the coming years. Sost is the last town of Gojal, Upper Hunza inside Pakistan on the Karakoram Highway before the Khunjerab Border. Currently, this region is also facing the shortfall of electricity and only Misghar power station is installed nearby this town. After commissioning the Proposed Project, current electricity shortfall scenario will be changed and routine trade will be accelerated.

### 8.3.7 Impacts on Social Life

The Project with an installed capacity of 54 MW will generate 373.69 GWh of electricity annually which will assist in meeting power demand of the Hunza Region. The project will implement several programs that are designed to improve living standard of the area. These programs will provide improved health, education and infrastructure facilities while other programs will provide alternative source of income and create improved employment opportunities.

Access roads will be built as part of the Project and will facilitate the people for goods and services accessibility. After completion of the Project, these facilities and infrastructure will be available to the general public. Moreover health facilities created during the construction phase will be available to local communities.

### 8.3.8 Clean Development Mechanism (CDM) Benefits

The CDM is an emission reduction (ER) trading agreement under the Kyoto Protocol between two countries, where greenhouse gas emission is reduced in a non-annex country and transferred to another country. Recently a number of international organizations such as Asian Development Bank (ADB) have established a means of purchasing (CERs) units. Unit can be traded in the open market on exchanging.

For the purposes of this analysis it is assumed that 373.69 GWh generated annually by this project will displace about 149,476 ton of $CO^2$ at 0.40 kg/kWh. One ton of CO2 corresponds to CER which is currently valued about 1.5 US$. Therefore, the CDM benefits worth will be 29.921 million PKR per annum.

## 8.4 ANTICIPATED IMPACTS DURING PRE-CONSTRUCTION PHASE

This section identifies the potentially adverse environmental impacts anticipated during the pre-construction phase of the Project along with their mitigation measures.


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### 8.4.1 Physical Environment

#### 8.4.1.1 Impacts due to Field Investigations

**Potential Impact**

Low level adverse impacts on the air quality, increase in noise level, contamination of surface water quality and soil erosion due to the pre-construction activities like geotechnical investigations including drilling, topographical surveys and seismic investigation will affect the existing settings. Activities like drilling, blasting, movement of machines and setup of EPC Contractor and Consultant camps will also impact the soil, wildlife, noise levels etc. This impact would be of medium significance.

**Mitigation Measures**

Good engineering practices and Standard Operating Procedures (SOPs) are required to be adopted by the EPC Contractor to mitigate this impact.

Measures such as sprinkling of water on the roads and dirt tracks, use of water to reduce air pollution during the stone crushing operation and tuning of vehicles and equipment will reduce the air pollution. The excavated material will be managed by ensuring proper storage areas located far away from the water bodies. The choice and design of these measures such as reduction of slope gradient and height, reduction in slope angle, removal of unstable material, use of reinforcement material etc. will be the responsibility of the EPC Contractor. The EPC Contractor will be required to train his workforce in the storage and handling of materials, like oil, diesel, petrol and chemicals, etc., which may potentially cause soil contamination. Special measures will be adopted to minimize the impacts on the nearby settlements such as avoiding noise generating activities during night time, etc.

#### 8.4.1.2 Seismic Hazard

**Potential Impact**

The Project area falls in Seismic Zone 2B (moderate hazard), which represents Peak ground acceleration from 0.16 to 0.24g, where g represents acceleration due to gravity. In this Zone, designing of various types of structures are done on the basis of Peak Ground Acceleration (PGA). A high intensity earthquake impacting the poorly designed project site can adversely impact the future development.

This factor requires special consideration of the designers keeping in view of the above points and the impact of the earthquake of October 08, 2005.

The main tectonic features around the project site within a radius of 200 km which could be controlling the maximum earthquake hazard are as follows: Hunza Fault, Main Karakoram Thrust (MKT) and Main Mantle Thrust.

The significance of impact is high to medium adverse.

**Mitigation Measures**

The proposed structure should be designed to withstand moderate to high earthquakes, a very careful analysis, followed by ICOLD Guidelines and using latest software, of the situation will be required during the design stage. For seismic hazard analysis, updated structural and seismic evaluations should be consulted. Moreover, geo-technical investigations must be conducted prior to construction phase.


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Continuous monitoring of the behavior of faults will be required during the operation stage and contingency plans to deal with such a situation must be part of the project management. Instruments to monitor seismic activity must be installed at the time of construction.

Based on the analysis, the following earthquakes design parameters are concluded and recommended for the proposed project:

**Operation Basis Earthquakes (OBE):** OBE at return period of 145 years is recommended as follows: OBE Horizontal = 0.24 g and OBE Vertical = 0.17 g

**Safety Evaluation Earthquakes (SEE):** For the design of dam / weir, the following PGA 'g' values for SEE (Safety Evaluation Earthquakes) are recommended: SEE Horizontal = 0.44g and SEE Vertical = 0.29g

For the design of appurtenant structures, the following PGA 'g' values for SEE (Safety Evaluation Earthquakes) are recommended: SEE Horizontal = 0.38g and SEE Vertical = 0.26.

#### 8.4.1.3 Impacts on Flooding

**Potential Impact**

Flooding of the Hunza River at the weir site is not a common feature although some floods of high intensity have been recorded in the past at upstream site e.g. the Glacial Lake Outburst Floods (GLOF) at Shimshal River.

Flood has been estimated from the available record. The maximum peak daily discharges of Danyor Bridge station at Hunza Rivers for every year recorded. The instantaneous peaks will definitely be higher than the measured daily flows. Instantaneous peak flows of Danyor Bridge station for the period 1966 to 2024 have been calculated and generated one day maximum peak Instantaneous flow for every year at proposed weir site. The estimated instantaneous peak flow for the period of 1966-2024 at Attabad Lake is graphically represented in the **Figure 8.2**.


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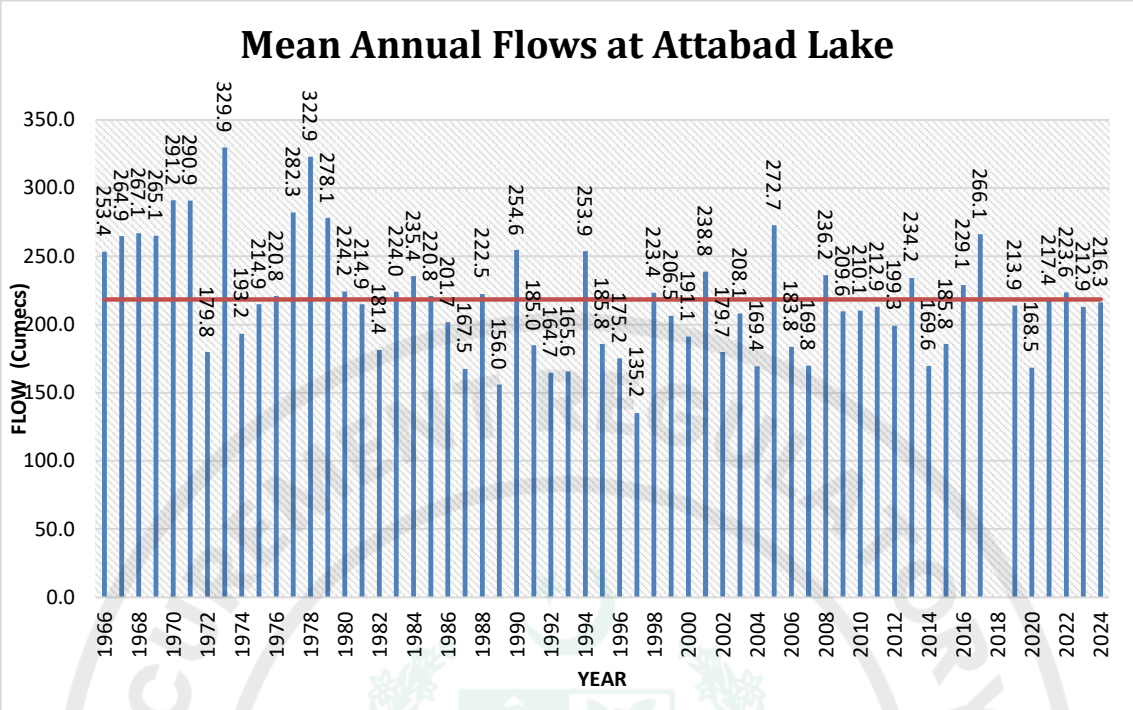


**Figure 8-2: Instantaneous Peak Flows at Attabad Lake HPP Site**

Keeping in view the flood estimation against returns periods by using different distributions, it is recommended to adopt Gumble Distribution against 10,000 years of return period with flood outcomes of 3,250 m³/s for the selection of design flood at the proposed weir site. A design flood of 3,250 m³/s, corresponding to a 10,000-year return period, has been selected for the design of hydraulic structures at the weir site. [16]

The flow in Hunza River varies greatly at different times of the year, the discharge is at a minimum during the colder months when Attabad Lake is frozen, and there is a rise of water in spring and early summer season when glaciers melt.

Recently a massive GLOF occurred in Hunza district's Hassanabad village sweeping away the Hassanabad Bridge on the Karakoram Highway. The Shisper Glacier started discharging 5,000 cusecs of water owing to premature melting, leaving Hunza, Gilgit disconnected.

As river water will pass through the headrace tunnel and overflow spillways, there is a chance that these tunnel and spillways could not accommodate the flows in abnormal years, which may pose a threat to the main structures and this impact may be treated as High Significant.

**Mitigation Measures**

Keeping in view the different types flood estimations and generation of high peaks due to GLOFs, it is recommended to adopt design flood of 10,000 years return period at weir site. Therefore, design flood of 3,250 m³/s at weir site has been assumed for the calculations of design of structures.

It is also suggested to have close monitoring of Glaciers in Hunza Region to have better judgment of GLOFs and remedial measures for the safety of Attabad Lake and downstream

[16] *Using Hydrologic Engineering Center's (HEC) Statistical Software Package (HEC-SSP) Software.*


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areas. However comprehensive study will be undertaken during Detailed Engineering Design of the Project by EPC Contractor.

#### 8.4.1.4 Resource Conservation

**Potential Impact**

Resources involved in the construction of proposed Project would include water, fuel and construction materials.

Excessive water consumption by the construction staff may stress water resources in the Project Area and in certain cases may disturb the existing water supplies in the Project Area. Construction material to be used for construction includes coarse aggregates, fine aggregates, asphalt, cement, sand, lining material, earthworks, reinforced and structural steel etc. . Almost all the materials to be used in the construction of proposed Project are non-renewable and therefore their efficient use is necessary for the future use.

Fuel will be used to operate construction machinery. Efficient use of energy resources is important to reduce air emissions. For conservation of energy, efficiency of the engines and burning processes is important. The impact significance is medium adverse.

**Mitigation Measures**

Following practices shall be adopted to conserve these natural resources:

- Use water bowser tanks for construction works and mineral water bottles/ ground water for drinking purpose;
- Reduction of wastage of water through training of workers involved in water use;
- Reuse of construction waste materials may be adopted wherever possible;
- The efficient and well maintained equipment and machinery should be used;
- The equipment and machinery should be turned off when not in use;
- Ensure adequate insulation to reduce heat loss through batching plants;
- Regularly monitor CO and CO2 content of the flue gases to verify that combustion systems are using practical excess air volumes; and
- A good camp design and an efficient worksite management plan can help the contractor to reduce the water demand, wastewater and solid waste volumes to the lowest levels.

### 8.4.2 Ecological Environment

#### 8.4.2.1 Flora

**Potential Impacts**

During the pre-construction phase, activities such as installation of construction camps, construction of temporary/access roads and mobility of construction staff may damage the local vegetation/trees. As the heavy machinery and camps will be moved and installed, which require significant space due to which available vegetation is expected to be removed. This impact is medium significant and needs to be encountered prior to the start of construction stage.

**Mitigation Measures**


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- The camps, mobility of machinery and construction of temporary/access road should be properly planned and well designed to avoid any loss to local green cover;
- It is recommended to establish the construction camps where minimum or no vegetation exists, as per criteria provided in section 3.7.12;
- Similarly, the alternate routes for roads and location for camps are recommended where no loss of vegetation is expected; and
- An inventory of trees/vegetation may be prepared by the EPC Contractor with the help of concerned department (Forest) before clearing the site.

#### 8.4.2.2 Fauna

**Potential Impacts**

As movement and installations of machinery and vehicles will take place so noise and habitat loss is expected. The routes of the available wildlife and other habitats may be affected due to camps set-up and machinery movements and installations. Temporary access road (if any) may also affect the habitat of locally available fauna. This impact is low significant.

**Mitigation Measures**

- The standard measures must be adopted to minimize noise due to machinery movements and installations;
- EPC Contractor shall ensure the compliance with NEQS.
- Wildlife movements and routes must be considered during activities and should be avoided to their maximum level;
- The camps shall be properly fenced and gated to check the entry of animals in search of eatable goods; and
- Wastes of the camps shall be properly disposed of to prevent it being eaten by local fauna/avi-fauna, as it may be hazardous to them.

#### 8.4.2.3 Aquatic Life

**Potential Impact**

Fisheries Department Hunza has introduced several thousand fingerlings of exotic fish species namely Salmo Trutta Fario ( Brown Trout ) at Attabad lake and downstream river during the period from 2012 to date for propagation and the said specie has made breeding grounds at Attabad lake and downstream as well. Besides this a number of indigenous fish species also exist in the same water bodies having commercial as well as ecological importance. The destruction of habitat will have significant adverse impact on the aquatic life and fisheries.

Fish usually migrate from one place to another for search of food, shelter and spawning/breeding. Due to implementation of the proposed Project fish migration might be affected up to some extent. Water requirements and movement of aquatics along with other risks may also be anticipated due to the proposed project. This impact is categorized as medium to high significant.

**Mitigation Measures**


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- Annual restocking plan of fish fingerlings shall be included in the project to compensate the stock depletion due to decrease in fish breeding grounds.
- Fish ladder shall be in sure for freely movement of fishes;
- Fish screening system shall be developed so that fish may not be trap at fore bay or penstock pipe or channel.
- Besides the above mentioned points, a Fisheries research unit and a brown trout hatchery with research/management staff should be established at the project side for research purposes as well as impact assessment during construction as well as operational phases of the said project.
- The establishment of fish hatcheries under this project should be ensured by GB Fisheries Department, Hunza in close consultation and coordination with GB EPA;
- The minimum flow to be ensured through the weir during the whole year. In case the hydrological records are enhanced, the figure of minimum requirement for maintenance of aquatic ecosystem has to be revised likewise;
- To conserve the freshwater fishery resources, it is important to involve fisheries scientists and local communities in all study phases of proposed project;
- Moreover, the impact on fish fauna, both up and downstream of the project site specially the migration patterns and breeding grounds need to be taken into account during all stages of the project and should be monitored by the contractor specialized professionals in consultation with GB, Fisheries Department Hunza;
- GB, Fisheries Department has authority to update, change and add/ recommend any standard as per law of land and in best public interest; and
- The custodian Department should have a close liaison with GB EPA and Fisheries Department GB to ensure the conservational aspects of fisheries during all stages of the project to avoid any negative impacts on local natural environment.

### 8.4.3 Socio-Economic Environment

#### 8.4.3.1 Permanent Land Acquisition

**Potential Impact**

Permanent land will be acquired for the Project components such as Powerhouse, Weir & Associated Structures, Access Roads and Project Colony. Total permanent land to be acquired is approximately 183 acres (05 acres for Contractor's Camp, 60 acres for Project Colony and Powerhouse Area, 103 acres for Intake Area and Access Corridor and 15 acres for Spoil Area) which includes both private and government land. This will result in loss of land. Similarly, due to the impounding of reservoir area, based on 2424 m.a.s.l, the estimated land required is 777.05 acres. However, the estimation of land requirement will be finalized after the detail design by the EPC Contractor.

The ownership record of affected land will be prepared by the Revenue Department according to separate categories of the land. The significance of impact is high adverse needs to be encountered prior to the start of construction stage.

**Mitigation Measures**


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Government owned land for the Project area will be acquired as per the policy of government of GB. While private land will be acquired as per provision of LAA, 1894. The process of land acquisition will start before the Project will enter into construction phase and section-4 of land acquisition act, 1894 will be notified by relevant agency.

The process of land acquisition and compensation should be followed in a transparent manner to minimize the impacts to provide judicious compensation to the displaced by providing sufficient budget in the project cost.

#### 8.4.3.2 Temporary Land on Rental/Lease Basis

**Potential Impact**

During the construction activities, EPC Contractor will establish contractor camps, storage areas for materials and equipment including vehicles, workshops, stockpile yard, etc. EPC Contractor need to lease the land for these areas in the vicinity of the construction sites. These areas will be acquired on temporary basis by direct negotiation and agreement with the owners or negotiated with or decided by the district administration office. Temporary acquisition will principally be the responsibility of the contractor. The significance of impact is high to medium adverse.

**Mitigation Measures**

Land for above mentioned facilities will be directly rented from the private landowners by the EPC Contractor. The provisions of the Land Acquisition Act (LAA), 1894 will not be involved as the acquisition of the land will be temporary and will be covered by short-term lease agreements between the landowners and EPC Contractor. Temporary acquisition will principally be the responsibility of the EPC Contractor. Rental terms should be negotiated to the satisfaction of the concerned landowners and the agreement should be made in local language to make the process clear.

As mentioned the location of these areas are not finalized yet, therefore a criterion has been suggested which should be followed to avoid the adverse impact on the environment. The land for above mentioned facilities should be selected and leased prior to the start of construction phase.

Lease agreement should also govern the process of site restoration of the leased or rented land after the construction phase and will ensure through the terms of the construction contracts that landowners are compensated according to the terms of the lease agreements and the site restoration plans agreed upon by the EPC Contractor are duly carried out.

The following general site selection criteria have been suggested to be complied by the EPC Contractor:

- Minimize the resettlement, relocation of the existing infrastructure like roads, cultural and religious sites etc. and avoid the cutting of trees;
- It should be elevated to avoid floods and for other security reasons;
- Proximity to the major disaster and emergency management authorities;
- Avoid potentially security vulnerable areas;
- Minimize disturbance to the natural habitats of flora and fauna;
- Avoid densely populated areas/towns;
- Avoid wildlife sanctuaries, national parks and game reserves;


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- Appropriate distance from the sensitive receptors (for instance, minimum 500m); and
- Avoid cultural, religious and historical buildings.

#### 8.4.3.3 Impact on Miscellaneous Structures

**Potential Impact**

In the reservoir area of the proposed project miscellaneous residential, commercial and community structures will be affected due to the project intervention. These structures will be demolished permanently and will have to relocate and move their dwellings elsewhere. The community and religious structures are very sensitive to impact and need special care during execution of the project; because people think that these structures might not be rebuilt if once demolished. A graveyards fall in the reservoir area of the proposed Project. Shifting and demolishing of the graveyard may cause serious social issues. Due to adverse impact on the residential, commercial, and community structures, human disturbance will occur which create magnitude social, gender, livelihood and cultural issues. This impact can be categorized as negative, local, high, permanent and irreversible. The inventory of structures along with the detailed measurement of structures will be completed by the EPC contractor during the phase of detailed planning.

**Mitigation Measures**

- Due consideration should be given to minimum and no impact on the residential, commercial, and religious structures;
- Compensation for the affected structures should be evaluated and provided as per market rates.
- Compensation should be given for all affected crops and trees;
- The effort will be made by making changes in design to avoid the sensitive and religious structures and to minimize the issues at possible extend. If needs demolishing/shifting, a mechanism will be developed for the restoration of these structures during the detailed design by the EPC contractor with the community consultation;
- Affected Persons should be compensated on full replacement cost of each category to construct a new structure of the same type; and
- Proper consultations and coordination's with project affected persons during resettlement process.

#### 8.4.3.4 Other Social Issues

**Potential Impact**

During the planning and design phase of the project, it is anticipated that there will not be any potentially significant adverse impact on the socio-economic environment. Locals may be temporarily disturbed due to the field investigations and drilling activities, disturbance to electricity poles and existing track/roads within project boundary. This impact can be categorized as medium Significant.

**Mitigation Measures**

- Proper compensation and restoration mechanism of public utilities will be considered during the detailed design of the Project;
- Complete rehabilitation of affected public utilities will be ensured;


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- The provision in the design and budget for the relocation of the existing utility infrastructures wherever required shall be finalized in consultation with the concerned department;
- Close coordination with the concerned departments to curtail inconvenience to the residents of the Project Area;
- Timely public notification of unexpected disruption of services; and
- Good engineering practices shall be adopted to avoid or reduce these impacts.

## 8.5 ANTICIPATED IMPACTS DURING CONSTRUCTION PHASE

The construction phase impacts are mostly of a temporary nature and their magnitudes are subject to the engineering management practices adopted during construction. Such impacts are related to soils (erosion and slope stability), water quality, noise, air quality and disruption to the biological environment, public health, interruption of communications, at-risk population / safety, community stability, and cultural and religious values / properties. The anticipated impacts during the construction phase are discussed below.

### 8.5.1 Physical Environment

#### 8.5.1.1 Aesthetics

**Potential Impact**

Attabad Lake is an important recreational site for the tourists including foreign visitors. Construction activities may result in some visual impacts. The construction activities will involve the cutting of trees/bushes, excavation, soil filling and cutting operation. This disturbs the natural scenic value of the environment. In addition to that the sitting of construction equipment and the lacks of resurfacing/replanting of exposed areas are also the leading factor to aesthetic reduction. The impact significance is medium adverse.

**Mitigation Measures**

The adverse environmental impacts related to the aesthetic could be effectively minimized at the construction phase. These will be mitigated by the control of clearing vegetation to the area in the construction limits and by plantation and quick re-vegetation during the construction phase. Good house-keeping, cleaning, efficient solid waste management system should be implemented to improve the aesthetics of the working environment.

#### 8.5.1.2 Topography

**Potential Impact**

Construction activities are not expected to impact the topography of the area significantly except for those areas where physical activities including digging and excavation, storing or dumping sites for excessive material and movement of heavy construction machinery will be carried out. The excavated material will be generated due to the construction of various components of the Project such as construction of Coffer Dams, Sediment Flushing Tunnel/Under sluice, Weir, Headrace Tunnel, Surge Tank, Penstock, Powerhouse, Tailrace Channel, Switchyard and Project colony. The area where excavated material is to be dumped may also be impacted. The impact significance is medium to low adverse.

**Mitigation Measures**

The excavated material will require safe disposal by the EPC Contractor. Most of the excavated material could be used in back filling purpose, where applicable. A detailed development and operation plan for borrow areas must be prepared by the EPC Contractor


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before the starts of extraction of material from each borrow area. EPC Contractor should strictly follow the provisions of approved plan in order to minimize any adverse impact associated with the borrow areas. Likewise, excavated material should be dumped at suitable and approved disposal sites.

#### 8.5.1.3 Landslide

**Potential Impact**

The construction activities for the proposed Project interventions involving cutting of rocks by blasting (where applicable), excavation, dumping of soil and to create space for the headrace tunnel and other structures may disturb the stable geological formation of the area.

High seismic potential and unstable geological formations are two major causes of land sliding in the area. Landslides are common in the project area due to the high steepness, unstable geological formations on both sides of the river and common seismic activities. These affects could promote landslide in unstable area. Furthermore, due to the Project activities, especially in case of blasting or cutting of rocks in some areas, the formation will become loose and the risk of landslides will increase in the immediate vicinity of the construction sites, especially at the right bank of Hunza River, which may be considered as a high adverse impact. The impact significance is high to medium adverse.

**Mitigation Measures**

To avoid the major risks, all structures have been proposed on the left bank of Hunza River. Blasting should be avoided or minimized where possible, if inevitable then low intensity explosive material should be used instead of high intensity explosive material. It is strongly recommended to perform appropriate confirmatory geotechnical investigations all along the alignment of Headrace tunnel and other components for assessing strength parameters of natural material either rocks, moraines or scree. This shall be done so that safety of this major Project component and adjacent areas can be ensured through proper design of cut slopes.

Landslide risks shall be mitigated by the installation of safety barriers at construction sites, and monitoring and informing locals about construction schedules, and any weather events that might exacerbate landslide risk. Construction work will be avoided during rain to the extent possible. The EPC Contractor will prepare the Management Plan for blasting activities and implement the same after approval from the Management Consultant and Client.

#### 8.5.1.4 Site Accessibility

**Potential Impact**

The proposed Project Area falls within the Hunza Valley which is located about 119 km from Gilgit city. The Project site can be accessed through Korakoram Highway (KKH) which is the only major mode of transportation in the Project area. Heavy vehicles will be utilized to transfer construction plants, equipment, construction materials, cement and fuel. These activities may have adverse impacts on the existing infrastructure. Apart from that it may cause air and noise pollution. The impact significance is high to medium adverse.

**Mitigation Measures**

The access roads to the hydropower site have to be pre-determined in consultation with the concerned departments. Access roads would have to be widened and/or improved to carry the anticipated load of traffic.


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During the course of construction of proposed Project, EPC Contractor will provide the signage and/or traffic control to the extent deemed necessary by the traffic utilizing or accessing the site roads. These signs will inform, control, warn, shift, or stop traffic on all site roads affected by the Project's heavy traffic. The following measures will be taken by the EPC Contractor during the construction phase for the effective implementation of the traffic plan:

- National and local traffic rules and regulations, instructions manual for motor vehicle and mobile machinery operation should be followed;
- No one will be allowed to drive motor vehicle or operate mobile machinery without a driving license;
- It should be prohibited to drive or operate vehicle in case of over fatigued or mental disease;
- Traffic speeds on unpaved roads should be limited to no more than allowable traffic speed;
- Traffic speed signs should be displayed prominently at all site entrances;
- A daily routine check-up of vehicles should be conducted no less than 5 minutes before its service;
- Use of appropriate signs, equipment, and traffic control measures that conform to the provisions in the traffic manual of city traffic police;
- Traffic inspection and security during transportation;
- Limit vehicular traffic designated access roads, construction laydown area, parking areas and the Project site;
- All damaged, destroyed or modified pavement legend, traffic control devices, signing and striping associated with the proposed development should be replaced as required prior to issuance of a certificate of occupancy; and
- Construction signs, lighting and barricading should be provided during construction as required.

The EPC Contractor should also be responsible to prepare a comprehensive Traffic Management Plan and follow the conditions of Contract Agreement.

#### 8.5.1.5 Natural Drainage

**Potential Impact**

Construction activities such as excavation, filling and construction will affect the existing soil pattern in the Project Area including water pathways its surroundings. In addition, this will lead to changes in the existing drainage pattern. The conditions will be more hazardous during the flood periods and may affect the construction activities. The impact significance is high to medium adverse.

**Mitigation Measures**

During the construction phase, excavated material should be properly disposed of ensuring that it will not block the natural drainage paths. Open drains for drainage of rain/flood water should be constructed, if considered necessary during construction period.

#### 8.5.1.6 Soil Contamination & Erosion

**Potential Impact**


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During the construction phase of the proposed Project, large quantities of materials, chemicals, fuel and lubricants will be used apart from the generation of solid waste and liquid waste from the construction camps. Fuels and chemicals will be stored at the site for their immediate use, which will contaminate the soil if not handled properly particularly at asphalt plant sites, workshop areas and equipment washing yards.

Similarly, removal of vegetation and shrubs for the purpose of construction activities will lead to loosing of the soil, soil disturbances, and exposure of bare soil surface. This causes problems of soil erosion during rain. Similarly, steep gradients increase erosion on these slopes due to reduced water infiltration and increased runoff accumulation. Soil erosion may also occur in the workshop areas as a result of improper drainage system of equipment washing-yards and improper management of construction activities. The impact significance is high to medium adverse.

**Mitigation Measures**

- Sites disturbed by construction activities will be restored to their original conditions upon completion of construction work and photographic record will be maintained to ensure pre-post subproject conditions intact;
- Soil contamination by asphalt should be minimized by placing all containers in caissons;
- The EPC Contractor will be required to instruct and train their workforce in the storage handling and management of materials and chemicals that can potentially cause soil contamination;
- Material Safety Data Sheets (MSDS) will be strictly followed during handling and storage of chemicals;
- If any contaminated soils are found at the construction sites or at camp sites, they shall be removed and deposited in a sealed pit in at designated area;
- The EPC Contractor will be required to prepare training manual and modules for all the construction related activities along with the schedule of training program and submit to the Supervision Consultant for approval;
- Solid waste generated at the camp sites will be properly treated and safely disposed only in the demarcated waste disposal sites/areas;
- Subproject sites will be selected to avoid or minimize vegetation removal/clearing which would accelerate erosion and increase landslide risk;
- The EPC Contractor shall adopt good engineering practices that will help to control or minimize the soil erosion both at the construction sites and in peripheral areas. All the disturbed areas need to be protected against soil erosion by stripping and stockpiling of all the available topsoil for later re-vegetation. Special slope protection measures will be adopted in the sensitive areas; and
- Site restoration plan for the Project should be strictly followed.

#### 8.5.1.7 Wastewater Generation

**Potential Impact**

Wastewater will be generated at the construction camps, from construction activities an residential colony (for EPC Contractor, the Consultant and the Employer staff). If the generated wastewater is not properly treated or disposed of, this may contaminate the surface water apart from soil contamination. Water from dewatering activities (during rainy season)


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has the potential to contain suspended solids and oil and grease and if disposed of untreated may affect the soil quality. The **Table 8.1** provides anticipated composition and estimate of the wastewater to be generated during the course of the construction phase of the project assuming that on average the water demand per person is 40 liters per day and that 80% of the water demand will become wastewater.

**Table 8-1: Estimated Wastewater Generated by Workers in Construction Camp**

| No. of Workers* | Estimated Total Water Demand** (liters/day) | Estimated Wastewater Generated (liters/day)*** |
|---|---|---|
| 350 | 14,000 | 11,200 |

* Refer Table 3-7 "Estimated Work Force Requirements"

** = (350)x(40) = 14,000 liters/day

*** = 14,000 (80%) = 11,200 liters/day

This 11,200 liters/day (approx.) of wastewater will be generated from the construction camps. This impact would be of medium significance.

**Mitigation Measures**

To dispose the liquid waste generated from the construction activities, the following steps will be taken by the EPC Contractor:

- Domestic and chemical effluents from the construction camp will be disposed by the development of on-site sanitation systems i.e. septic tanks (as provided in **Figure 8.3**);
- The domestic sewage will be treated with biological treatment technology and will be discharged as per NEQS. Proper monitoring to check the compliance of NEQS will be carried out;
- Proper monitoring to check the compliance of NEQS will be carried out. Septic tank will be located adjacent to the construction camp;
- Sewage from construction camps will be disposed of after proper pre-treatment;
- Water discharged to drains should contain a minimum quantity of suspended solids; and
- Site for construction camp will be selected at least 500 m away from the settlements.


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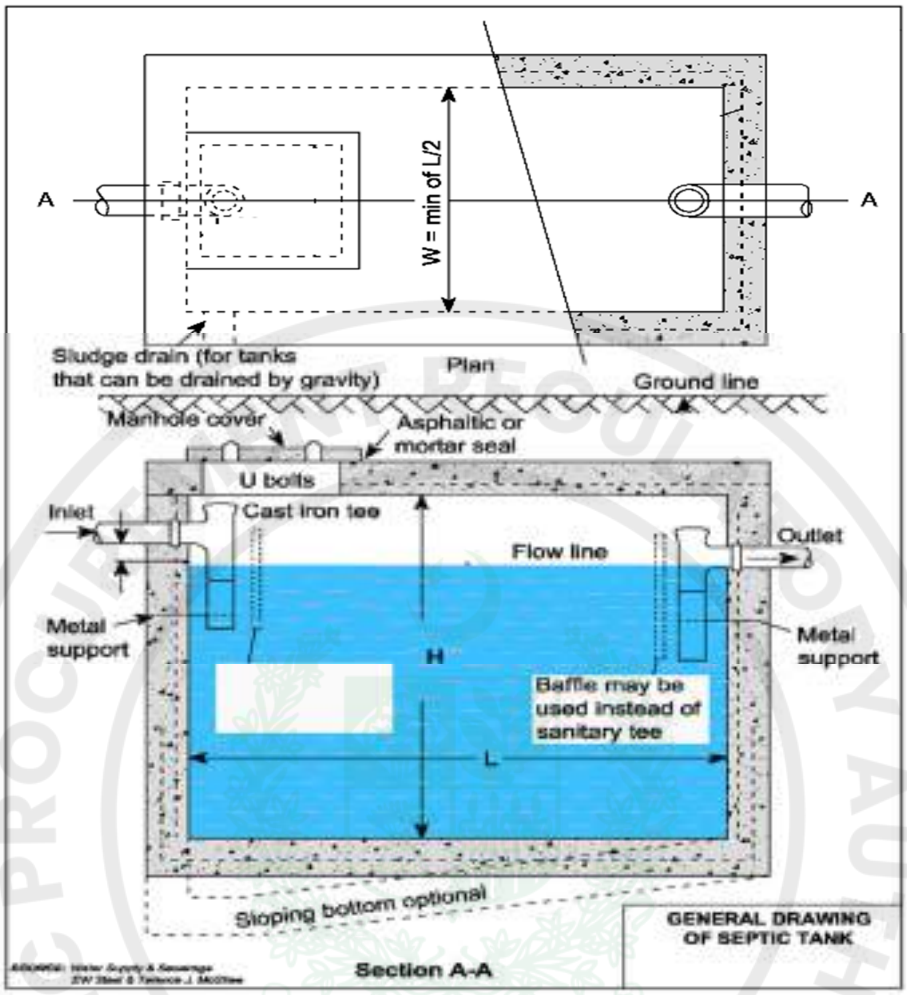


**Figure 8-3: General Drawing of Septic Tank**

### 8.5.1.8 Generation of Solid Waste (Construction, Municipal and Hazardous Waste)

**Potential Impact**

Different types of waste including construction (waste concrete and asphalt, empty containers, excavated material), municipal (from construction camps) and hazardous wastes (including empty containers of paint, lubricants, grease, fuel oil, electrical wiring, pipis etc.) are likely to be generated during the construction phase of the proposed Project and from the EPC Contractor's Camps (the solid waste generation is estimated to be 157.5 kg/day (as per 0.45 kg/capita/day waste generation)[17] for 350 construction workers) which may have potential to serve as breeding grounds for the disease spreading vectors and rodents. During the construction phase, significant quantities of rock will to be excavated. In order to reduce the amount of rock to be disposed, excavated rock can be used in the Project for different types of infrastructural works. The remaining spoil will be disposed in designated and safe disposal areas. Throwing away of solid wastes into water channels may cause blockages in drainage

[17] *The World Bank Report 2012 – What a Waste: A global review of solid waste management. Based on UNEP estimates for waste generation in the Asia Pacific. Average is 0.45 kg/capita/day*


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channels, contamination of nearby water bodies and soil contamination (render them unfit for plantation).

Empty containers containing the toxic, flammable and corrosive materials may pose hazard to the workers. This may result in health risk to work force and public, if disposal site is improperly selected.

All these, if left unattended, can become a source of nuisance and environmental pollution in the subprojects area. Discarded materials and equipment may also pose traffic safety risks if left on or near transport routes. This impact is moderate adverse in nature.

**Mitigation Measures**

- Minimize the generation of spoils by recycling the excavated rock to the maximum extent possible by using them as aggregate material in the concrete works;
- Construction waste will be routinely collected and safely disposed of in clearly demarcated waste disposal sites located near each subproject site following international best practices;
- Waste disposal will be carried out following international best practices and will ensure that there are no negative impacts on soil, water bodies, existing waste management systems, transport routes, and aesthetic value of the area;
- The debris produced during construction would preferably be dumped at nearby depressions rather than being thrown away and left unattended. Leftover material would not be dumped into water bodies;
- The labor workforce (including community labor) will be trained on the handling, storage, and disposal of construction waste. Burning of waste shall be prohibited;
- PPEs shall be provided and worn by the personnel involved in construction activities and training them in their use;
- Waste containers with proper color coding will be provided on site to store different type of waste;
- Site Specific Solid Waste Management Plans (SWMPs) will be developed and implemented by Contractors; and
- It will be ensured that no waste or left over construction material is left behind in the cultivation fields.

#### 8.5.1.9 Surface Water Quality

**Potential Impact**

Surface water quality of the Attabad Lake may get deteriorated due to the construction activities. During the construction phase of the proposed Project, materials like sand, gravel and stones will be required in large quantities. Extraction of the materials will also affect the surface water quality by increasing the sediment load. This water will be used during different construction activities. The movements of heavy vehicles on the unpaved tracks, excavation activities, cut and fill processes in the Project Area, fuel and chemical spills may deteriorate the quality of the surface water. These activities will also increase the sediments and turbidity of the water.

Waste streams can bleed toxic materials from items such as batteries, used computer equipment, leftover paints and pathogenic organisms include specific strains of bacteria like E. coli into the leachate of dumps. Leachate from waste piles caused by exposure to


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precipitation and from residual liquids in the waste itself may contain organic matter, nutrients, metals, salts, pathogens, and hazardous chemicals. If allowed to migrate, leachate can contaminate surface water. This impact is moderate adverse in nature.

**Mitigation Measures**

The excavated material will be managed by ensuring proper storage areas located far away from the water bodies. All the solid waste from the camps should be properly collected at source by placing containers and disposed of through proper solid waste management system**.** To reduce the impact of sediment, load the EPC Contractor should make arrangements such as fine screens and drains to limit the siltation into the water bodies. A simplified sedimentation tank shall be built on the construction site for the primary treatment of the construction equipment wastewater, detergents and mud. Wastewater effluent from the Contractors' workshops and equipment washing-yards should be passed through gravel/sand beds to remove oil/grease contaminants before discharging into the natural streams. This is the general guideline principle for the contractor. Appropriate sanitation and water supply facilities will be provided in the labor camps.

Spillage of fuel/oils and other construction materials shall be contained with best handling/construction practices and strict skilled supervision. The EPC Contractor will ensure that construction debris does not find their way into the water bodies without proper treatment

Treating and disposing the sewage in a manner that the soil and water is not contaminated and ensure compliance with NEQS or international standards/guidelines, whichever is stringent will be followed.

#### 8.5.1.10 Ambient Air Quality and Climate Change Aspect

**Potential Impact**

A large number of machinery and equipment will be deployed at site for the implementation of the Project. Different varieties of machinery/equipment will be required during the construction phase of the Project.

During construction period, the impacts on air quality are mainly due to material movement and the construction activities (particularly blasting of rocks, operation of batching and mixing plants, drilling, stone crushers) causing an increase of emission of carbon monoxide, sulfur oxides, nitrogen oxides, un-burnt hydrocarbons and other greenhouse gases, as well as fine particulate matter. The pollution causing activities during the construction phase are: loading/ unloading and stocking of construction material, transportation of construction and excavated material, diesel generator, construction equipment, vehicles rock cutting operations, site clearance, excavation, concrete batching and concrete mixer. The ambient air quality over the immediate influence area will be affected and the criteria pollutants levels and greenhouse gases in ambient air might increase, over longer distances depending on atmospheric conditions. Emission of greenhouse gases causes global warming and other climatic changes on regional and global scale. Cutting of trees will also reduce the carbon sequestering and overall increase the $CO_2$ content in atmosphere.

The impact of emissions is assessed to be temporary and moderate and is unlikely to have lasting impacts after construction work is complete.

**Mitigation Measures**


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- In order to reduce the dust emissions in the construction area due to material transport and construction activities, provisions will be made for sprinkling of water in the area where earth filling, excavation and other dust emissions causing activities being carried out. It will be ensured that the construction debris is removed on daily basis;
- Construction materials and spoil materials will be transported through trucks covered with tarpaulins. During windy conditions stockpiles of fine material will be wetted or covered with plastic;
- In no case, loose earth will be allowed to pile up along the approach roads/ public access areas;
- PPEs such as dust masks will be made available to the construction workers at the site to avoid potential health hazards;
- Idling of delivery trucks or other equipment will not be permitted during periods of unloading or when they are not in active use;
- Open burning of solid waste at construction site will not be allowed;
- All vehicles and other equipment used during construction will be properly and regularly tuned and maintained;
- Ensure compliance with the NEQS;
- Diesel generator should be fitted with acoustic enclosure and stack of appropriate height for the proper dispersion of emission;
- Awareness programs of causes and effects of climate change will be conducted for mitigating GHG emissions, ensure plantation of trees and use solar panels where possible;
- Regular monitoring of air quality in accordance with the formulated environmental monitoring plan (given in EIA).

#### 8.5.1.11 Noise/ Vibration

**Potential Impact**

Noise and vibration will occur due to the operation of construction machinery and other equipment. The major sources of noise and vibration[18] are construction activities, movement of vehicles, construction equipment, blasting, drilling, pouring equipment, stone crushers and generators etc.

Existing environment of the area is free from noise pollution and the use of machines such as vehicles in the daily activities of the locals is almost negligible. During construction phase, the increase in traffic may also lead to increase in noise levels. Similarly, use of explosives during the excavation and construction will have a significant adverse impact on the safety of the workers. High background noise levels can cause significant disturbance to local wildlife, and have adverse psychological and physiological effects on individuals residing in nearby communities.

[18] *According to British Standards of Noise and Vibration, humans are particularly sensitive to vibration with the threshold of perception typically being in the range of 0.14 to 0.3 mm/sec. Peak Particle Velocity (PPV) and levels above this may cause annoyance. However, significantly higher levels than this can be tolerated for single short-term events and do not cause annoyance or disturbance to humans.*


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Significant noise pollution impacts are expected only during the construction phase of activities involving large civil works. The cumulative effects from several machines can be significant and may cause significant nuisances. In all cases, the impacts are likely to be short-term and mitigatable and will not have any lasting effects once construction activities have completed. The significant impact may be of high magnitude for the labor working in a place that is close to the area where explosives are in operation. This impact medium adverse in nature.

**Mitigation Measures**

- Construction vehicles and machinery will be kept in good working condition, and be properly tuned and maintained through the duration of construction work with the objective of minimizing excessive noise and vibration;
- High noise/vibration emitting equipment will be used during regular working hours (9 AM to 5 PM) so as to reduce the potential of creating a noise nuisance during the night to nearby communities. This equipment will be fitted with noise reduction devices such as mufflers and silencers wherever possible
- The vibration from major construction activities such as excavation, compacting, drilling, blasting, etc. are considered intermittent and short-term, and likely to be tolerated if prior warning is given to potentially affected residents;
- Vibration measurement will be carried out during construction phase by the EPC Contractor near the settlements;
- Personal Protective Equipment (PPEs) shall be provided and worn by the personnel involved in construction activities and training them in their use;
- Construction schedules will be disclosed to all nearby communities within vicinity of project sites prior to commencement of construction work;
- The EPC Contractor shall ensure the compliance with NEQS; and
- All complaints will be recorded and responded to in a timely and professional manner.

### 8.5.2 Ecological Environment

#### 8.5.2.1 Flora

**Potential Impact**

The project will involve destruction of vegetation cover due to the implementation of proposed Project. It is initially examined that approximately 575 number of trees may be affected (**Annex - II**) due to proposed project activities. The number of possibly impacted trees is calculated by using Remote Sensing technique through GIS and field observation. Moreover, no impact on the production of medicinal plants is anticipated, as the area has least number of these plants.

Exhaust of noxious gases from movement of heavy machinery and dust will pollute air which will adversely affect health and vigor of plants. During construction activities the EPC Contractor's workers may damage the vegetation and trees (for use as fire-wood to fulfill the camps requirements). This impact is categorized as medium significant.

#### 8.5.2.2 Loss of Agriculture Land

Due to the impounding of reservoir area, based on 2424 m.a.s.l, it is estimated that about 14.28 acres of crops of agriculture land may be affected. However, it is anticipated that there will be no impact on agriculture land due to the construction activities for other components


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(such as weir, headrace tunnel, surge tank, penstock, powerhouse, switchyard and tailrace). This impact can be categorized as medium significant.

#### 8.5.2.3 Pasture and Grazing Land

The Power House will be constructed on the communal land owned by the Ganish village, having grazing area. Similarly, impounding of reservoir area may also result in loss of vegetation cover which will subsequently affect the community's pasture and grazing area and livestock. This impact is categorized as permanent, irreversible and moderate in nature.

**Mitigation Measures**

- Incorporate technical design measures to minimize removal of trees, if possible;
- Cutting of trees and disturbance shall be avoided, as far as possible so, that negative effects on the process of natural regeneration of species are minimized;
- A tree plantation program shall be formulated with the recommendations and technical support of concerned Forest Department;
- As a principal, ten trees shall be planted in place of felling of one tree in consideration of mortality. Total 5,750 trees will be planted in lieu/compensation of 575 affected trees of similar floral function at the available spaces in/around the project area;
- Proponent shall implement the plantation program with the help of Forest Department and with the consultation of Supervision Consultant;
- The Forest Department shall involve the communities (if required) for carrying out plantation;
- Open fires should be banned in the area to avoid hazards of fire in the area;
- Clearing of vegetation cannot be avoided at the areas specified for project structures, but damage to the natural vegetation may be minimized by establishing camp sites, workshops and batching plants on waste/barren land rather than on forested or agriculturally productive land;
- However, if such type of land is not available, it shall be ensured that minimum clearing of the vegetation is carried out and minimum damage is caused to trees and undergrowth;
- Construction vehicles, machinery and equipment will remain confined within their designated areas of movement;
- The EPC Contractor's staff and labor shall be strictly directed not to damage any vegetation such as trees or bushes;
- EPC Contractor shall provide gas cylinders at the camps for cooking purposes and cutting of trees/bushes for fuel shall not be allowed;
- Compensation for the loss of crops to the land owners and cultivators as the case may be will be paid, in accordance with the prevailing market prices and uniformity in rates will be ensured within the local areas;
- The whole process of the payment to the farmers will be made transparent, judicious and without any discrimination or favour; and
- As far as possible, barren land without any crop will be selected for the camp sites and disturbance to the crops and natural vegetation will be avoided as much as possible.


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#### 8.5.2.4 Fauna

**Potential Impact**

During construction phase the existing population of mammals and reptiles of the construction areas may be affected due to disturbance arising from construction activities involving excavation, movement of machinery and vehicular traffic, movement of labor, camping, blasting, excavation, drilling etc. The existing animals will leave the directly affected areas due to construction activities and human intervention. Some animals particularly reptiles may get killed during the earthworks operations.

Moreover, the movements of the mammals and reptiles will be restricted during the construction phase;

Birds as well will tend to move away from the construction areas and find shelter and food elsewhere due to the activities mentioned above for fear of being hunted / trapped.

Noise generated from machinery particularly during the night hours will even scare the wildlife residing in habitats located at some distance from the construction areas. Uncontrolled blasting may even disturb the wildlife of the Project Areas. Food and refuse at the EPC Contractor's camps may attract animals that might in turn be hunted by the workers. This impact is medium significant.

**Mitigation Measures**

- Care shall be taken during construction activities for avoiding purposely or chance killing of animals;
- If found any wild species and habitat during construing that must dealt carefully and local wildlife department officials should be called;
- Hunting, poaching and harassing of wild animals shall be strictly prohibited, and Contractor shall be required to instruct and supervise its labor force accordingly and clear orders should be given in this regard;
- EPC Contractor must be held responsible for instructing his work force accordingly and for enforcing this restriction. In addition, this shall have to be controlled by the Wildlife Department;
- Client must have obtained NOC from the relevant departments prior to construction phase;
- Special measures shall be adopted to minimize impacts on the wild birds, such as avoiding noise generating activities during the critical periods of breeding;
- Similarly, wastes of the camps shall be properly disposed of to prevent it being eaten by animals, as it may be hazardous to them; and
- Noise produced by construction activities may be kept to acceptable level and ensure compliance with NEQS.

#### 8.5.2.5 Aquatic Ecology

During construction phase of proposed Project, cutting, blasting, excavation, drilling, extraction, removing and dumping activities of materials at large scale will contribute heavy sedimentation and soil erosion which may cause habitat destruction, contamination and toxic accumulation of waste not only at Attabad lake but its impact can be seen downstream up to confluence of Gilgit River and beyond. Heavy machinery and equipment shall be used during construction phase, which may also result in heaps of leftovers of explosives, grease,


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chemicals, lubricants, and other harmful materials. These pollutants through run off rain water enter into the lake and river course increase toxicity of water causing rapid destruction of fish population and riverine ecology.

This situation can contribute up to great extent to destruct the aquatic life, ecology, breeding and spawning grounds of fishes, benthic fauna, food chain and abundance of micro and macro living organisms. This may lead rapid shortage of food like benthic population, phytoplankton, zooplankton, nekton etc. which play an important role to sustain food chain with different trophic level in any eco-system. This impact is categorized as medium to high significant.

**Mitigation Measures**

- Solid waste generated from construction and camp sites will be safely disposed in demarcated waste disposal sites and the EPC Contractor will provide a proper waste management plan, to avoid the water contamination;
- Land sliding and soil erosion are also the main factor to contribute silt load on river bed manifold causing damage to resting and nesting grounds of fishes. Construction of protective walls and gabions at certain points to make sure the stoppage of sliding debris. Plantation and vegetation cover can also be helpful for slope stabilization. Plants, herbs and shrubs reduce the level of pollution and toxicity at a great extent as bio-filter and carbon suckers;
- Prior NOC from Fisheries Department may also be considered for smooth implementation of the project activities;
- The labour working at construction site should be aware to protect especially edible fish and to avoid fish catching by any means. As according to law of land fish hunt is prohibited with all types including net, cages and by the use of dynamite;
- Training of work force in the storage and handling of hazardous materials and chemicals should be encouraged and educated to practice waste minimization and reuse to reduce quantity of the waste;
- Immediate collection of spilled oils/fuels/lubricants by collection of contaminated soils and skipping oils from surface water by applying appropriate technologies;
- Construction waste should be crushed and reused in other sites, where possible;
- It will be ensured that no waste or left over construction material is left behind in the cultivation fields;
- Construction vehicles and machinery will be kept in good working condition, and be properly tuned and maintained through the duration of construction work with the objective of minimizing excessive noise and vibration; and
- EPC Contractor shall ensure the compliance with NEQS.

### 8.5.3 Socio Economic Environment

#### 8.5.3.1 Discovery and Impact on of Heritage Sites and Structures during Excavation

**Potential Impact**

During excavation, there is a chance of finding artifacts. In case of finding any artifact, the contractor shall immediately report through Supervision Consultant to Directorate General (DG) of Tourism, Sports, Culture, and Archaeology & Museums Department Government of GB to take further suitable action to preserve those antiques or sensitive remains.


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According to the field survey, no notified archeological site was present in the Project Area. This impact can be categorized as low to medium significant in nature.

**Mitigation Measures**

- In case of finding archeological remains during excavation, the EPC Contractor shall immediately report through Supervision Consultant to Tourism, Sports, Culture, Archaeology & Museums Department Government of GB to take further suitable action to preserve those antiques or sensitive remains. Chance finds procedure is given in **Annex- III; and**
- EPC Contractor needs to obtain approval for excavation and submit the plan of rehabilitation of the site after excavation.

#### 8.5.3.2 Social and Cultural Conflicts

**Potential Impact**

During the construction phase of the project, conflicts may arise between labor force and local community. Use of local resources and products by the construction workers can generate stress on the local resources. Furthermore, difference in cultural values may also cause discomfort to local residents. This impact is medium adverse in nature.

**Mitigation Measures**

- Local labor especially from nearby communities will be given preference for the construction works;
- Careful planning and training of work force to minimize disturbance to the local people;
- Public notification through print or electronic media during the entire construction phase to avoid any inconvenience in accessibility to the locals; and
- Adequate training of especially for the transitive workforce of the station (involved both in the construction process and in the commissioning) to regard the customs of the area so that the locals do not feel insecure.
- Code of Conduct will be prepared by the EPC Contractor and adopted during the project execution. All project personnel will be required to sign and follow the Code of Conduct.

#### 8.5.3.3 Occupational Health and Safety

**Potential Impact**

Occupational Health and Safety (OHS) related impacts may arise during construction phase of the proposed Project due to installation of Contractor camp, movement of machinery & equipment, lifting operations, work at height, concrete pouring, working in night and manual handling during loading/unloading operation, as result of these works there will be a direct impact on the health and safety of all staff working on the Project. The most common impacts include eye injuries which may occur due to stone or metal particles, hazard of being hit by falling objects, major hand-arm and whole body vibration hazards, skin and respiratory tract irritation from exposure to cement dust, overexertion and awkward postures etc.

Other impacts will be falling in trench, contact with electrical and mechanical equipment, equipment failure, uncontrolled movement, unguarded moving mechanical equipment parts, fatigue, unbalanced load, falling objects, hand and head injury, slip and trip hazards, exposed


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to high levels of noise for longer durations etc. This impact may be classified as high adverse in nature.

**Mitigation Measures**

- The EPC Contractor will be required to follow the national/local acts related to OHS and World Bank Group General EHS Guidelines, 2007. The EPC Contractor will prepare the site specific occupational health and safety plan;
- Occupational health and safety monitoring programs of the EPC Contractor should verify the effectiveness of prevention and control strategies;
- Providing basic medical training to specified work staff and basic medical service to workers. The EPC Contractor will ensure the provision of basic medicines, first aid kits etc. at the camp site;
- Ensure periodic medical screening of the staff;
- Complying with the safety precautions for the construction workers as per applicable International Labor Organization (ILO) Conventions;
- Training of workers in construction safety procedures, environmental awareness, equipping all construction workers with safety proper task specific Personal Protective Equipment (PPEs);
- Moreover, proper planning should be done for food storage, setting up of kitchens, wastewater collection system and solid waste management. Improper planning for these facilities may result in multiplication of rodents like rats, mice and shrew etc. and vectors like mosquitoes, bugs and flies which will have a negative impact on workers' health and safety;
- Efforts will be made to create awareness about road safety among the drivers operating construction vehicles;
- All trenches deeper than two meter should be protected with wooden bracing to avoid safety risks to workers and locals; Ensure that the site will be restricted for the entry of irrelevant people particularly children, disabled and elderly people;
- Ensure the use of safety and warning signs at the construction site;
- Ensure the provision of fire prevention and firefighting equipment; and
- Ensure the provision of training related to emergency prevention, preparedness and response arrangements by the EPC Contractor.

These requirements will be incorporated into the bidding specification and contract documents, and will be binding on the EPC Contractor, at risk of penalty for noncompliance, as charges to be recovered from EPC Contractor for unsafe act or condition.

#### 8.5.3.4 Community Health and Safety

**Potential Impact**

Community health and safety issues during the construction of proposed project may include dust, noise, and vibration from construction vehicle transit, and communicable disease associated with the influx of temporary construction labor. The construction activities and vehicular movement at construction sites may result in roadside accidents particularly inflicting

local communities who are not familiar with presence of heavy equipment. Quality of water resources available in the nearby local communities may be affected due to the oil spillage and leakage, roadside accidents, etc. Conflicts may arise between the local community and the construction workers, which may be related to religious, cultural or ethnic differences, or based on competition for local resources. The labor works with different transmittable diseases (HIV/AIDS, COVID-19, respiratory diseases, and skin and eye infections etc.) may cause spread out of those diseases in the locals of nearby community. The impact significance is moderate adverse.

**Mitigation Measures**

- The EPC Contractor will prepare the site specific community health and safety plan in compliance with relevant sections of the WBG General Environmental Health and Safety Guidelines (WBG 2007), chosen methodology and will be required to strictly follow;
- Ensure that the site will be restricted for the entry of irrelevant people particularly children, disabled and elderly peoples. Ensure the use of safety signs at the construction site;
- Providing basic medical training to specified work staff and basic medical service and supplies to workers;
- Ensure proper maintenance and repair of all vehicles, machinery and equipment to prevent the oil spills;
- Efforts will be made to create awareness about road safety among the drivers operating construction vehicles;
- Timely public notification on planned construction works;
- Close consultation with local communities to identify optimal solutions for diversions to maintain community integrity and social links;
- Provision of proper safety and diversion signage, particularly at sensitive/accident-prone spots;
- Setting up speed limits in close consultation with the local stakeholders;
- The mitigation measures provided in the sub-sections for air and noise & vibration shall be adopted to reduce the air pollution, noise pollution and vibrational impacts on nearby community;
- Ensure effective implementation of GRM (to be prepared by the EPC Contractor) to timely address the issues;
- The communicable disease of most concern during construction phase, like Sexually-Transmitted Disease (STDs) such as HIV/AIDS, COVID-19 will be prevented by successful initiative typically involving health awareness; education initiatives; training heath workers in disease treatment; immunization program and providing health service;


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- All workers must perform complete sanitization at the site as per updated / latest SOPs/guidelines issued by WHO and the national guidelines issued by the GoP[19];
- Ensure prevention of larval and adult propagation of vectors through sanitary improvements and elimination of breeding habitat near to human settlements and by eliminating any unusable impounding of water; and
- EPC Contractor will take due care of the local community and observe sanctity of local customs and traditions by his staff. EPC Contractor will warn the staff strictly not to involve in any unethical activities and to obey the local norms and cultural restrictions.

Any environmental condition that is disagreeable to the public and causes an avoidable nuisance can be addressed with additional provisions in addition to those described above.

These requirements will be incorporated into the bidding specification and contract documents, and will be binding on the EPC Contractor, at risk of penalty for noncompliance, as charges to be recovered from EPC Contractor for unsafe act or condition.

#### 8.5.3.5 Influx of Labor

**Potential Impact**

For the implementation of Project activities, skilled and unskilled labor is required by the EPC Contractor. Mostly, skilled and unskilled workers have been associated with the EPC Contractor since long which they utilize, where they are required for the Projects, and while other workers are hired from the different areas that belong to different cultural backgrounds. Social problems and conflicts that are associated with Labor Influx are as follows:

- Risk of social conflict: Conflicts may arise between the local community and the construction workers, which may be related to religious, cultural or ethnic differences, or based on competition for local resources. Ethnic and regional conflicts may be aggravated if workers from one group are moving into the territory of the other;
- Increased risk of illegitimate behavior and crime: The influx of workers and service providers into communities may increase the rate of crimes and a perception of insecurity by the local community. Such illegitimate behavior and crimes can include theft, physical assaults, substance abuse, sexual assault and human trafficking;
- Impacts on community dynamics: Depending on the number of incoming workers and their engagement with the host community, the composition of the local community, and with it the community dynamics, may change significantly. Pre-existing social conflict may intensify as a result of such changes;
- Increased burden on and competition for public service provision: The presence of construction workers and service providers (and in some cases family members of either or both) can generate additional demand for the provision of public services, such as water, electricity, medical services, transport, education and social services. This is particularly the case when the influx of workers is not accommodated by additional and separate supply systems;

[19] *https://covid.gov.pk/guideline*


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- Increased risk of communicable diseases and burden on local health services: The influx of people may bring communicable diseases to the project area, including sexually transmitted diseases (STDs), or the incoming workers may be exposed to diseases to which they have low resistance. Workers with health concerns relating to substance abuse, mental issues or STDs may not wish to visit the Project's medical facility and instead go anonymously to local medical providers, this can result in an additional burden on local health resources;
- Local inflation of prices, accommodations and rents: A significant increase in demand for goods and services due to labor influx may lead to local price hikes and crowding out of community consumers. Depending on project worker income and form of accommodation provided, there may be increased demand for accommodations, which again may lead to price hikes and crowding out of local residents; and
- Increase in traffic and related accidents: Delivery of supplies for construction workers and the transportation of workers can lead to an increase in traffic, rise in accidents, as well as additional burden on the transportation infrastructure.

This impact is medium negative and temporary in nature.

**Mitigation Measures**

- Contractor camp will be established away from residential and populated area;
- Preference will be given to the local people to work with EPC Contractor, and EPC Contractor will hire maximum labor force from the project area because this will reduce the labor influx;
- Awareness will be created among the work force to ensure respect for local customs;
- Construction work will be completed within the stipulated time to move workers to next location;
- Labor force will be shuffled with the time;
- Create awareness among workers on proper sanitation and hygiene practices to endorse proper health and maintain good housekeeping practices at all Project sites;
- Provide adequate personal hygiene facilities in good condition with adequate supply of clean water;
- Make arrangements to treat the affected workers on time to control the movement of vectors disease;
- Sensitize workers and surrounding communities on awareness and prevention of COVID-19, HIV/AIDS and sexually transmitted infections (STI) through training, awareness campaigns and workshops during community meetings;
- Provide proper and free HIV/AIDS and STI health screening and counselling for site workers and community members;
- Develop and enforce a strict Code of Conduct for workers to regulate behavior in the local communities;


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- Taking all sensible precautions to avert illicit, vicious conduct by or amongst the EPC Contractor's personnel, and to preserve unity and harmony, and protection of people and property on and near the sites;
- Prohibiting drugs, alcohol, weapons, and ammunition on the worksite among personnel;
- Site security preparations must be contained within the Bills of Quantities (BoQs) to avoid any delays which might be caused due to insecurity;
- Appropriate fencing, security check points, gates and security guards will be provided at the construction sites to ensure the security of all plant, equipment, machinery and materials, as well as to secure the safety of site staff; and
- The EPC Contractor must guarantee that good relations are maintained with local communities and their leaders to help reduce the risk of vandalism and theft.

#### 8.5.3.6 Gender Based Violence (GBV)

**Potential Impact**

In the society, female plays important role in managing household as well as in income earning activities, but they face various challenges to get access to educational institutions and employment opportunities due to cultural bindings, economic vulnerability and lack of facilities.

According to Pakistan Demographic and Health Survey (PDHS), 2017-18, 28 percent of women of Pakistan age 15 to 49 have experienced physical violence, six percent have experienced sexual violence, and seven percent experienced violence during pregnancy. Three in ten women who have ever experienced physical or sexual violence sought help to stop the violence, yet 56 percent never sought help nor told anyone.

During construction phase gender based violence might arise due to discrimination made against women by unequal work distribution and unequal pay structure among others. Sexual harassment against women might occur as a consequence of mixing of men and women at the construction site, and moving on the roads and markets. Women in the Project area are participating in other outdoor activities such as livestock rearing, bringing of potable water, collection of fire wood etc. that may also be affected by the Project activities. This impact is medium negative in nature during construction stage.

**Mitigation Measures**

- Trainings will be given to construction workers, alongside the implementation of strict measures and punishments in case of any sexual assaults, or gender based violence.
- During the timing of educational institutions workers will not be allowed to crowd in the surroundings;
- Alternative routes for pedestrian will be provided to avoid mixing of women with workers;
- Gender protection act will strictly be enforced during the construction activities in the project area, and monitor the implementation through field staff and district level structure;


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- Raise awareness among the communities of the potential risks of GBV, and establish response services in the communities that can respond to instances of GBV (particularly those related to issues of labor influx);
- The EPC Contractor will make sure that no discrimination is made on the basis of gender while hiring of workers. Complete SOPs will be formed and implemented by the contactor regarding working women at site. Implementation on these SOPs will be monitored by the Supervision Consultants;
- Provisions of gender disaggregate bathing, changing, and sanitation facilities; and
- Contractor will take proper measures to address and resolve issues relating to harassment, intimidation, and exploitation, especially in relation to women.
- Establish workers' camps separated from local communities with strict protocols for interaction with local communities in order to avoid project impacts from labor influx.
- Project staff will receive training on the prevention of SEA/SH. Engagement of skilled trainers to raise awareness among project workers of the risks, expected behaviors, and consequences of violations, communicated through training, and publicized codes of conduct. It may also be important to raise awareness of the risks among community members and local health authorities and inform them about available grievance mechanisms.
- Arrange and support local organizations and/or government initiatives on community STD education, prevention, and treatment programs.
- Extensive training for awareness raising strategy which describes how workers and local communities will be sensitized to SEA and SH risks, and the worker's responsibilities under the Code of Conduct.
- The routes/places used by the women will be avoided as far as possible. If unavoidable, alternate routes will be identified for the communities, if required, especially along routes frequented by women folk, such as route to the local water source.
- Construction crew will avoid entering villages and settlements.
- Communities will be informed and consulted before commencing works inside or near the communities.
- Provision related to SEA/SH will be incorporated in the bidding document.

#### 8.5.3.7 Child Labor

**Potential Impact**

There are two basic conventions on child labor adopted by the ILO, and one adopted by the United Nations. The ILO Minimum Age Convention, 1973 (No. 138) and its accompanying Recommendation (No. 146) set the goal of elimination of child labor, and the basic minimum age for employment or work (in developing countries at 14 years of age or the end of compulsory schooling, whichever is higher; and 15 or the end of compulsory schooling for developed countries). The Convention sets a minimum age of 2 years younger for "light work," i.e., 12 and 13 years, respectively; and a higher minimum age for dangerous or hazardous work (basically 18 years of age, but 16 in certain circumstances). The Convention also has


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various other flexibility clauses.

Inhabitants of the Project Area have mix economic background and different sources of income. Children of low income groups mostly involve in different earning activities, as their parents prefer to get their children hired in small shops as helpers, and waiters in hotels for earning money, and supporting household livelihoods. However, the Employment of Children Act, 1991 prohibits the employment of child and restrict the employment of adolescents in certain occupations and processes such as construction industry, and whoever employs or permits a child (person under the age of 14 years) to work in an establishment shall be liable to punishment with imprisonment.

The child labor impact might arise during construction stage, as large number of skilled and unskilled labor will be required by the EPC Contractor for the construction activities of the proposed Project. This impact is medium negative in nature during construction stage.

**Mitigation Measures:**

- Awareness will be created among the local communities about the adverse impacts of child labor. For the public awareness, meetings will be held in the Project area, and announcements will be made using the available local platforms with the involvement of all sectors of the society;
- EPC Contractor through contractual agreement will be bound to follow the labor standards, rules and regulations during hiring the labor force and all activities will be monitored by the social and environmental staff of the implementing agency;
- Client and Supervision consultant will ensure that EPC Contractor shall have its employment policy in accordance with relevant act and labor policies in Pakistan;
- EPC Contractor will ensure the presence of all persons at site are adults and have their proper identity cards with them;
- Penalize EPC Contractors/employees using the child labor and penalize adults who violate children's rights and who force children to enter child labor.

#### 8.5.3.8 Indigenous People

**Potential Impact**

During the social field survey of the Project, no indigenous group of people was identified, which comes under the definition of the "Indigenous People". So, no impact on the indigenous people is envisaged due to the implementation of the Project.

**Mitigation Measures**

No mitigation required.

#### 8.5.3.9 Other Social Issues

**Potential Impact**

The community belonging to the reservoir and Project Area will be affected during the construction phase as follows:

- During the construction phase, the general mobility of the local residents and their livestock in and around the Study Area is likely to be hindered;
- Unmonitored construction activities, e.g. blasting may create an accidental risk for the local residents particularly the women and children;


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- Usage of community common resources like potable water, fuel wood etc. by Contractor workforce may create conflicts between the community and the Contractor;
- Community will have to face the noise and dust problems during the construction activities;
- Induction of outside workers in the Contractor labor may cause cultural issues with the local community; and
- Theft problems to the community by the Contractor's workers and vice versa.

This impact is Site Specific, Medium Term, Irreversible, Likely, Medium Significant.

**Mitigation Measures**

- During the construction phase, mobility of the workers in the nearby areas should be strictly restricted by the Contractor to avoid any inconvenience to the local communities;
- Proper arrangements in the form of alternative routes should be made to ensure that the mobility of locals should not be disturbed;
- Before starting the construction activities, Contractor should inform residents of the Project Area about the scheme of work, likely disturbances, and their duration as to whom they should addressed their complaints.
- The Contractors will be required to maintain close liaison with the local communities to ensure that any potential conflicts relating to the common resource utilization are resolved quickly;
- Contractor will take care of the concerns of the local community and the sensitivity towards the local customs. Contractor also needs a proper security to avoid any theft issue by the community;
- Use of good engineering practices such as water sprinkling, encasement and provision of silencer and mini stacks of generators etc. should be adopted to avoid inconvenience to the locals due to noise, smoke and fugitive dust; and
- The Contractor will warn the workers not to indulge in any theft activities and if anyone gets involved in such activities, he will have to pay heavy penalty and would be handed over to the police. Similarly, at the time of employing, the Contractor has to take care that the workers should be of good repute. The Contractor camp should be fenced properly and main gate.

### 8.5.3.10 Impact on Tourism

**Potential Impact**

The Attabad Lake has become one of the biggest tourist attraction in valley, offering activities like boating, jet-skiing, fishing and other recreational activities. Tourists also enjoy Ice Skating the Lake gets frozen during winters, making it the perfect place for ice skating. Passu Cones is also a popular tourist destination in Hunza valley and all over the world because of its easy accessible sweeping landscapes and vistas of the 7,478m (24,534 ft) tall Passu Sar mountain, the Passu Glacier and Tupopdan.

Due to construction activities of Attabad Hydropower Project and movement of heavy machinery on roads the traffic flow is likely to be affected during construction activities and damage of roads as well, tourists will face the difficulties to reach at their desire destination


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like Attabad Lake for boating and jet-skiing, to visit the Passu Cones, Khanjrab Pass other tourists spots and high peaks for hiking.

Due to construction of Attabad Hydropower Project livelihood of the locals will disturb who are directly associated with tourism business like boat owners and operators, owners of fast food restaurants, shopkeepers, hotels owners and working labor and so many others attach with tourism.

**Mitigation Measures**

- The EPC Contractor will prepare and implement the site specific environmental, health and safety management plans to ensure the safety of the locals and tourists.
- Necessary measures will be taken to ensure the safety of traffic during construction, including barricades, safety signs, pavement markings, flags, and lights, erected for tourists and locals as well.
- A Traffic Management Plan will be implemented that will aim at ensuring access tourists to reach their destinations safe and sound, residential areas, and preventing of unsafe situations, especially near construction areas, camps and offices;
- Liaison with traffic police will be maintained in order to facilitate the tourists both local and foreigner; and
- Vehicle speeds near / within the communities will be kept low, to avoid safety hazards.

#### 8.5.3.11 Communication Loss

**Potential Impact**

The general mobility of the local residents and their livestock in and around the Project Area is likely to be hindered and may need to be travel long distances.

Likewise access to the natural resource may be affected. This particularly implies to the women folk and children where women observe norms and values and do not interact with non-locals. This impact is medium significant in nature.

**Mitigation Measures**

The EPC Contractor will ensure that the mobility of the local communities and their livestock is not hindered by the construction activities. The EPC Contractor will provide crossing points at appropriate places to facilitate the locals for their daily works, where applicable.

The EPC Contractor shall always consider the local sensitivities while performing the Project activities. All the personnel engaged would also be properly briefed about the local norms and ethics prior to commencement of work.

## 8.6 ANTICIPATED IMPACTS DURING OPERATIONAL PHASE

The anticipated environmental impacts during the operation are discussed herewith;

### 8.6.1 Physical Environment

#### 8.6.1.1 Sedimentation

**Potential Impact**

Sediment sources are glaciers, precipitation in the form of storms and heavy rains, hill slopes, landslides gully erosion, etc. The suspended load is influenced by the availability of sediment sources and triggering events. In Karakorum and Himalayas, large amounts of yearly


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suspended sediments per square kilometers of the catchment area (more than 2,000 tons/year/ km²) are reported in the river system. The annual suspended sediment load at the weir site is 22.5 M-Tons. The total annual sediment load in Attabad Lake is estimated to be 27.08 M-Tons. The total annual sediment load in volume is 27.71 MCM or 22,466 AF. Almost all of the suspended sediment is brought down by the river during the period of June to September. The river carries on average, about 27% sand, 50% silt, and 21% clay. The unit weight of fresh deposits of this sediment is about 62 lbs/ft³. Based on hydrographic study, It had been observed that river bed level increased by sediment deposition and attained level of 2374m at approximately 600m distance from proposed weir. This rapid increased of bed level in 2020 and present year, 2024 against 2011 year are about approx. 38m and 44m, respectively.

Accumulation of sediment may disturb the efficiency of Project components. Sediment load released from the sand trap could have adverse effect and synergetic with low flow of water will put aquatic system under stress. However, it should be kept in mind that during low flows the sediment concentration is very low. Floods and heavy rains carry large sediment loads, which could have a more severe medium impact than the sand trap flushing.

**Mitigation Measures**

A sediment flushing tunnel will be constructed at the left side under the Power Tunnel section, consisting of low level outlets and during construction of overflow structure will be used as diversion tunnel. The invert level of sediment flushing tunnel is planned at El. 2380 m.a.s.l. Systematic operation of the flushing tunnel shall be ensured by the Client to flush the sediments.

It is also recommended to conduct a detailed watershed management study of the area and the outcome mitigation measures should be implemented to control the sediment inflow in the river.

#### 8.6.1.2 Liquid and Solid Waste Generation

**Potential Impact**

Wastewater may generate by the workers during the operation and maintenance related activities and from the residential colony. However, at this stage it is not possible to estimate quantity of waste generation. The improper disposal of liquid waste can cause air, water, and soil pollution. Different types of solid waste including construction, dismantled material, municipal and hazardous (chemicals, spent solvents and oily rags, empty paint cans, chemical containers, used lubricating oil, electrical wires and lighting equipment) wastes are likely to be generated during the operation phase, can potentially cause soil and water contamination. The quantity of this liquid waste is expected to be small. This impact can be categorized as medium to low significant in nature.

**Mitigation Measures**

- Ensure training program regarding waste minimization quantity of the waste;
- Solid waste generated will be safely disposed in demarcated waste disposal sites and ensure provision of PPEs to workers;
- Ensure immediate collection of solid waste after the competition of maintenance works, no waste or left over construction material is left behind;


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- Proponent should make final disposal arrangements in consultation with the concerned government department and should take approvals for final disposal of the waste at the designated disposal site.
- A separate solid waste management system for waste from the office building and other allied facilities will be required. During the collection of solid waste, recyclable and reusable waste will be separated for resource recovery and reuse of the generated material; and
- Proper monitoring to check the compliance of NEQS will be carried out, if required;

#### 8.6.1.3 Soil and Surface Water Contamination

**Potential Impact**

The accidental oil leakages from the power house may contaminate the soil and water quality of the Attabad Lake and Hunza River downstream of the powerhouse. The maintenance works (may involve the use of materials, chemicals, fuel and lubricants) may also have potential to contaminate the soil and surface water. This impact is site-specific and can be classified as medium significant.

**Mitigation Measures**

Proper drainage and dewatering system is recommended for the proposed Project. A drainage pump of appropriate capacity will be specified to cope with the leakage of powerhouse. Dewatering pumps will be specified for Unit dewatering. Both of these pumps will be installed in drainage and dewatering pit and they will provide redundancy for each other. Sites disturbed by the maintenance works shall be restored to their original conditions upon completion of works and photographic record will be maintained to ensure pre-post conditions intact. It will be ensured that no soil is left unconsolidated after completion of work and excess will be disposed of at designated sites. Storage of fuel, paint, and oil containers, oil filters, oily parts, and oily rags on impervious floor under shade or storing of fuel and lubricants on a sand flooring of at least 6 inches thick done on brick edge flooring lined with polyethylene sheet. Material Safety Data Sheets (MSDS) will be strictly followed.

#### 8.6.1.4 Fire Breaking

**Potential Impact**

For the proposed hydropower plant there is also a risk of fire breaking out in powerhouse which may become a serious risk for residents living in allied facilities and/or nearby in the vicinity of the proposed hydropower Project. This impact can be classified as medium significant.

**Mitigation Measures**

- Fire protection and detection systems shall be provided and implemented to protect life, property, equipment, and operation of the powerhouse. The detection and fire alarm, fire protection and fire-fighting systems shall include, but not be limited to the following:
    - Firefighting water storage, may be combined with raw water tank, depending on local regulations;
    - Firefighting pumps;
    - Fire water ring main system, including hydrants;
    - Fire protection systems; and


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- Fire alarm and detection system.

- The building / tunnel shall be subdivided into various fire areas, separated by approved fire resistant barriers and elements;
- Fire walls, ceilings and partitions shall have a fire resistance rate of not less than 2 hours;
- All penetrations for electrical cables or pipes in fire resistant walls or ceilings shall be sealed with approved seals;
- One electric motor driven fire pump and one electric motor driven stand-by fire pump, located in a pump house adjacent to the water storage tank, shall draw fire fighting water from the tank and supply it through the fire service main to the hose stations and water spray fixed systems. One electric motor driven jockey pump with a capacity of approx. 3 l/s shall also be provided to keep the line pressure of 5 bars. The fire pump shall have a capacity of approx. 40 l/s at a delivery head of approx. 6 bars;
- The water spray fixed systems shall be designed, installed and tested in accordance with NFPA15;
- The total flooding carbon dioxide extinguishing systems shall be designed in accordance with NFPA 12, standard on carbon Dioxide extinguishing systems (latest edition) and will be adopted for the fire protection of Attabad HPP generators;
- The selection, installation and testing of portable fire extinguisher shall be in accordance with NFPA-10 for initial firefighting. Portable fire extinguishers with capacities of 6 kg chemical dry powder, for rooms containing electrical equipment with capacities of 5 kg clean agent, shall be provided and placed in the rooms and buildings at strategic locations and next to exits;
- In addition to the portable extinguishers, two mobile 30 kg clean agent, and two mobile 50 kg dry powder extinguishers, mounted on wheeled hand carts and furnished with 6 m hoses, shall be provided and located in the machine hall of the powerhouse and GIS floor and diesel generator room; and
- All systems shall be subject to the approval of the insurance company. The system shall be complete with all necessary piping, pumps, safety valves, mobile equipment, and vehicles. The EPC Contractor shall prepare an Emergency Response Plan (ERP) to cope with the emergency situations. Fire protection system for Generator fire protection system is also recommended.

#### 8.6.1.5 Ambient Air Quality and Climate Change Aspect

**Potential Impact**

The air quality of the area will improve significantly in comparison to construction phase. Vegetation cover in the area will also increase after tree planation. However, during operation phase, operation of stand-by generator and un-necessary idling of diesel run will also result in the emission of pollutants (CO, Smoke, $NO_2$, $SO_2$, $PM_{2.5}$ and $PM_{10}$ etc.) into the air, thus deteriorating air quality. Ambient Air quality may also be affected during the maintenance works of subprojects. These emissions may adversely affect the health of the nearby residents and working staff. This impact is moderate in nature.

**Mitigation Measures**

- Ensure the use of low Sulphur fuel;


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- Ensure plantation of trees around the project area that will help in absorbing the emissions;
- The height of the generator stacks shall be enough to disperse the emissions in the air; and
- Ensure compliance with NEQS and provision of budget for regular monitoring of ambient air quality in accordance with the NEQS.

#### 8.6.1.6 Noise and Vibration

**Potential Impact**

During operation phase, noise and vibration levels may be generated due to the operation of proposed project, standby generators and traffic which will be a constant source of nuisance for the staff and the nearby communities. Noise levels may also be increased during the maintenance works. The significance of this impact is considered to be low adverse.

**Mitigation Measures**

- Ensure regular maintenance and periodic checking all parts of the standby generators, replacement in case of malfunctioning and periodic noting of noise levels;
- Installation signs to disallow the use of pressure horns;
- Plantation of trees will also help to attenuate the noise impacts to the surrounding area;
- Ensure compliance with NEQS and provision of budget for regular monitoring of noise levels in accordance with the NEQS and vibration (where applicable).

#### 8.6.1.7 Change in Land Use

**Potential Impact**

During the operational phase the land use pattern of the area will be changed to some extent. The commercial and recreational activities will also be increased which may affect ecosystem of the area and bring economic boom in the area. This impact is Site-specific, Long Term, Irreversible, Likely, Medium Significant.

**Mitigation Measures**

The tree plantation will be carried out in and nearby the Study Area and will have positive impact on the eco system of the area.

### 8.6.2 Ecological Environment

#### 8.6.2.1 Flora

**Potential Impact**

During operational stage of the Project, there will be minimal effect on flora or release of any significant pressure detrimental to flora. Low level impact is expected at operational phase on Flora due to the operation and maintenance activities. This impact is low Significant.

**Mitigation Measures**

- The implementation of plantation plan recommends compensation for cutting of trees and work should be started during operational phase to ensure the ecological balance and to avoid any impact on local environment;


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- Large scale planting with suitable indigenous trees, shrubs and ornamental plants in the form of tree groves, and linear plantation will be carried out in accordance with the Tree Plantation Plan to improve aesthetic value and offset the effect of removal of vegetation;
- Proper check and balance for above activities is highly recommended. Plantations so raised must be maintained according to the Silvicultural practices which includes proper irrigation, cleaning, pruning, thinning at prescribed intensity, silt clearance and trench-opening, etc.;
- Maintenance and security of the plantation should be done for at-least four years (in consultation with the Forest department). Measures such as fencing, watch guards and fire protection should be considered; and
- All activities must be done under the technical supervision of forest department

#### 8.6.2.2 Fauna

**Potential Impact**

There is no protected area, game reserve, game sanctuary or national park in the project area so no major impact on wildlife and livestock in the area is expected through noise, vibration and any type of normal activity in the project area. This impact is Insignificant.

However, proposed reservoir area, which is nearly 8 Km in length, shall not be available for grazing to livestock and other wildlife existing in the area, which is adverse impact on fauna.

**Mitigation Measures**

Strict control must be exercised for stoppage of killing/poaching of available wildlife species (if any) by enhancing protection practices; and

The precautionary measures described for future shall also be applicable during operation phase as relevant for the conservation of wildlife species in the Study Area.

Improved micro climate and moisture conditions along the periphery of the reservoir will help in grass production and improved vegetation, which will be useful for livestock grazing and improve habitat for birds.

#### 8.6.2.3 Aquatic Life

Once the construction phase is completed and water diverted at the site of weir will change the water flow regime from weir to powerhouse. The adverse impact on aquatic life will be due to low flow in the Hunza River especially during low flow season. The minimum environmental flow needs proper follow-up.

**Mitigation Measures**

- Annual restocking plan of fish fingerlings should be included in the said project to compensate the stock depletion due to decrease in fish breeding grounds.
- Fisheries research unit and a brown trout hatchery with research/management staff should be established at the project side for research purposes as well as impact assessment during operational phases of the project.
- To conserve the aquatic life of the river downstream of the weir, minimum flow of 3 $m^3/s$ has been calculated as the environmental flow. It will be obligatory for project operating agency to release 3 $m^3/s$ in the river throughout the year as environmental flow.


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- The design recommended measures should be implemented and maintained by the proponents.

### 8.6.3 Socio-economic Environment

#### 8.6.3.1 Safety During Reservoir Operation

**Potential Impact**

During operational stage of the Project, due to the impounding of the reservoir, the safety issues will arise. Main reservoir area is the major threat for accidents. Locals and workers can drown. This impact is site specific and high significant in nature.

**Mitigation Measures**

Since the reservoir was formed in January 2010 as a result of massive land slide and no new area would be submerged.

However, during operational stage of the Project, a security plan should be prepared for the reservoir area to prohibit youths from using reservoir for bathing, swimming and other recreational activities. Boating should not be allowed without the provision of life saving jackets and presence of a lifeguard.

#### 8.6.3.2 HSE Considerations

**Potential Impact**

During the operation phase, health and safety issues related to workers and communities may arise. Operation and maintenance activities may cause health and safety risks such as movement of machinery and manual handling during loading unloading operation, poor handling and storage of hazardous substances, injuries due to electric shocks, falling of objects, slips or trips, dust, noise, accidents, transmittable diseases etc. The impact is moderate to low adverse in nature.

**Mitigation Measures**

- Ensure proper maintenance of machinery and equipment;
- Proper storage and handling of generator fuel, chemicals, solvents and other hazardous substances;
- Ensure emergency prevention, preparedness and response arrangements;
- Emergency numbers should be clearly posted and communicated to the staff and community (where applicable);
- Fire extinguishing equipment should be installed at adequate and appropriate locations;
- Ensure provision of PPEs to the skilled and unskilled labors and visitors;
- Proper training should be given to workers on health and safety measures;
- Hazardous materials should be well labeled and stored in their original containers;
- Ensure that the site will be restricted for the entry of irrelevant people;
- Ensure health awareness; education initiatives; training heath workers in disease treatment and prevention; immunization program and providing health service; and
- Staff will strictly warned, not to involve in any unethical activities and to obey the local norms and cultural restrictions.


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### 8.6.3.3 Water Rights in Lower Riparian

**Potential Impact**

The capacity of the reservoir at El 2,409 m.a.s.l is calculated as 125 Mm³, which is very small compared to inflows. As the Attabad Lake HPP is a run-of-river power project, with the implementation of the project there is no chance of reduction of discharge in the river except in the section between weir and end of tailrace (2 km). Presently, in this section of the river, water is not being used for any purposes either for human consumption or for agriculture. Therefore, it is anticipated that there will be no impact on human population due to the diversion of discharge into the tunnel, therefore, no mitigation is required.

### 8.6.3.4 Employment Opportunities

After completion of the construction works, employment opportunities will suddenly seize and unemployment for local residents may increase. However, with the experience gained from the proposed Project, the local people will have potential opportunities in future hydropower projects in GB, and other parts of country. WAPDA could develop a preferential system for local workers with good qualifications and experience at the end of construction of proposed Project. Construction workers could also qualify for positions in operation and maintenance activities.

### 8.6.3.5 Impact on Civic Amenities

The accessibility to the project area will be improved due to the construction of link roads and widening of existing road. Schools, mosques, dispensary will be constructed for the project staff but after the completion of the project these facilities will also be available for the locals of the project area. The impacts will be in the category of high beneficial.

### 8.6.3.6 Impacts on Local Public Health

The project area is lacking in health facilities. After the construction of this project, better health facilities will be available in the area which is a positive impact of the project.


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# 9 ENVIRONMENTAL MANAGEMENT PLAN

## 9.1 GENERAL

This Chapter provides an overall approach for the implementation, management and monitoring of the mitigation measures to reduce or avoid the identified potentially significant environment and social impacts for the proposed Attabad Hydropower Project. EMP provide institutional framework, resource allocations and environmental costs required to be included in the Project budget for the implementation of the suggested measures.

EMP is the tool for the implementation of the mitigation measures for the potential adverse environmental and social impacts during the project life cycle and covers all the stages from design to operation and maintenance. However, it is a live document and needs to be reviewed and updated at each stage of the Project based on the changes in the Project design monitoring and evaluation.

## 9.2 OBJECTIVES OF EMP

The basic objective of the EMP is to manage potentially significant adverse environmental and social impacts of the Project. The specific objectives of the EMP are to:

- Provide the details of the Project impacts along with the proposed mitigation measures, and the corresponding implementation activities;
- To ensure that all necessary corrective actions are carried out and monitored in time to counter any adverse environmental and social impact under a systematic monitoring approach;
- Provide a procedure for timely action in the face of unanticipated environmental situation;
- Define the role and responsibilities of the Project Proponent (WAPDA), EPC Contractor, Management Consultant and other key players in order to effectively communicate environmental and social issues among them;
- Define a monitoring mechanism, reporting frequency and identify monitoring parameters to ensure that all the mitigation measures are completely and effectively implemented;
- Design the training and capacity building plan for enhancing the capacities of the WAPDA, EPC Contractor and Management Consultant on environmental and social management;
- Identify the resources required to implement the EMP and outline the corresponding financing arrangements; and
- Define the requirements necessary for documenting compliance with EMP and communicating it to all the concerned regulatory agencies.

The EMP will be managed through a number of tasks and activities and site specific management plans. One purpose of the EMP is to record the procedure and methodology for management of mitigation identified for each adverse impacts of the Project. The management will clearly delineate the responsibility of various participants and stakeholders involved in planning, implementation and operation of the Project.

## 9.3 LEGAL REQUIREMENT

All the legal requirements have been discussed in detail in Section-2.


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## 9.4 INSTITUTIONAL SETUP FOR IMPLEMENTATION AND MANAGEMENT OF EMP

The institutional requirements for the implementation of EMP of the proposed project are provided in below sections.

### 9.4.1 Institutional Setup for Implementation and Management of EMP

The key players involved during construction phase of the proposed project are the WAPDA as proponent, GB EPA, Management Consultant and the EPC Contractor.

WAPDA will make EPC Contractor bound through contract documents to implement the EMP and other terms and conditions of the Environmental Permit/No Objection Certificate. The whole EMP will be included as a clause of the contract documents. Construction camps will be established after necessary approvals and submission of Site-Specific EMPs to be developed in the light of the relevant agencies' requirements, before commencement of construction works. The organizational setup for implementation of EMP during construction phase is provided in **Figure 9.1**.

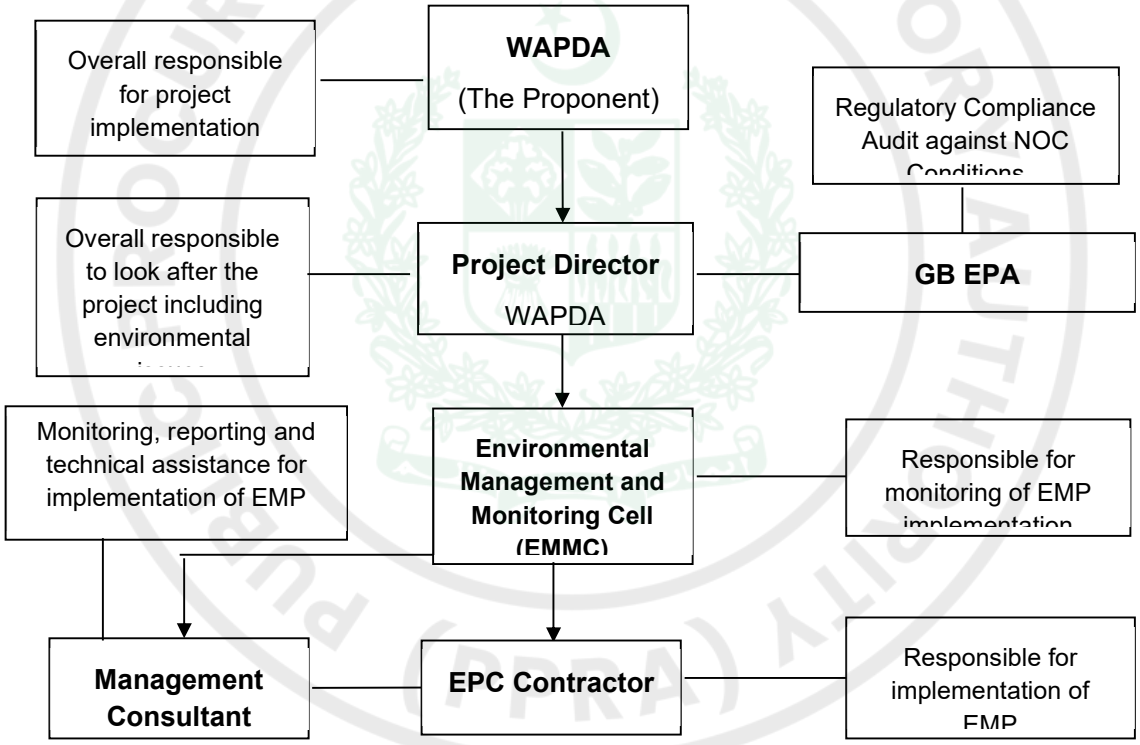


**Figure 9-1: Institutional Arrangement for Implementation of EMP**

### 9.4.2 Roles and Responsibilities for EMP Implementation during construction Phase

#### a. WAPDA / Environmental Management & Monitoring Cell EMMC

WAPDA will set-up Environmental Management/ Monitoring Cell (EMMC) specifically for ALHPP. The staff of EMMC will be deputed from WAPDA. The EMMC will be headed by Deputy Director Environment & Resettlement, who will report to the Project Director of Attabad Lake Hydropower Project. Deputy Director Environment & Resettlement will be assisted by a two member professional team consisting of Assistant Director Environment and Assistant Director Social. The EMMC will be responsible for the proper environmental monitoring


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proposed under the Project, overseeing and coordinating the work of the Management Consultant on behalf of WAPDA. They will also be responsible for interaction with the Community/ NGO's etc. for socioeconomic and resettlement issues. The specific responsibilities of WAPDA/EMMC are as follows:

- Setting up systems for environmental management;
- Ensuring that the EPC Contractor develop and carry out environmental implementation plans that are consistent with the EMP;
- Liaising between the project staff and the Supervisory Consultant's staff to monitor environmental and social compliance during construction phase;
- Ensuring that the required environmental and social training is provided to the concerned staff;
- Responsible for carrying out random site visits to the construction sites to review the environmental performance of the EPC Contractors;
- Monitoring the progress of environment and social related activities;
- Make sure that the EPC Contractor is implementing the additional measures, suggested by the Supervisory Consultant in monthly environmental monitoring reports;
- To assist EPC Contractor for obtaining necessary approvals from the concerned departments;
- Maintaining interface with the other lined departments/stakeholders; and
- Reporting to the GB EPA on status of EMP implementation.

**b. Management Consultant (MC)**

The Management Consultant (MC) will administer the civil work's contracts, make engineering decisions, be responsible for quality assurance, provide general guidance and furnish timely responses to the EPC Contractor in all matters relating to the civil works, and ensure that all clauses of the Contract Agreement including environmental and social clauses between the civil works EPC Contractor and WAPDA are respected. MC will have a full-time field based environmental and social specialist to ensure the implementation of EMP. Two separate experts, one for environment and one for social aspects, will be hired. The environmental and social specialist of MC will also develop training modules, conduct environmental and social trainings for the EPC Contractor staff, and ensure social issues are properly addressed and mitigated during the project life.

Environmental and Social Experts (ESEs) of MC will oversee the performance of EPC contractor to make sure that the EPC contractor is carrying out the work in accordance with EMP as mentioned in the contract documents. He will provide guidance to the EPC contractor's ESE for implementing each of the activity as given in EMP. ESEs will be responsible for record keeping, providing instruction through the Resident Engineer (RE) for corrective actions and will ensure the compliance of various statutory and legislative requirements.

However, overall responsibilities of ESEs are as follows:

- To oversee the performance of the EPC Contractor to make sure that the Contractor is complying with EMP;
- Discussing various environmental and social issues and environmental mitigation, enhancement and monitoring actions with all concerned personnel's;


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- Inspect, supervise and monitor all the construction and allied activities related to the EMP for the project and oversee the performance of the EPC Contractor to make sure that the EPC Contractor is complying with EMP;
- Visiting construction sites including incomplete construction work sites, where there is no contractor's activities, active construction work sites, completed areas of work sites, construction camps and workshop areas to ensure EPC Contractor compliance with EMP stipulations and conditions of statutory bodies;
- Assisting the EPC Contractor in all matters related to public contacts including public consultation pertaining to environmental and community issues;
- To organize periodic environmental training programs and workshops for the concerned staff;
- Periodic reporting as mentioned in EMP; and
- Suggest any additional mitigation measures (if required).

**c. EPC Contractor**

Site Environmental and Social Experts of EPC contractor will carry out the implementation of the mitigation measures at construction site. EPC Contractor will be bound through contract documents to appoint the Site Environmental and Social Experts with relevant educational background and experience. The responsibilities of ESEs of EPC Contractor are as follows:

- ESEs will be responsible for Implementation of the mitigation measures at construction site;
- ESEs will prepare Site Specific Environmental Management Plan (SSEMP) and will submit all the plans to the MC.
- ESEs of EPC Contractor will be responsible for the implementation of EMP and to take effective measures against corrective actions plan;
- ESEs will prepare the monthly compliance and monitoring reports as per schedule and will submit it to the MC;
- Provision of proper Personal Protective Equipment's (PPEs) to the workers and train them for their proper use;
- ESEs will conduct the environmental, health and safety trainings for the staff and labor; and
- The EPC Contractor shall submit the Code of Conduct that will apply to all of the Contractor's staff. The EPC Contractor shall submit an outline of how the Code of Conduct will be implemented. The aspects to be addressed include:
    - Ensure compliance with applicable environment, health and safety standards and procedures associated with risks and impacts of project activities;
    - Ensure compliance with all acquired approvals, applicable to the proposed project;
    - Ensure protection of local community (including vulnerable and disable assemblies), and the EPC Contractor's staff, sub-contractors and daily wage workers;
    - Ensure employment of fulltime security guards, and necessary security measures and instruments (CCTV) at site;
    - Ensure provision of adequately stocked first aid kit at site for dealing with accidental injuries, and natural hazards;


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- Prohibit use of illegal items such as weapons, alcohol and drugs at site;
- Ensure that project property is protected against vandalism, theft, and noxious activity;
- Ensure that positive attitude of respect and warmth is given to staff and community members;
- Ensure good housekeeping practices shall be adopted at site;
- Ensure that employment decisions are not made on the basis of personal characteristics unrelated to inherent job requirements, including race, gender, nationality, religion or belief, disability, age, sexual orientation, or ethnic, social and indigenous origin;
- Ensure establishment and strictly enforcement of “No Sexual Harassment Policy”;
- Ensure provision of necessary sanitation requirements for site workers (both for men and women);
- Ensure workers only use specified sanitary facilities provided by their employer and not in open areas;
- Restriction on burning solid waste;
- Restriction on dumping solid and liquid waste into nearby water bodies;
- Prohibition for cutting trees, and clearing vegetative areas for construction camps, and for cooking purpose as a source of fuel; and
- Prohibition on illegal hunting of local fauna.

The Code of Conduct should be written in local and simple language (Urdu and English) and signed by each site staff to specify that they have received a copy of the code; code explained and clarified to them; acknowledged adherence to this Code of Conduct as a condition of employment; and understood that violations of the Code can result in serious consequences. A copy of the code shall be displayed at strategic location of the site, and mainly in the EPC Contractor site office.

### d. GB Environmental Protection Agency

GB EPA is the regulatory authority for issuance of NOC for the proposed project. As part of its mandate, protection of environment is its responsibility. Therefore, the agency will undertake an audit (as and when required) of the activities of the project (both phases i.e. construction and operation) with respect to the protocols as defined in EMP and in NOC. The specific responsibilities are as follows:

- Liaison with the Project Director of WAPDA on the proposed project to ensure compliance of measures as given in the EMP and in NOC issued by it for the construction activities of the proposed project;
- Environmental Audit of the activities being undertaken by WAPDA and all other relevant stakeholders as provided in the EMP and NOC through random site visits and meetings.

## 9.5 PARTICIPATORY CONSULTATION FRAMEWORK

This aspect has been discussed in detail in the Chapter 6.


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## 9.6 PLANNING FOR EMP IMPLEMENTATION

### 9.6.1 NOC and Other Approvals

- **EPA Approval Process**

The EIA report duly reconciled with WAPDA is to be submitted to GB EPA for obtaining NOC. A demand draft of required EIA review fee has to be deposited along with the report by the Proponent to GB EPA for initiating the review and EIA approval process. The approval from GB EPA is the mandatory requirement before commencement of the proposed project activities.

- **Provincial Departments of Wildlife, Forest and Archaeology**

At the feasibility stage of the project as per the requirement of EPA guidelines for the Sensitive and Critical Areas, concerned provincial forest and wildlife departments are informed through letters for the proposed project.

During the construction stage, if the implementation of the proposed project involves the clearing of vegetation and trees which belongs to the forest or wildlife department, the EPC Contractor will be responsible for acquiring a NOC from the provincial department. The application for an NOC will need to be endorsed by WAPDA. Similarly, if any Archaeological monument or site is crossed by or near to the proposed project concerned provincial archeological department needs to be contacted for NOC.

Where construction is to be carried out in the close proximity of the any archaeology sites (if identified during construction stage), WAPDA is required to coordinate with the concerned departments to ensure that the impacts are minimized. The EPC Contractor is also required to contact with concerned department before the start of the construction work.

- **Provincial Revenue Departments**

Under the national law, matters relating to the land-use and ownership are the provincial subjects and the revenue department of the concerned province is empowered to carry out the acquisition of private land or built-up property for public purposes, including on behalf of other provinces. For this purpose, the concerned department must lodge an application with the concerned provincial department to depute a Land Acquisition Collector (LAC) and other revenue staff, who will be responsible for handling the matters related to the acquisition and disbursement of compensation.

### 9.6.2 Stakeholder Coordination

Notwithstanding the efforts so far put in for public participation, this activity will have to be pursued through the forthcoming implementation phases of the Project. In particular, the focus will be on the improvement and modification of the proposed intervention designs.

Participation mechanisms facilitate the consultative process and include information sharing and dissemination, disclosure, and participation of affected people and other stakeholders in the proposed project related activities. In the particular social set-up of the project area, it is also important to involve the religious leaders as representatives of the public as well as part of effective communication process. They can provide a very effective medium to bring information to the affected male population through Friday prayers. Local business community, especially the affected one, should also be brought into the process of awareness and participation.


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The related institutional arrangements should also be in place for continuous consultation throughout the process of planning and implementation. During construction, WAPDA Node will have to implement EMP.

The construction schedule will be established / updated before the commencement of construction work considering the activities specifically suggested in EMP for its implementation.

## 9.7 ENVIRONMENTAL MANAGEMENT PLAN

The Environmental Management Plan (EMP) provides the framework for the implementation of the mitigating measures and environmental management and monitoring during the design, construction and operation phases of the proposed project. **Tables 9.1** shows impacts, targets, mitigations and the responsible organizations for the implementation of the mitigation measures during the design, construction and the operation phases respectively.

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**Table 9-1: Environmental Management Plan**

| Sr. No. | Impacts | Mitigation Measure | Responsibility | |
|---|---|---|---|---|
| | | | Implementation | Monitoring |
| **Design/ Pre-Construction Phase** | | | | |
| 1 | **Field Investigations and setting up of construction camps**<br><br>Low level adverse impacts on the air quality, increase in noise level, contamination of surface water quality and soil erosion due to the pre-construction activities like geotechnical investigations including drilling, topographical surveys and seismic investigation will affect the existing settings. Activities like drilling, blasting, movement of machines and setup of EPC Contractor and Consultant camps will also impact the soil, wildlife, noise levels etc. This impact would be of medium significance | Good engineering practices and Standard Operating Procedures (SOPs) are required to be adopted by the EPC Contractor to mitigate this impact.<br><br>Measures such as sprinkling of water on the roads and dirt tracks, use of water to reduce air pollution during the stone crushing operation and tuning of vehicles and equipment will reduce the air pollution. The excavated material will be managed by ensuring proper storage areas located far away from the water bodies. The choice and design of these measures such as reduction of slope gradient and height, reduction in slope angle, removal of unstable material, use of reinforcement material etc. will be the responsibility of the EPC Contractor. The EPC Contractor will be required to train his workforce in the storage and handling of materials, like oil, diesel, petrol and chemicals, etc., which may potentially cause soil contamination. Special measures will be adopted to minimize the impacts on the nearby settlements such as avoiding noise generating activities during night time, etc. | EPC Contractor | MC<br>WAPDA |
| 2 | **Seismicity**<br><br>The Project area falls in Seismic Zone 2B (moderate hazard), which represents Peak ground acceleration from 0.16 to 0.24g, where g represents acceleration | The proposed structure should be designed to withstand moderate to high earthquakes, a very careful analysis, followed by ICOLD Guidelines and using latest software, of the situation will be required during the design stage. For seismic hazard analysis, updated structural and seismic evaluations should be consulted. | EPC Contractor | MC<br>WAPDA |



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| | | | Implementation | Monitoring |
| | due to gravity. In this Zone, designing of various types of structures are done on the basis of Peak Ground Acceleration (PGA). A high intensity earthquake impacting the poorly designed project site can adversely impact the future development. | Moreover, geo-technical investigations must be conducted prior to construction phase.<br><br>Continuous monitoring of the behavior of faults will be required during the operation stage and contingency plans to deal with such a situation must be part of the project management. Instruments to monitor seismic activity must be installed at the time of construction.<br><br>Based on the analysis, the following earthquakes design parameters are concluded and recommended for the proposed project:<br><br>**Operation Basis Earthquakes (OBE):** OBE at return period of 145 years is recommended as follows: OBE Horizontal = 0.24 g and OBE Vertical = 0.17 g<br><br>**Safety Evaluation Earthquakes (SEE):** For the design of dam / weir, the following PGA 'g' values for SEE (Safety Evaluation Earthquakes) are recommended: SEE Horizontal = 0.44g and SEE Vertical = 0.29g<br><br>For the design of appurtenant structures, the following PGA 'g' values for SEE (Safety Evaluation Earthquakes) are recommended: SEE Horizontal = 0.38g and SEE Vertical = 0.26 | | |
| 3 | **Flooding** | Keeping in view the different types flood estimations and generation of high peaks due to GLOFs, it is | EPC Contractor | MC<br>WAPDA |



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| | As river water will pass through the headrace tunnel and overflow spillways, there is a chance that these tunnel and spillways could not accommodate the flows in abnormal years, which may pose a threat to the main structures and this impact may be treated as High Significant | recommended to adopt design flood of 10,000 years return period at weir site. Therefore, design flood of 3,250 $m^3/s$ at weir site has been assumed for the calculations of design of structures.<br><br>It is also suggested to have close monitoring of Glaciers in Hunza Region to have better judgment of GLOFs and remedial measures for the safety of Attabad Lake and downstream areas. However comprehensive study will be undertaken during Detailed Engineering Design of the Project by EPC Contractor. | | |
| 4 | **Resource Conservation**<br><br>Resources involved in the construction of proposed Project would include water, fuel and construction materials.<br><br>Excessive water consumption by the construction staff may stress water resources in the Project Area and in certain cases may disturb the existing water supplies in the Project Area. Construction material to be used for construction includes coarse aggregates, fine aggregates, asphalt, cement, sand, lining material, earthworks, reinforced and structural steel etc. . Almost all the materials to be used in the construction of proposed Project are non-renewable and | ▪ Use water bowser tanks for construction works and mineral water bottles/ ground water for drinking purpose;<br>▪ Reduction of wastage of water through training of workers involved in water use;<br>▪ Reuse of construction waste materials may be adopted wherever possible;<br>▪ The efficient and well maintained equipment and machinery should be used;<br>▪ The equipment and machinery should be turned off when not in use;<br>▪ Ensure adequate insulation to reduce heat loss through batching plants;<br>▪ Regularly monitor CO and $CO_2$ content of the flue gases to verify that combustion systems are using practical excess air volumes; and | EPC Contractor | MC<br>WAPDA |



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| | therefore their efficient use is necessary for the future use.<br><br>Fuel will be used to operate construction machinery. Efficient use of energy resources is important to reduce air emissions. For conservation of energy, efficiency of the engines and burning processes is important. The impact significance is medium adverse | ▪ A good camp design and an efficient worksite management plan can help the contractor to reduce the water demand, wastewater and solid waste volumes to the lowest levels. | | |
| 5 | Flora<br>During the pre-construction phase, activities such as installation of construction camps, construction of temporary roads and mobility of construction staff may damage the local vegetation/trees. As the heavy machinery and camps will be moved and installed, which require significant space due to which available vegetation is expected to be removed. This impact is site-specific, temporary, reversible, possible, medium significant and needs to be encountered prior to the start of construction stage. | ▪ The camps, mobility of machinery and construction of temporary road should be properly planned and well designed to avoid any loss to local green cover;<br>▪ It is recommended to establish the construction camps where minimum or no vegetation exists;<br>▪ Similarly, the alternate routes for roads and location for camps are recommended where no loss of vegetation is expected; and<br>▪ An inventory of trees/vegetation may be prepared by the contractor with the help of concerned department (Forest) before clearing the site | EPC Contractor | MC<br>WAPDA |
| 6 | **Fauna**<br>As movement and installations of machinery and vehicles will take place so noise and habitat loss is expected. The | ▪ As movement and installations of machinery and vehicles will take place so noise and habitat loss is expected. The routes of the available wildlife and other habitats may be affected due to camps set-up and machinery movements and installations. | EPC Contractor | MC<br>WAPDA |



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| Sr. No. | Impacts | Mitigation Measure | Responsibility | |
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| | routes of the available wildlife and other habitats may be affected due to camps set-up and machinery movements and installations. Temporary access road (if any) may also affect the habitat of locally available fauna. This impact is site-specific, temporary, irreversible, possible and low significant | Temporary access road (if any) may also affect the habitat of locally available fauna. This impact is site-specific, temporary, irreversible, possible and low significant | | |
| 7 | **Aquatic Life**<br>Fisheries Department Hunza has introduced several thousand fingerlings of exotic fish species namely Salmo Trutta Fario ( Brown Trout ) at Attabad lake and downstream river during the period from 2012 to date for propagation and the said specie has made breeding grounds at Attabad lake and downstream as well. Besides this a number of indigenous fish species also exist in the same water bodies having commercial as well as ecological importance. The destruction of habitat will have significant adverse impact on the aquatic life and fisheries.<br>Fish usually migrate from one place to another for search of food, shelter and spawning/breeding. Due to implementation of the proposed Project fish migration might be affected up to some extent. Water requirements and movement of aquatics along with other risks may also be anticipated due to the | ▪ Annual restocking plan of fish fingerlings shall be included in the project to compensate the stock depletion due to decrease in fish breeding grounds.<br>▪ Fish ladder shall be in sure for freely movement of fishes;<br>▪ Fish screening system shall be developed so that fish may not be trap at fore bay or penstock pipe or channel.<br>▪ Besides the above mentioned points, a Fisheries research unit and a brown trout hatchery with research/management staff should be established at the project side for research purposes as well as impact assessment during construction as well as operational phases of the said project.<br>▪ The establishment of fish hatcheries under this project should be ensured by GB Fisheries Department, Huzna in close consultation and coordination with GB EPA;<br>▪ The minimum flow to be ensured through the weir during the whole year. In case the hydrological records are enhanced, the figure of minimum | EPC Contractor | MC<br>WAPDA |



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| | proposed project. This impact is categorized as medium to high significant. | requirement for maintenance of aquatic ecosystem has to be revised likewise;<br>▪ To conserve the freshwater fishery resources, it is important to involve fisheries scientists and local communities in all study phases of proposed project;<br>▪ Moreover, the impact on fish fauna, both up and downstream of the project site specially the migration patterns and breeding grounds need to be taken into account during all stages of the project and should be monitored by the contractor specialized professionals in consultation with GB, Fisheries Department Hunza;<br>▪ GB, Fisheries Department has authority to update, change and add/ recommend any standard as per law of land and in best public interest; and<br>▪ The custodian Department should have a close liaison with GB EPA and Fisheries Department GB to ensure the conservational aspects of fisheries during all stages of the project to avoid any negative impacts on local natural environment. | | |
| 8 | **Permanent land** will be acquired for the Project components such as Powerhouse, Weir & Associated Structures, Access Roads and Project Colony. Total land to be acquired is approximately 183 acres (05 acres for Contractor's Camp, 60 acres for Project Colony and Powerhouse Area, 103 acres for Intake Area and Access Corridor and 15 acres for Spoil Area) for project components which includes both private | Government owned land for the Project area will be acquired as per the policy of government of GB. While private land will be acquired as per provision of LAA, 1894. The process of land acquisition will start before the Project will enter into construction phase and section-4 of land acquisition act, 1894 will be notified by relevant agency.<br><br>The process of land acquisition and compensation should be followed in a transparent manner to minimize | EPC Contractor | MC<br>WAPDA |



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| | and government land. The estimated total land to be acquired is 777.5 acres due to the impounding of reservoir up to maximum conservation level including free board, including river bed. This will result in loss of land. The estimation of land requirement will be finalized after the detail design by the EPC Contractor.<br><br>The ownership record of affected land will be prepared by the Revenue Department according to separate categories of the land. The significance of impact is high adverse needs to be encountered prior to the start of construction stage | the impacts to provide judicious compensation to the displaced by providing sufficient budget in the project cost | | |
| 9 | **Temporary Land acquisition**<br><br>During the construction activities, EPC Contractor will establish contractor camps, storage areas for materials and equipment including vehicles, workshops, stockpile yard, etc. EPC Contractor need to lease the land for these areas in the vicinity of the construction sites. These areas will be acquired on temporary basis by direct negotiation and agreement with the owners or negotiated with or decided by the district administration office. Temporary acquisition will principally be the responsibility of the contractor. The | Land for above mentioned facilities will be directly rented from the private landowners by the EPC Contractor. The provisions of the Land Acquisition Act (LAA), 1894 will not be involved as the acquisition of the land will be temporary and will be covered by short-term lease agreements between the landowners and EPC Contractor. Temporary acquisition will principally be the responsibility of the EPC Contractor. Rental terms should be negotiated to the satisfaction of the concerned landowners and the agreement should be made in local language to make the process clear.<br><br>As mentioned, the location of these areas are not finalized yet, therefore a criterion has been suggested which should be followed to avoid the adverse impact on the environment. The land for above mentioned | EPC Contractor | MC<br>WAPDA |



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| | significance of impact is high to medium adverse. | facilities should be selected and leased prior to the start of construction phase.<br><br>Lease agreement should also govern the process of site restoration of the leased or rented land after the construction phase and will ensure through the terms of the construction contracts that landowners are compensated according to the terms of the lease agreements and the site restoration plans agreed upon by the EPC Contractor are duly carried out.<br><br>The following general site selection criteria have been suggested to be complied by the EPC Contractor:<br><br>▪ Minimize the resettlement, relocation of the existing infrastructure like roads, cultural and religious sites etc. and avoid the cutting of trees;<br>▪ It should be elevated to avoid floods and for other security reasons;<br>▪ Proximity to the major disaster and emergency management authorities;<br>▪ Avoid potentially security vulnerable areas;<br>▪ Minimize disturbance to the natural habitats of flora and fauna;<br>▪ Avoid densely populated areas/towns;<br>▪ Avoid wildlife sanctuaries, national parks and game reserves; | | |



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| | | ▪ Appropriate distance from the sensitive receptors (for instance, minimum 500m); and<br>▪ Avoid cultural, religious and historical buildings | | |
| 10 | **Impact on structures**<br><br>In the reservoir area of the proposed project miscellaneous residential, commercial and community structures will be affected due to the project intervention. These structures will be demolished permanently and will have to relocate and move their dwellings elsewhere. The community and religious structures are very sensitive to impact and need special care during execution of the project; because people think that these structures might not be rebuilt if once demolished. A graveyards fall in the reservoir area of the proposed Project. Shifting and demolishing of the graveyard may cause serious social issues. Due to adverse impact on the residential, commercial, and community structures, human disturbance will occur which create magnitude social, gender, livelihood and cultural issues. This impact can be categorized as negative, local, high, permanent and irreversible. The inventory of structures along with the detailed measurement of structures will | ▪ Due consideration should be given to minimum and no impact on the residential, commercial, and religious structures;<br>▪ Compensation for the affected structures should be evaluated and provided as per market rates.<br>▪ Compensation should be given for all affected crops and trees;<br>▪ The effort will be made by making changes in design to avoid the sensitive and religious structures and to minimize the issues at possible extend. If needs demolishing/shifting, a mechanism will be developed for the restoration of these structures during the detailed design by the EPC contractor with the community consultation;<br>▪ Affected Persons should be compensated on full replacement cost of each category to construct a new structure of the same type; and<br>▪ Proper consultations and coordination's with project affected persons during resettlement process. | EPC Contractor | MC<br>WAPDA |



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| | be completed by the EPC contractor during the phase of detailed planning. | | | |
| 11 | **Impact on Social Life**<br><br>During the planning and design phase of the project, it is anticipated that there will not be any potentially significant adverse impact on the socio-economic environment. Locals may be temporarily disturbed due to the field investigations and drilling activities, disturbance to electricity poles and existing track/roads within project boundary. This impact can be categorized as medium Significant. | ▪ Proper compensation and restoration mechanism of public utilities will be considered during the detailed design of the Project;<br>▪ Complete rehabilitation of affected public utilities will be ensured;<br>▪ The provision in the design and budget for the relocation of the existing utility infrastructures wherever required shall be finalized in consultation with the concerned department;<br>▪ Close coordination with the concerned departments to curtail inconvenience to the residents of the Project Area;<br>▪ Timely public notification of unexpected disruption of services; and<br>▪ Good engineering practices shall be adopted to avoid or reduce these impacts. | EPC Contractor | MC<br>WAPDA |
| **Construction Phase** | | | | |
| 1. | **Aesthetic value of the project area**<br>Attabad Lake is an important recreational site for the tourists including foreign visitors. Construction activities may result in some visual impacts. The construction activities will involve the cutting of trees/bushes, excavation, soil filling and cutting operation. This disturbs the natural scenic value of the environment. In | The adverse environmental impacts related to the aesthetic could be effectively minimized at the construction phase. These will be mitigated by the control of clearing vegetation to the area in the construction limits and by plantation and quick re-vegetation during the construction phase. Good house-keeping, cleaning, efficient solid waste management system should be implemented to improve the aesthetics of the working environment. | EPC Contractor | MC<br>WAPDA |



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| | addition to that the sitting of construction equipment and the lacks of resurfacing/replanting of exposed areas are also the leading factor to aesthetic reduction. The impact significance is medium adverse. | ▪ | | |
| 2. | **Topography**<br><br>Construction activities are not expected to impact the topography of the area significantly except for those areas where physical activities including digging and excavation, storing or dumping sites for excessive material and movement of heavy construction machinery will be carried out. The excavated material will be generated due to the construction of various components of the Project such as construction of Coffer Dams, Sediment Flushing Tunnel/Under sluice, Weir, Headrace Tunnel, Surge Tank, Penstock, Powerhouse, Tailrace Channel, Project colony. The area where excavated material is to be dumped may also be impacted. The impact significance is medium to low adverse. | ▪ The excavated material will require safe disposal by the EPC Contractor. Most of the excavated material could be used in back filling purpose, where applicable. A detailed development and operation plan for borrow areas must be prepared by the EPC Contractor before the starts of extraction of material from each borrow area. EPC Contractor should strictly follow the provisions of approved plan in order to minimize any adverse impact associated with the borrow areas. Likewise, excavated material should be dumped at suitable and approved disposal sites | EPC Contractor | MC<br>WAPDA |
| 3. | **Land Slide** | To avoid the major risks, all structures have been proposed on the left bank of Hunza River. Blasting should be avoided or minimized where possible, if inevitable then low intensity explosive material should be used instead of high intensity explosive material. It is | EPC Contractor | MC<br>WAPDA |



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| | Landslides are common in the project area<br><br>Due to the Project activities, especially in case of blasting or cutting of rocks in some areas, the formation will become loose and the risk of landslides will increase in the immediate vicinity of the construction sites, especially at the right bank of Hunza River, which may be considered as a high adverse impact. The impact significance is high to medium adverse. | strongly recommended to perform appropriate confirmatory geotechnical investigations all along the alignment of Headrace tunnel and other components for assessing strength parameters of natural material either rocks, moraines or scree. This shall be done so that safety of this major Project component and adjacent areas can be ensured through proper design of cut slopes.<br><br>▪ Landslide risks shall be mitigated by the installation of safety barriers at construction sites, and monitoring and informing locals about construction schedules, and any weather events that might exacerbate landslide risk. Construction work will be avoided during rain to the extent possible. The EPC Contractor will prepare the Management Plan for blasting activities and implement the same after approval from the Supervision Consultant and Client | | |
| 4. | **Site accessibility**<br><br>The proposed Project Area falls within the Hunza Valley which is located about 119 km from Gilgit city. The Project site can be accessed through Korakoram Highway (KKH) which is the only major mode of transportation in the Project area. Heavy vehicles will be utilized to transfer construction plants, equipment, construction materials, cement and fuel. These activities may have adverse impacts on the existing infrastructure. Apart from that it may cause air and noise | The access roads to the hydropower site have to be pre-determined in consultation with the concerned departments. Access roads would have to be widened and/or improved to carry the anticipated load of traffic.<br><br>During the course of construction of proposed Project, EPC Contractor will provide the signage and/or traffic control to the extent deemed necessary by the traffic utilizing or accessing the site roads. These signs will inform, control, warn, shift, or stop traffic on all site roads affected by the Project's heavy traffic. The following measures will be taken by the EPC Contractor during | EPC Contractor | MC<br>WAPDA |



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| | pollution. The impact significance is high to medium adverse. | the construction phase for the effective implementation of the traffic plan:<br>▪ National and local traffic rules and regulations, instructions manual for motor vehicle and mobile machinery operation should be followed;<br>▪ No one will be allowed to drive motor vehicle or operate mobile machinery without a driving license;<br>▪ It should be prohibited to drive or operate vehicle in case of over fatigued or mental disease;<br>▪ Traffic speeds on unpaved roads should be limited to no more than allowable traffic speed;<br>▪ Traffic speed signs should be displayed prominentl y at all site entrances;<br>▪ A daily routine check-up of vehicles should be conducted no less than 5 minutes before its service;<br>▪ Use of appropriate signs, equipment, and traffic control measures that conform to the provisions in the traffic manual of city traffic police;<br>▪ Traffic inspection and security during transportation;<br>▪ Limit vehicular traffic designated access roads, construction laydown area, parking areas and the Project site;<br>▪ All damaged, destroyed or modified pavement legend, traffic control devices, signing and striping associated with the proposed development should be replaced as required prior to issuance of a certificate of occupancy; and | | |



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| | | ▪ Construction signs, lighting and barricading should be provided during construction as required.<br>▪ The EPC Contractor should also be responsible to prepare a comprehensive Traffic Management Plan and follow the conditions of Contract Agreement. | | |
| 5 | **Natural Drainage**<br>Construction activities such as excavation, filling and construction will affect the existing soil pattern in the Project Area including water pathways its surroundings. In addition, this will lead to changes in the existing drainage pattern. The conditions will be more hazardous during the flood periods and may affect the construction activities. The impact significance is high to medium adverse. | During the construction phase, excavated material should be properly disposed of ensuring that it will not block the natural drainage paths. Open drains for drainage of rain/flood water should be constructed, if considered necessary during construction period.<br>▪ | EPC Contractor | MC<br>WAPDA |
| 6 | **Soil Contamination & Erosion**<br>During the construction phase of the proposed Project, large quantities of materials, chemicals, fuel and lubricants will be used apart from the generation of solid waste and liquid waste from the construction camps. Fuels and chemicals will be stored at the site for their immediate use, which will contaminate the soil if not handled properly particularly | ▪ Sites disturbed by construction activities will be restored to their original conditions upon completion of construction work and photographic record will be maintained to ensure pre-post subproject conditions intact;<br>▪ Soil contamination by asphalt should be minimized by placing all containers in caissons;<br>▪ The EPC Contractor will be required to instruct and train their workforce in the storage handling and management of materials and chemicals that can potentially cause soil contamination; | EPC Contractor | MC<br>WAPDA |



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| | at asphalt plant sites, workshop areas and equipment washing yards.<br><br>Similarly, removal of vegetation and shrubs for the purpose of construction activities will lead to loosing of the soil, soil disturbances, and exposure of bare soil surface. This causes problems of soil erosion during rain. Similarly, steep gradients increase erosion on these slopes due to reduced water infiltration and increased runoff accumulation. Soil erosion may also occur in the workshop areas as a result of improper drainage system of equipment washing-yards and improper management of construction activities. The impact significance is high to medium adverse. | ▪ Material Safety Data Sheets (MSDS) will be strictly followed during handling and storage of chemicals;<br>▪ If any contaminated soils are found at the construction sites or at camp sites, they shall be removed and deposited in a sealed pit in at designated area;<br>▪ The EPC Contractor will be required to prepare training manual and modules for all the construction related activities along with the schedule of training program and submit to the Supervision Consultant for approval;<br>▪ Solid waste generated at the camp sites will be properly treated and safely disposed only in the demarcated waste disposal sites/areas;<br>▪ Subproject sites will be selected to avoid or minimize vegetation removal/clearing which would accelerate erosion and increase landslide risk;<br>▪ The EPC Contractor shall adopt good engineering practices that will help to control or minimize the soil erosion both at the construction sites and in peripheral areas. All the disturbed areas need to be protected against soil erosion by stripping and stockpiling of all the available topsoil for later re-vegetation. Special slope protection measures will be adopted in the sensitive areas; and<br>▪ Site restoration plan for the Project should be strictly followed. | | |
| 7. | **Wastewater Generation** | To dispose the liquid waste generated from the construction activities, the following steps will be taken by the EPC Contractor: | EPC Contractor | MC<br>WAPDA |



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| | | | Implementation | Monitoring |
| | Wastewater will be generated at the construction camps, from construction activities an residential colony (for EPC Contractor, the Consultant and the Employer staff). If the generated wastewater is not properly treated or disposed of, this may contaminate the surface water apart from soil contamination. Water from dewatering activities (during rainy season) has the potential to contain suspended solids and oil and grease and if disposed of untreated may affect the soil quality. | ▪ Domestic and chemical effluents from the construction camp will be disposed by the development of on-site sanitation systems i.e., septic tanks;<br>▪ The domestic sewage will be treated with biological treatment technology and will be discharged as per NEQS. Proper monitoring to check the compliance of NEQS will be carried out;<br>▪ Proper monitoring to check the compliance of NEQS will be carried out. Septic tank will be located adjacent to the construction camp;<br>▪ Sewage from construction camps will be disposed of after proper pre-treatment;<br>▪ Water discharged to drains should contain a minimum quantity of suspended solids; and<br>▪ Site for construction camp will be selected at least 500 m away from the settlements | | |
| 8. | **Solid Waste**<br><br>Different types of waste including construction (waste concrete and asphalt, empty containers, excavated material), municipal (from construction camps) and hazardous wastes (including empty containers of paint, lubricants, grease, fuel oil, electrical wiring, pipis etc.) are likely to be generated during the construction phase of the proposed | ▪ Minimize the generation of spoils by recycling the excavated rock to the maximum extent possible by using them as aggregate material in the concrete works;<br>▪ Construction waste will be routinely collected and safely disposed of in clearly demarcated waste disposal sites located near each subproject site following international best practices;<br>▪ Waste disposal will be carried out following international best practices and will ensure that there are no negative impacts on soil, water bodies, | EPC Contractor | MC<br>WAPDA |



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| | Project and from the EPC Contractor's Camps (the solid waste generation is estimated to be 157.5 kg/day (as per 0.45 kg/capita/day waste generation)[20] for 350 construction workers) which may have potential to serve as breeding grounds for the disease spreading vectors and rodents. During the construction phase, significant quantities of rock will to be excavated. In order to reduce the amount of rock to be disposed, excavated rock can be used in the Project for different types of infrastructural works. The remaining spoil will be disposed in designated and safe disposal areas. Throwing away of solid wastes into water channels may cause blockages in drainage channels, contamination of nearby water bodies and soil contamination (render them unfit for plantation).<br><br>Empty containers containing the toxic, flammable and corrosive materials may pose hazard to the workers. This may result in health risk to work force and public, if disposal site is improperly selected. | existing waste management systems, transport routes, and aesthetic value of the area;<br>▪ The debris produced during construction would preferably be dumped at nearby depressions rather than being thrown away and left unattended. Leftover material would not be dumped into water bodies;<br>▪ The labor workforce (including community labor) will be trained on the handling, storage, and disposal of construction waste. Burning of waste shall be prohibited;<br>▪ PPEs shall be provided and worn by the personnel involved in construction activities and training them in their use;<br>▪ Waste containers with proper color coding will be provided on site to store different type of waste;<br>▪ Site Specific Solid Waste Management Plans (SWMPs) will be developed and implemented by Contractors; and<br>▪ It will be ensured that no waste or left over construction material is left behind in the cultivation fields | | |

[20] *The World Bank Report 2012 – What a Waste: A global review of solid waste management. Based on UNEP estimates for waste generation in the Asia Pacific. Average is 0.45 kg/capita/day*



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| | All these, if left unattended, can become a source of nuisance and environmental pollution in the subprojects area. Discarded materials and equipment may also pose traffic safety risks if left on or near transport routes. This impact is moderate adverse in nature. | | | |
| 9. | **Surface Water**<br><br>Surface water quality of the Attabad Lake may get deteriorated due to the construction activities. During the construction phase of the proposed Project, materials like sand, gravel and stones will be required in large quantities. Extraction of the materials will also affect the surface water quality by increasing the sediment load. This water will be used during different construction activities. The movements of heavy vehicles on the unpaved tracks, excavation activities, cut and fill processes in the Project Area, fuel and chemical spills may deteriorate the quality of the surface water. These activities will also increase the sediments and turbidity of the water.<br><br>Waste streams can bleed toxic materials from items such as batteries, used | The excavated material will be managed by ensuring proper storage areas located far away from the water bodies. All the solid waste from the camps should be properly collected at source by placing containers and disposed of through proper solid waste management system. To reduce the impact of sediment, load the EPC Contractor should make arrangements such as fine screens and drains to limit the siltation into the water bodies. A simplified sedimentation tank shall be built on the construction site for the primary treatment of the construction equipment wastewater, detergents and mud. Wastewater effluent from the Contractors' workshops and equipment washing-yards should be passed through gravel/sand beds to remove oil/grease contaminants before discharging into the natural streams. This is the general guideline principle for the contractor. Appropriate sanitation and water supply facilities will be provided in the labor camps.<br><br>Spillage of fuel/oils and other construction materials shall be contained with best handling/construction practices and strict skilled supervision. The EPC Contractor will ensure that construction debris does not | EPC Contractor | MC<br>WAPDA |



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| | computer equipment, leftover paints and pathogenic organisms include specific strains of bacteria like E. coli into the leachate of dumps. Leachate from waste piles caused by exposure to precipitation and from residual liquids in the waste itself may contain organic matter, nutrients, metals, salts, pathogens, and hazardous chemicals. If allowed to migrate, leachate can contaminate surface water. This impact is moderate adverse in nature. | find their way into the water bodies without proper treatment<br>Treating and disposing the sewage in a manner that the soil and water is not contaminated and ensure compliance with NEQS or international standards/guidelines, whichever is stringent will be followed. | | |
| 10. | **Ambient Air Quality and Climate Change Aspects**<br>During construction period, the impacts on air quality are mainly due to material movement and the construction activities (particularly blasting of rocks, operation of batching and mixing plants, drilling, stone crushers) causing an increase of emission of carbon monoxide, sulfur oxides, nitrogen oxides, un-burnt hydrocarbons and other greenhouse gases, as well as fine particulate matter. The pollution causing activities during the construction phase are: loading/ unloading and stocking of construction | ▪ In order to reduce the dust emissions in the construction area due to material transport and construction activities, provisions will be made for sprinkling of water in the area where earth filling, excavation and other dust emissions causing activities being carried out. It will be ensured that the construction debris is removed on daily basis;<br>▪ Construction materials and spoil materials will be transported through trucks covered with tarpaulins. During windy conditions stockpiles of fine material will be wetted or covered with plastic;<br>▪ In no case, loose earth will be allowed to pile up along the approach roads/ public access areas;<br>▪ PPEs such as dust masks will be made available to the construction workers at the site to avoid potential health hazards; | EPC Contractor | MC<br>WAPDA |



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| | material, transportation of construction and excavated material, diesel generator, construction equipment, vehicles rock cutting operations, site clearance, excavation, concrete batching and concrete mixer. The ambient air quality over the immediate influence area will be affected and the criteria pollutants levels and greenhouse gases in ambient air might increase, over longer distances depending on atmospheric conditions. Emission of greenhouse gases causes global warming and other climatic changes on regional and global scale. Cutting of trees will also reduce the carbon sequestering and overall increase the $CO_2$ content in atmosphere.<br><br>The impact of emissions is assessed to be temporary and moderate and is unlikely to have lasting impacts after construction work is complete | ▪ Idling of delivery trucks or other equipment will not be permitted during periods of unloading or when they are not in active use;<br>▪ Open burning of solid waste at construction site will not be allowed;<br>▪ All vehicles and other equipment used during construction will be properly and regularly tuned and maintained;<br>▪ Ensure compliance with the NEQS;<br>▪ Diesel generator should be fitted with acoustic enclosure and stack of appropriate height for the proper dispersion of emission;<br>▪ Awareness programs of causes and effects of climate change will be conducted for mitigating GHG emissions, ensure plantation of trees and use solar panels where possible;<br>▪ Regular monitoring of air quality in accordance with the formulated environmental monitoring plan (given in EMP). | | |
| 11 | **Noise and Vibration**<br><br>Noise and vibration will occur due to the operation of construction machinery and other equipment. The major sources of | ▪ Construction vehicles and machinery will be kept in good working condition, and be properly tuned and maintained through the duration of construction work with the objective of minimizing excessive noise and vibration;<br>▪ High noise/vibration emitting equipment will be used during regular working hours (9 AM to 5 PM) so as to reduce the potential of creating a noise nuisance during the night to nearby communities. This | EPC Contractor | MC<br>WAPDA |



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| | noise and vibration[21] are construction activities, movement of vehicles, construction equipment, blasting, drilling, pouring equipment, stone crushers and generators etc.<br><br>High background noise levels can cause significant disturbance to local wildlife, and have adverse psychological and physiological effects on individuals residing in nearby communities.<br><br>Significant noise pollution impacts are expected only during the construction phase of activities involving large civil works. The cumulative effects from several machines can be significant and may cause significant nuisances. In all cases, the impacts are likely to be short-term and mitigatable and will not have any lasting effects once construction activities have completed. The significant impact may be of high magnitude for the labor working in a place that is close to the area where explosives are in operation. This impact medium adverse in nature. | equipment will be fitted with noise reduction devices such as mufflers and silencers wherever possible<br>▪ The vibration from major construction activities such as excavation, compacting, drilling, blasting, etc. are considered intermittent and short-term, and likely to be tolerated if prior warning is given to potentially affected residents;<br>▪ Vibration measurement will be carried out during construction phase by the EPC Contractor near the settlements;<br>▪ Personal Protective Equipment (PPEs) shall be provided and worn by the personnel involved in construction activities and training them in their use;<br>▪ Construction schedules will be disclosed to all nearby communities within vicinity of project sites prior to commencement of construction work;<br>▪ The EPC Contractor shall ensure the compliance with NEQS; and<br>▪ All complaints will be recorded and responded to in a timely and professional manner. | | |

[21] *According to British Standards of Noise and Vibration, humans are particularly sensitive to vibration with the threshold of perception typically being in the range of 0.14 to 0.3 mm/sec. Peak Particle Velocity (PPV) and levels above this may cause annoyance. However, significantly higher levels than this can be tolerated for single short-term events and do not cause annoyance or disturbance to humans.*



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| 12 | **Flora**<br><br>The project will involve destruction of vegetation cover due to the implementation of proposed Project. It is initially examined that approximately 575 number of trees/saplings may be affected (**Annex - II**) due to proposed project activities. The number of possibly impacted trees is calculated by using Remote Sensing technique through GIS and field observation. Moreover, no impact on the production of medicinal plants is anticipated, as the area has least number of these plants.<br><br>Exhaust of noxious gases from movement of heavy machinery and dust will pollute air which will adversely affect health and vigor of plants. During construction activities the EPC Contractor's workers may damage the vegetation and trees (for use as fire-wood to fulfill the camps requirements). This impact is categorized as medium significant.<br><br>**Loss of Agriculture Land**<br><br>Due to the impounding of reservoir area, based on 2424 m.a.s.l, it is estimated that about 14.28 acres of crops of agriculture land may be affected. However, it is anticipated that there will be no impact on agriculture land due to the construction | ▪ Incorporate technical design measures to minimize removal of trees, if possible;<br><br>▪ Cutting of trees and disturbance shall be avoided, as far as possible so, that negative effects on the process of natural regeneration of species are minimized;<br><br>▪ A tree plantation program shall be formulated with the recommendations and technical support of concerned Forest Department;<br><br>▪ As a principal, ten trees shall be planted in place of felling of one tree in consideration of mortality. Total 5,750 trees will be planted in lieu/compensation of 575 affected trees of similar floral function at the available spaces in/around the project area;<br><br>▪ Proponent shall implement the plantation program with the help of Forest Department and with the consultation of Supervision Consultant;<br><br>▪ The Forest Department shall involve the communities (if required) for carrying out plantation;<br><br>▪ Open fires should be banned in the area to avoid hazards of fire in the area;<br><br>▪ Clearing of vegetation cannot be avoided at the areas specified for project structures, but damage to the natural vegetation may be minimized by establishing camp sites, workshops and batching plants on waste/barren land rather than on forested or agriculturally productive land;<br><br>▪ However, if such type of land is not available, it shall be ensured that minimum clearing of the vegetation | EPC Contractor | MC<br>WAPDA |



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| | activities for other components (such as weir, headrace tunnel, surge tank, penstock, powerhouse, switchyard and tailrace). This impact can be categorized as medium significant.<br>**Pasture and Grazing Land**<br>The Power House will be constructed on the communal land owned by the Ganish village, having grazing area. Similarly, impounding of reservoir area may also result in loss of vegetation cover which will subsequently affect the community's pasture and grazing area and livestock. This impact is categorized as permanent, irreversible and moderate in nature. | is carried out and minimum damage is caused to trees and undergrowth;<br>▪ Construction vehicles, machinery and equipment will remain confined within their designated areas of movement;<br>▪ The EPC Contractor's staff and labor shall be strictly directed not to damage any vegetation such as trees or bushes;<br>▪ EPC Contractor shall provide gas cylinders at the camps for cooking purposes and cutting of trees/bushes for fuel shall not be allowed;<br>▪ Compensation for the loss of crops to the land owners and cultivators as the case may be will be paid, in accordance with the prevailing market prices and uniformity in rates will be ensured within the local areas;<br>▪ The whole process of the payment to the farmers will be made transparent, judicious and without any discrimination or favour; and<br>▪ As far as possible, barren land without any crop will be selected for the camp sites and disturbance to the crops and natural vegetation will be avoided as much as possible. | | |
| 13 | **Fauna**<br>During construction phase the existing population of mammals and reptiles of the construction areas may be affected due to disturbance arising from construction | ▪ Care shall be taken during construction activities for avoiding purposely or chance killing of animals;<br>▪ If found any wild species and habitat during construing that must dealt carefully and local wildlife department officials should be called; | EPC Contractor | MC<br>WAPDA |



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| | activities involving excavation, movement of machinery and vehicular traffic, movement of labor, camping, blasting, excavation, drilling etc. The existing animals will leave the directly affected areas due to construction activities and human intervention. Some animals particularly reptiles may get killed during the earthwork's operations.<br><br>Moreover, the movements of the mammals and reptiles will be restricted during the construction phase;<br><br>Birds as well will tend to move away from the construction areas and find shelter and food elsewhere due to the activities mentioned above for fear of being hunted / trapped.<br><br>Noise generated from machinery particularly during the night hours will even scare the wildlife residing in habitats located at some distance from the construction areas. Uncontrolled blasting may even disturb the wildlife of the Project Areas. Food and refuse at the EPC Contractor's camps may attract animals that might in turn be hunted by the workers. This impact is medium significant. | ▪ Hunting, poaching and harassing of wild animals shall be strictly prohibited, and Contractor shall be required to instruct and supervise its labor force accordingly and clear orders should be given in this regard;<br><br>▪ EPC Contractor must be held responsible for instructing his work force accordingly and for enforcing this restriction. In addition, this shall have to be controlled by the Wildlife Department;<br><br>▪ Client must have obtained NOC from the relevant departments prior to construction phase;<br><br>▪ Special measures shall be adopted to minimize impacts on the wild birds, such as avoiding noise generating activities during the critical periods of breeding;<br><br>▪ Similarly, wastes of the camps shall be properly disposed of to prevent it being eaten by animals, as it may be hazardous to them; and<br><br>▪ Noise produced by construction activities may be kept to acceptable level and ensure compliance with NEQS | | |
| 14 | **Aquatic Life**<br><br>During construction phase of proposed Project, cutting, blasting, excavation, | ▪ Solid waste generated from construction and camp sites will be safely disposed in demarcated waste disposal sites and the EPC Contractor will provide | EPC Contractor | MC<br>WAPDA |



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| | drilling, extraction, removing and dumping activities of materials at large scale will contribute heavy sedimentation and soil erosion which may cause habitat destruction, contamination and toxic accumulation of waste not only at Attabad lake but its impact can be seen downstream up to confluence of Gilgit River and beyond. Heavy machinery and equipment shall be used during construction phase, which may also result in heaps of leftovers of explosives, grease, chemicals, lubricants, and other harmful materials. These pollutants through run off rain water enter into the lake and river course increase toxicity of water causing rapid destruction of fish population and riverine ecology.<br><br>This situation can contribute up to great extent to destruct the aquatic life, ecology, breeding and spawning grounds of fishes, benthic fauna, food chain and abundance of micro and macro living organisms. This may lead rapid shortage of food like benthic population, phytoplankton, zooplankton, nekton etc. which play an important role to sustain food chain with different trophic level in any eco-system. This impact is categorized as medium to high significant. | a proper waste management plan, to avoid the water contamination;<br>▪ Land sliding and soil erosion are also the main factor to contribute silt load on river bed manifold causing damage to resting and nesting grounds of fishes. Construction of protective walls and gabions at certain points to make sure the stoppage of sliding debris. Plantation and vegetation cover can also be helpful for slope stabilization. Plants, herbs and shrubs reduce the level of pollution and toxicity at a great extent as bio-filter and carbon suckers;<br>▪ Prior NOC from Fisheries Department may also be considered for smooth implementation of the project activities;<br>▪ The labour working at construction site should be aware to protect especially edible fish and to avoid fish catching by any means. As according to law of land fish hunt is prohibited with all types including net, cages and by the use of dynamite;<br>▪ Training of work force in the storage and handling of hazardous materials and chemicals should be encouraged and educated to practice waste minimization and reuse to reduce quantity of the waste;<br>▪ Immediate collection of spilled oils/fuels/lubricants by collection of contaminated soils and skipping oils from surface water by applying appropriate technologies;<br>▪ Construction waste should be crushed and reused in other sites, where possible; | | |



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| | | ▪ It will be ensured that no waste or left over construction material is left behind in the cultivation fields;<br>▪ Construction vehicles and machinery will be kept in good working condition, and be properly tuned and maintained through the duration of construction work with the objective of minimizing excessive noise and vibration; and<br>▪ EPC Contractor shall ensure the compliance with NEQS. | | |
| 15 | **Discovery and Impact on of Heritage Sites and Structures during Excavation**<br><br>During excavation, there is a chance of finding artifacts. In case of finding any artifact, the contractor shall immediately report through Supervision Consultant to Directorate General (DG) of Tourism, Sports, Culture, and Archaeology & Museums Department Government of GB to take further suitable action to preserve those antiques or sensitive remains.<br><br>According to the field survey, no notified archeological site was present in the Project Area. This impact can be categorized as low to medium significant in nature. | ▪ In case of finding archeological remains during excavation, the EPC Contractor shall immediately report through Supervision Consultant to Tourism, Sports, Culture, Archaeology & Museums Department Government of GB to take further suitable action to preserve those antiques or sensitive remains. Chance finds procedure is given in **Annex- III; and**<br>▪ EPC Contractor needs to obtain approval for excavation and submit the plan of rehabilitation of the site after excavation.<br>▪ | EPC Contractor | MC<br>WAPDA |



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| 16 | **Social and Cultural Conflicts**<br><br>During the construction phase of the project, conflicts may arise between labor force and local community. Use of local resources and products by the construction workers can generate stress on the local resources. Furthermore, difference in cultural values may also cause discomfort to local residents. This impact is medium adverse in nature. | ▪ Local labor especially from nearby communities will be given preference for the construction works;<br>▪ Careful planning and training of work force to minimize disturbance to the local people;<br>▪ Public notification through print or electronic media during the entire construction phase to avoid any inconvenience in accessibility to the locals; and<br>▪ Adequate training of especially for the transitive workforce of the station (involved both in the construction process and in the commissioning) to regard the customs of the area so that the locals do not feel insecure.<br>▪ Code of Conduct will be prepared by the EPC Contractor and adopted during the project execution. All project personnel will be required to sign and follow the Code of Conduct. | EPC Contractor | MC<br>WAPDA |
| 17 | **Occupational Health and Safety**<br><br>Occupational Health and Safety (OHS) related impacts may arise during construction phase of the proposed Project due to installation of Contractor camp, movement of machinery & equipment, lifting operations, work at height, concrete pouring, working in night and manual handling during loading/unloading operation, as result of these works there will be a direct impact on the health and safety of all staff | ▪ The EPC Contractor will be required to follow the national/local acts related to OHS and World Bank Group General EHS Guidelines, 2007. The EPC Contractor will prepare the site specific occupational health and safety plan;<br>▪ Occupational health and safety monitoring programs of the EPC Contractor should verify the effectiveness of prevention and control strategies;<br>▪ Providing basic medical training to specified work staff and basic medical service to workers. The EPC Contractor will ensure the provision of basic medicines, first aid kits etc. at the camp site;<br>▪ Ensure periodic medical screening of the staff; | EPC Contractor | MC<br>WAPDA |



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| | working on the Project. The most common impacts include eye injuries which may occur due to stone or metal particles, hazard of being hit by falling objects, major hand-arm and whole body vibration hazards, skin and respiratory tract irritation from exposure to cement dust, overexertion and awkward postures etc.<br><br>Other impacts will be falling in trench, contact with electrical and mechanical equipment, equipment failure, uncontrolled movement, unguarded moving mechanical equipment parts, fatigue, unbalanced load, falling objects, hand and head injury, slip and trip hazards, exposed to high levels of noise for longer durations etc. This impact may be classified as high adverse in nature. | ▪ Complying with the safety precautions for the construction workers as per applicable International Labor Organization (ILO) Conventions;<br>▪ Training of workers in construction safety procedures, environmental awareness, equipping all construction workers with safety proper task specific Personal Protective Equipment (PPEs);<br>▪ Moreover, proper planning should be done for food storage, setting up of kitchens, wastewater collection system and solid waste management. Improper planning for these facilities may result in multiplication of rodents like rats, mice and shrew etc. and vectors like mosquitoes, bugs and flies which will have a negative impact on workers' health and safety;<br>▪ Efforts will be made to create awareness about road safety among the drivers operating construction vehicles;<br>▪ All trenches deeper than two meter should be protected with wooden bracing to avoid safety risks to workers and locals; Ensure that the site will be restricted for the entry of irrelevant people particularly children, disabled and elderly people;<br>▪ Ensure the use of safety and warning signs at the construction site;<br>▪ Ensure the provision of fire prevention and firefighting equipment; and<br>▪ Ensure the provision of training related to emergency prevention, preparedness and response arrangements by the EPC Contractor. | | |



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| | | These requirements will be incorporated into the bidding specification and contract documents, and will be binding on the EPC Contractor, at risk of penalty for noncompliance, as charges to be recovered from EPC Contractor for unsafe act or condition. | | |
| 18 | **Community Health and Safety**<br><br>Community health and safety issues during the construction of proposed project may include dust, noise, and vibration from construction vehicle transit, and communicable disease associated with the influx of temporary construction labor. The construction activities and vehicular movement at construction sites may result in roadside accidents particularly inflicting local communities who are not familiar with presence of heavy equipment. Quality of water resources available in the nearby local communities may be affected due to the oil spillage and leakage, roadside accidents, etc. Conflicts may arise between the local community and the construction workers, which may be related to religious, cultural or ethnic differences, or based on competition for local resources. The labor works with different transmittable diseases (HIV/AIDS, COVID-19, respiratory | ▪ The EPC Contractor will prepare the site specific community health and safety plan in compliance with relevant sections of the WBG General Environmental Health and Safety Guidelines (WBG 2007), chosen methodology and will be required to strictly follow;<br>▪ Ensure that the site will be restricted for the entry of irrelevant people particularly children, disabled and elderly peoples. Ensure the use of safety signs at the construction site;<br>▪ Providing basic medical training to specified work staff and basic medical service and supplies to workers;<br>▪ Ensure proper maintenance and repair of all vehicles, machinery and equipment to prevent the oil spills;<br>▪ Efforts will be made to create awareness about road safety among the drivers operating construction vehicles;<br>▪ Timely public notification on planned construction works; | EPC Contractor | MC<br>WAPDA |



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| | diseases, and skin and eye infections etc.) may cause spread out of those diseases in the locals of nearby community. The impact significance is moderate adverse. | ▪ Close consultation with local communities to identify optimal solutions for diversions to maintain community integrity and social links;<br>▪ Provision of proper safety and diversion signage, particularly at sensitive/accident-prone spots;<br>▪ Setting up speed limits in close consultation with the local stakeholders;<br>▪ The mitigation measures provided in the sub-sections for air and noise & vibration shall be adopted to reduce the air pollution, noise pollution and vibrational impacts on nearby community;<br>▪ Ensure effective implementation of GRM (to be prepared by the EPC Contractor) to timely address the issues;<br>▪ The communicable disease of most concern during construction phase, like Sexually-Transmitted Disease (STDs) such as HIV/AIDS, COVID-19 will be prevented by successful initiative typically involving health awareness; education initiatives; training heath workers in disease treatment; immunization program and providing health service;<br>▪ All workers must perform complete sanitization at the site as per updated / latest SOPs/guidelines issued by WHO and the national guidelines issued by the GoP[22]; | | |

[22] *https://covid.gov.pk/guideline*



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| | | | Implementation | Monitoring |
| | | ▪ Ensure prevention of larval and adult propagation of vectors through sanitary improvements and elimination of breeding habitat near to human settlements and by eliminating any unusable impounding of water; and<br>▪ EPC Contractor will take due care of the local community and observe sanctity of local customs and traditions by his staff. EPC Contractor will warn the staff strictly not to involve in any unethical activities and to obey the local norms and cultural restrictions.<br><br>Any environmental condition that is disagreeable to the public and causes an avoidable nuisance can be addressed with additional provisions in addition to those described above.<br><br>These requirements will be incorporated into the bidding specification and contract documents, and will be binding on the EPC Contractor, at risk of penalty for noncompliance, as charges to be recovered from EPC Contractor for unsafe act or condition. | | |
| 19 | **Labour Influx**<br><br>For the implementation of Project activities, skilled and unskilled labor is required by the EPC Contractor. Mostly, skilled and unskilled workers have been associated with the EPC Contractor since | ▪ Contractor camp will be established away from residential and populated area;<br>▪ Preference will be given to the local people to work with EPC Contractor, and EPC Contractor will hire maximum labor force from the project area because this will reduce the labor influx; | EPC Contractor | MC<br>WAPDA |



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| | long which they utilize, where they are required for the Projects, and while other workers are hired from the different areas that belong to different cultural backgrounds. Social problems and conflicts that are associated with Labor Influx are as follows:<br>▪ Risk of social conflict: Conflicts may arise between the local community and the construction workers, which may be related to religious, cultural or ethnic differences, or based on competition for local resources. Ethnic and regional conflicts may be aggravated if workers from one group are moving into the territory of the other;<br>▪ Increased risk of illegitimate behavior and crime: The influx of workers and service providers into communities may increase the rate of crimes and a perception of insecurity by the local community. Such illegitimate behavior and crimes can include theft, physical assaults, substance abuse, sexual assault and human trafficking;<br>▪ Impacts on community dynamics: Depending on the number of incoming workers and their engagement with the host community, the composition of the local community, and with it the | ▪ Awareness will be created among the work force to ensure respect for local customs;<br>▪ Construction work will be completed within the stipulated time to move workers to next location;<br>▪ Labor force will be shuffled with the time;<br>▪ Create awareness among workers on proper sanitation and hygiene practices to endorse proper health and maintain good housekeeping practices at all Project sites;<br>▪ Provide adequate personal hygiene facilities in good condition with adequate supply of clean water;<br>▪ Make arrangements to treat the affected workers on time to control the movement of vectors disease;<br>▪ Sensitize workers and surrounding communities on awareness and prevention of COVID-19, HIV/AIDS and sexually transmitted infections (STI) through training, awareness campaigns and workshops during community meetings;<br>▪ Provide proper and free HIV/AIDS and STI health screening and counselling for site workers and community members;<br>▪ Develop and enforce a strict Code of Conduct for workers to regulate behavior in the local communities;<br>▪ Taking all sensible precautions to avert illicit, vicious conduct by or amongst the EPC Contractor's personnel, and to preserve unity and harmony, and protection of people and property on and near the sites; | | |



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| | community dynamics, may change significantly. Pre-existing social conflict may intensify as a result of such changes;<br>▪ Increased burden on and competition for public service provision: The presence of construction workers and service providers (and in some cases family members of either or both) can generate additional demand for the provision of public services, such as water, electricity, medical services, transport, education and social services. This is particularly the case when the influx of workers is not accommodated by additional and separate supply systems;<br>▪ Increased risk of communicable diseases and burden on local health services: The influx of people may bring communicable diseases to the project area, including sexually transmitted diseases (STDs), or the incoming workers may be exposed to diseases to which they have low resistance. Workers with health concerns relating to substance abuse, mental issues or STDs may not wish to visit the Project's medical facility and instead go anonymously to local medical providers, this can result in an additional burden on local health resources; | ▪ Prohibiting drugs, alcohol, weapons, and ammunition on the worksite among personnel;<br>▪ Site security preparations must be contained within the Bills of Quantities (BoQs) to avoid any delays which might be caused due to insecurity;<br>▪ Appropriate fencing, security check points, gates and security guards will be provided at the construction sites to ensure the security of all plant, equipment, machinery and materials, as well as to secure the safety of site staff; and<br>▪ The EPC Contractor must guarantee that good relations are maintained with local communities and their leaders to help reduce the risk of vandalism and theft. | | |



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| | ▪ Local inflation of prices, accommodations and rents: A significant increase in demand for goods and services due to labor influx may lead to local price hikes and crowding out of community consumers. Depending on project worker income and form of accommodation provided, there may be increased demand for accommodations, which again may lead to price hikes and crowding out of local residents; and<br>▪ Increase in traffic and related accidents: Delivery of supplies for construction workers and the transportation of workers can lead to an increase in traffic, rise in accidents, as well as additional burden on the transportation infrastructure.<br><br>This impact is medium negative and temporary in nature. | | | |
| 20 | **Gender Based Violence**<br><br>In the society, female plays important role in managing household as well as in income earning activities, but they face various challenges to get access to | ▪ Trainings will be given to construction workers, alongside the implementation of strict measures and punishments in case of any sexual assaults, or gender based violence.<br>▪ During the timing of educational institutions workers will not be allowed to crowd in the surroundings; | EPC Contractor | MC<br>WAPDA |



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| | educational institutions and employment opportunities due to cultural bindings, economic vulnerability and lack of facilities.<br><br>According to Pakistan Demographic and Health Survey (PDHS), 2017-18, 28 percent of women of Pakistan age 15 to 49 have experienced physical violence, six percent have experienced sexual violence, and seven percent experienced violence during pregnancy. Three in ten women who have ever experienced physical or sexual violence sought help to stop the violence, yet 56 percent never sought help nor told anyone.<br><br>During construction phase gender based violence might arise due to discrimination made against women by unequal work distribution and unequal pay structure among others. Sexual harassment against women might occur as a consequence of mixing of men and women at the construction site, and moving on the roads and markets. Women in the Project area are participating in other outdoor activities such as livestock rearing, bringing of potable water, collection of fire wood etc. that may also be affected by the Project | ▪ Alternative routes for pedestrian will be provided to avoid mixing of women with workers;<br>▪ Gender protection act will strictly be enforced during the construction activities in the project area, and monitor the implementation through field staff and district level structure;<br>▪ Raise awareness among the communities of the potential risks of GBV, and establish response services in the communities that can respond to instances of GBV (particularly those related to issues of labor influx);<br>▪ The EPC Contractor will make sure that no discrimination is made on the basis of gender while hiring of workers. Complete SOPs will be formed and implemented by the contactor regarding working women at site. Implementation on these SOPs will be monitored by the Supervision Consultants;<br>▪ Provisions of gender disaggregate bathing, changing, and sanitation facilities; and<br>▪ Contractor will take proper measures to address and resolve issues relating to harassment, intimidation, and exploitation, especially in relation to women.<br>▪ Establish workers' camps separated from local communities with strict protocols for interaction with local communities in order to avoid project impacts from labor influx.<br>▪ Project staff will receive training on the prevention of SEA/SH. Engagement of skilled trainers to raise | | |



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| | activities. This impact is medium negative in nature during construction stage. | awareness among project workers of the risks, expected behaviors, and consequences of violations, communicated through training, and publicized codes of conduct. It may also be important to raise awareness of the risks among community members and local health authorities and inform them about available grievance mechanisms.<br>▪ Arrange and support local organizations and/or government initiatives on community STD education, prevention, and treatment programs.<br>▪ Extensive training for awareness raising strategy which describes how workers and local communities will be sensitized to SEA and SH risks, and the worker's responsibilities under the Code of Conduct.<br>▪ The routes/places used by the women will be avoided as far as possible. If unavoidable, alternate routes will be identified for the communities, if required, especially along routes frequented by women folk, such as route to the local water source.<br>▪ Construction crew will avoid entering villages and settlements.<br>▪ Communities will be informed and consulted before commencing works inside or near the communities.<br>▪ Provision related to SEA/SH will be incorporated in the bidding document. | | |
| 21 | **Child Labour** | ▪ Awareness will be created among the local communities about the adverse impacts of child labor. For the public awareness, meetings will be | EPC Contractor | MC<br>WAPDA |



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| | There are two basic conventions on child labor adopted by the ILO, and one adopted by the United Nations. The ILO Minimum Age Convention, 1973 (No. 138) and its accompanying Recommendation (No. 146) set the goal of elimination of child labor, and the basic minimum age for employment or work (in developing countries at 14 years of age or the end of compulsory schooling, whichever is higher; and 15 or the end of compulsory schooling for developed countries). The Convention sets a minimum age of 2 years younger for "light work," i.e., 12 and 13 years, respectively; and a higher minimum age for dangerous or hazardous work (basically 18 years of age, but 16 in certain circumstances). The Convention also has various other flexibility clauses.<br><br>Inhabitants of the Project Area have mix economic background and different sources of income. Children of low income groups mostly involve in different earning activities, as their parents prefer to get their children hired in small shops as helpers, and waiters in hotels for earning money, and supporting household livelihoods. However, the Employment of Children Act, 1991 prohibits the employment of child and restrict the employment of adolescents in | held in the Project area, and announcements will be made using the available local platforms with the involvement of all sectors of the society;<br>▪ EPC Contractor through contractual agreement will be bound to follow the labor standards, rules and regulations during hiring the labor force and all activities will be monitored by the social and environmental staff of the implementing agency;<br>▪ Client and Supervision consultant will ensure that EPC Contractor shall have its employment policy in accordance with relevant act and labor policies in Pakistan;<br>▪ EPC Contractor will ensure the presence of all persons at site are adults and have their proper identity cards with them;<br>▪ Penalize EPC Contractors/employees using the child labor and penalize adults who violate children's rights and who force children to enter child labor.<br>▪ | | |



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| | certain occupations and processes such as construction industry, and whoever employs or permits a child (person under the age of 14 years) to work in an establishment shall be liable to punishment with imprisonment.<br><br>The child labor impact might arise during construction stage, as large number of skilled and unskilled labor will be required by the EPC Contractor for the construction activities of the proposed Project. This impact is medium negative in nature during construction stage. | | | |
| 22 | **Other Social Issues**<br><br>The community belonging to the reservoir and Project Area will be affected during the construction phase as follows:<br><br>▪ During the construction phase, the general mobility of the local residents and their livestock in and around the Study Area is likely to be hindered;<br>▪ Unmonitored construction activities, e.g. blasting may create an accidental risk for the local residents particularly the women and children; | ▪ During the construction phase, mobility of the workers in the nearby areas should be strictly restricted by the Contractor to avoid any inconvenience to the local communities;<br>▪ Proper arrangements in the form of alternative routes should be made to ensure that the mobility of locals should not be disturbed;<br>▪ Before starting the construction activities, Contractor should inform residents of the Project Area about the scheme of work, likely disturbances, and their duration as to whom they should addressed their complaints.<br>▪ The Contractors will be required to maintain close liaison with the local communities to ensure that any potential conflicts relating to the common resource utilization are resolved quickly; | EPC Contractor | MC<br>WAPDA |



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| | ▪ Usage of community common resources like potable water, fuel wood etc. by Contractor workforce may create conflicts between the community and the Contractor;<br>▪ Community will have to face the noise and dust problems during the construction activities;<br>▪ Induction of outside workers in the Contractor labor may cause cultural issues with the local community; and<br>▪ Theft problems to the community by the Contractor's workers and vice versa.<br><br>This impact is Site Specific, Medium Term, Irreversible, Likely, Medium Significant. | ▪ Contractor will take care of the concerns of the local community and the sensitivity towards the local customs. Contractor also needs a proper security to avoid any theft issue by the community;<br>▪ Use of good engineering practices such as water sprinkling, encasement and provision of silencer and mini stacks of generators etc. should be adopted to avoid inconvenience to the locals due to noise, smoke and fugitive dust; and<br>▪ The Contractor will warn the workers not to indulge in any theft activities and if anyone gets involved in such activities, he will have to pay heavy penalty and would be handed over to the police. Similarly, at the time of employing, the Contractor has to take care that the workers should be of good repute. The Contractor camp should be fenced properly and main gate. | | |
| 23 | **Impact on Tourism**<br><br>The Attabad Lake has become one of the biggest tourist attraction in valley, offering activities like boating, jet-skiing, fishing and other recreational activities. Tourists also enjoy Ice Skating the Lake gets frozen during winters, making it the perfect place for ice skating. Passu Cones is also a popular tourist destination in | ▪ The EPC Contractor will prepare and implement the site specific environmental, health and safety management plans to ensure the safety of the locals and tourists.<br>▪ Necessary measures will be taken to ensure the safety of traffic during construction, including barricades, safety signs, pavement markings, flags, and lights, erected for tourists and locals as well.<br>▪ A Traffic Management Plan will be implemented that will aim at ensuring access tourists to reach their destinations safe and sound, residential areas, and | EPC Contractor | MC<br>WAPDA |



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| | Hunza valley and all over the world because of its easily accessible sweeping landscapes and vistas of the 7,478m (24,534 ft) tall Passu Sar mountain, the Passu Glacier and Tupopdan.<br><br>Due to construction activities of Attabad Hydropower Project and movement of heavy machinery on roads the traffic flow is likely to be affected during construction activities and damage of roads as well, tourists will face the difficulties to reach at their desire destination like Attabad Lake for boating and jet-skiing, to visit the Passu Cones, Khanjrab Pass other tourists spots and high peaks for hiking.<br><br>Due to construction of Attabad Hydropower Project livelihood of the locals will disturb who are directly associated with tourism business like boat owners and operators, owners of fast food restaurants, shopkeepers, hotels owners and working labor and so many others attach with tourism. | preventing of unsafe situations, especially near construction areas, camps and offices;<br>▪ Liaison with traffic police will be maintained in order to facilitate the tourists both local and foreigner; and<br>▪ Vehicle speeds near / within the communities will be kept low, to avoid safety hazards. | | |
| 24 | **Communication Loss** | The EPC Contractor will ensure that the mobility of the local communities and their livestock is not hindered by the construction activities. The EPC Contractor will | EPC Contractor | MC<br>WAPDA |



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| | The general mobility of the local residents and their livestock in and around the Project Area is likely to be hindered and may need to be travel long distances.<br>Likewise access to the natural resource may be affected. This particularly implies to the women folk and children where women observe norms and values and do not interact with non-locals. This impact is medium significant in nature. | provide crossing points at appropriate places to facilitate the locals for their daily works, where applicable.<br>The EPC Contractor shall always consider the local sensitivities while performing the Project activities. All the personnel engaged would also be properly briefed about the local norms and ethics prior to commencement of work. | | |
| **Operational Phase** | | | | |
| 1 | **Sedimentation**<br>Accumulation of sediment may disturb the efficiency of Project components. Sediment load released from the sand trap could have adverse effect and synergetic with low flow of water will put aquatic system under stress. However, it should be kept in mind that during low flows the sediment concentration is very low. Floods and heavy rains carry large sediment loads, which could have a more severe medium impact than the sand trap flushing | ▪ A sediment flushing tunnel will be constructed at the left side under the Power Tunnel section, consisting of low level outlets and during construction of overflow structure will be used as diversion tunnel. The invert level of sediment flushing tunnel is planned at El. 2380 m.a.s.l. Systematic operation of the flushing tunnel shall be ensured by the Client to flush the sediments.<br>▪ It is also recommended to conduct a detailed watershed management study of the area and the outcome mitigation measures should be implemented to control the sediment inflow in the river. | WAPDA | |
| 2 | **Liquid and Solid Waste Generation** | ▪ Ensure training program regarding waste minimization quantity of the waste; | WAPDA | |



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| | Wastewater may generate by the workers during the operation and maintenance related activities and from the residential colony. The improper disposal of liquid waste can cause air, water, and soil pollution. Different types of solid waste are likely to be generated during the operation phase, can potentially cause soil and water contamination. This impact can be categorized as medium to low significant in nature | ▪ Solid waste generated will be safely disposed in demarcated waste disposal sites and ensure provision of PPEs to workers;<br>▪ Ensure immediate collection of solid waste after the competition of maintenance works, no waste or left over construction material is left behind;<br>▪ Proponent should make final disposal arrangements in consultation with the concerned government department and should take approvals for final disposal of the waste at the designated disposal site.<br>▪ A separate solid waste management system for waste from the office building and other allied facilities will be required. During the collection of solid waste, recyclable and reusable waste will be separated for resource recovery and reuse of the generated material; and<br>▪ Proper monitoring to check the compliance of NEQS will be carried out, if required | | |
| 3 | **Soil and Surface Water Contamination**<br><br>The accidental oil leakages from the power house may contaminate the soil and water quality of the Attabad Lake and Hunza River downstream of the powerhouse. The maintenance works (may involve the use of materials, chemicals, fuel and lubricants) may also have potential to contaminate the soil and surface water. This impact is site-specific | ▪ Proper drainage and dewatering system is recommended for the proposed Project. A drainage pump of appropriate capacity will be specified to cope with the leakage of powerhouse. Dewatering pumps will be specified for Unit dewatering. Both of these pumps will be installed in drainage and dewatering pit and they will provide redundancy for each other. Sites disturbed by the maintenance works shall be restored to their original conditions upon completion of works and photographic record will be maintained to ensure pre-post conditions intact. It will be ensured that no soil is left | WAPDA | |



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| | and can be classified as medium significant. | unconsolidated after completion of work and excess will be disposed of at designated sites. Storage of fuel, paint, and oil containers, oil filters, oily parts, and oily rags on impervious floor under shade or storing of fuel and lubricants on a sand flooring of at least 6 inches thick done on brick edge flooring lined with polyethylene sheet. Material Safety Data Sheets (MSDS) will be strictly followed | | |
| 4 | **Risk of Fire**<br><br>For the proposed hydropower plant there is also a risk of fire breaking out in powerhouse which may become a serious risk for residents living in allied facilities and/or nearby in the vicinity of the proposed hydropower Project. This impact can be classified as medium significant. | ▪ Fire protection and detection systems shall be provided and implemented to protect life, property, equipment, and operation of the powerhouse. The detection and fire alarm, fire protection and fire-fighting systems shall include, but not be limited to the following:<br>o Firefighting water storage, may be combined with raw water tank, depending on local regulations;<br>o Firefighting pumps;<br>o Fire water ring main system, including hydrants;<br>o Fire protection systems; and<br>o Fire alarm and detection system.<br>▪ The building / tunnel shall be subdivided into various fire areas, separated by approved fire resistant barriers and elements;<br>▪ Fire walls, ceilings and partitions shall have a fire resistance rate of not less than 2 hours; | WAPDA | |



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| | | ▪ All penetrations for electrical cables or pipes in fire resistant walls or ceilings shall be sealed with approved seals;<br>▪ One electric motor driven fire pump and one electric motor driven stand-by fire pump, located in a pump house adjacent to the water storage tank, shall draw fire fighting water from the tank and supply it through the fire service main to the hose stations and water spray fixed systems. One electric motor driven jockey pump with a capacity of approx. 3 l/s shall also be provided to keep the line pressure of 5 bars. The fire pump shall have a capacity of approx. 40 l/s at a delivery head of approx. 6 bars;<br>▪ The water spray fixed systems shall be designed, installed and tested in accordance with NFPA15;<br>▪ The total flooding carbon dioxide extinguishing systems shall be designed in accordance with NFPA 12, standard on carbon Dioxide extinguishing systems (latest edition) and will be adopted for the fire protection of Attabad HPP generators;<br>▪ The selection, installation and testing of portable fire extinguisher shall be in accordance with NFPA-10 for initial firefighting. Portable fire extinguishers with capacities of 6 kg chemical dry powder, for rooms containing electrical equipment with capacities of 5 kg clean agent, shall be provided and placed in the rooms and buildings at strategic locations and next to exits;<br>▪ In addition to the portable extinguishers, two mobile 30 kg clean agent, and two mobile 50 kg dry powder extinguishers, mounted on wheeled hand carts and | | |



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| | | furnished with 6 m hoses, shall be provided and located in the machine hall of the powerhouse and GIS floor and diesel generator room; and<br>▪ All systems shall be subject to the approval of the insurance company. The system shall be complete with all necessary piping, pumps, safety valves, mobile equipment, and vehicles. The EPC Contractor shall prepare an Emergency Response Plan (ERP) to cope with the emergency situations. Fire protection system for Generator fire protection system is also recommended. | | |
| 5 | **Ambient Air Quality and Climate Change Aspect**<br><br>The air quality of the area will improve significantly in comparison to construction phase. Vegetation cover in the area will also increase after tree planation. However, during operation phase, operation of stand-by generator and un-necessary idling of diesel run will also result in the emission of pollutants (CO, Smoke, $NO_2$, $SO_2$, $PM_{2.5}$ and $PM_{10}$ etc.) into the air, thus deteriorating air quality. Ambient Air quality may also be affected during the maintenance works of subprojects. These emissions may adversely affect the health of the nearby residents and working staff. This impact is moderate in nature. | ▪ Ensure the use of low Sulphur fuel;<br>▪ Ensure plantation of trees around the project area that will help in absorbing the emissions;<br>▪ The height of the generator stacks shall be enough to disperse the emissions in the air; and<br>▪ Ensure compliance with NEQS and provision of budget for regular monitoring of ambient air quality in accordance with the NEQS. | WAPDA | |



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| 6 | **Noise and Vibration**<br>During operation phase, noise and vibration levels may be generated due to the operation of proposed project, standby generators and traffic which will be a constant source of nuisance for the staff and the nearby communities. Noise levels may also be increased during the maintenance works. The significance of this impact is considered to be low adverse. | ▪ Ensure regular maintenance and periodic checking all parts of the standby generators, replacement in case of malfunctioning and periodic noting of noise levels;<br>▪ Installation signs to disallow the use of pressure horns;<br>▪ Plantation of trees will also help to attenuate the noise impacts to the surrounding area;<br>▪ Ensure compliance with NEQS and provision of budget for regular monitoring of noise levels in accordance with the NEQS and vibration (where applicable). | WAPDA | |
| 7 | **Change in Land use**<br>During the operational phase the land use pattern of the area will be changed to some extent. The commercial and recreational activities will also be increased which may affect ecosystem of the area and bring economic boom in the area. This impact is Site-specific, Long Term, Irreversible, Likely, Medium Significant. | ▪ The tree plantation will be carried out in and nearby the Study Area and will have positive impact on the eco system of the area | WAPDA | |
| 8 | **Flora**<br>During operational stage of the Project, there will be minimal effect on flora or release of any significant pressure detrimental to flora. Low level impact is expected at operational phase on Flora | ▪ The implementation of plantation plan recommends compensation for cutting of trees and work should be started during operational phase to ensure the ecological balance and to avoid any impact on local environment;<br>▪ Large scale planting with suitable indigenous trees, shrubs and ornamental plants in the form of tree | WAPDA | |



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| | due to the operation and maintenance activities. This impact is low Significant | groves, and linear plantation will be carried out in accordance with the Tree Plantation Plan to improve aesthetic value and offset the effect of removal of vegetation;<br>▪ Proper check and balance for above activities is highly recommended. Plantations so raised must be maintained according to the Silvicultural practices which includes proper irrigation, cleaning, pruning, thinning at prescribed intensity, silt clearance and trench-opening, etc.;<br>▪ Maintenance and security of the plantation should be done for at-least four years (in consultation with the Forest department). Measures such as fencing, watch guards and fire protection should be considered; and<br>▪ All activities must be done under the technical supervision of forest department | | |
| 9 | **Fauna**<br>There is no protected area, game reserve, game sanctuary or national park in the project area so no major impact on wildlife and livestock in the area is expected through noise, vibration and any type of normal activity in the project area. This impact is Insignificant.<br><br>However, proposed reservoir area, which is nearly 8 Km in length, shall not be available for grazing to livestock and other | Strict control must be exercised for stoppage of killing/poaching of available wildlife species (if any) by enhancing protection practices; and<br>The precautionary measures described for future shall also be applicable during operation phase as relevant for the conservation of wildlife species in the Study Area.<br>Improved micro climate and moisture conditions along the periphery of the reservoir will help in grass production and improved vegetation, which will be useful for livestock grazing and improve habitat for birds. | WAPDA | |



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| | wildlife existing in the area, which is adverse impact on fauna. | | | |
| 10 | **Aquatic Life**<br>Once the construction phase is completed and water diverted at the site of weir will change the water flow regime from weir to powerhouse. The adverse impact on aquatic life will be due to low flow in the Hunza River especially during low flow season. The minimum environmental flow needs proper follow-up. | ▪ Annual restocking plan of fish fingerlings should be included in the said project to compensate the stock depletion due to decrease in fish breeding grounds.<br>▪ Fisheries research unit and a brown trout hatchery with research/management staff should be established at the project side for research purposes as well as impact assessment during operational phases of the project.<br>▪ To conserve the aquatic life of the river downstream of the weir, minimum flow of 3 $m^3/s$ has been calculated as the environmental flow. It will be obligatory for project operating agency to release 3 $m^3/s$ in the river throughout the year as environmental flow.<br>▪ The design recommended measures should be implemented and maintained by the proponents. | WAPDA | |
| 11 | **Safety During Reservoir Operation**<br>During operational stage of the Project, due to the impounding of the reservoir, the safety issues will arise. Main reservoir area is the major threat for accidents. Locals and workers can drown. This impact is site specific and high significant in nature. | Since the reservoir was formed in January 2010 as a result of massive land slide and no new area would be submerged.<br>However, during operational stage of the Project, a security plan should be prepared for the reservoir area to prohibit youths from using reservoir for bathing, swimming and other recreational activities. Boating should not be allowed without the provision of life saving jackets and presence of a lifeguard. | WAPDA | |



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| 12 | **HSE Considerations**<br><br>During the operation phase, health and safety issues related to workers and communities may arise. Operation and maintenance activities may cause health and safety risks such as movement of machinery and manual handling during loading unloading operation, poor handling and storage of hazardous substances, injuries due to electric shocks, falling of objects, slips or trips, dust, noise, accidents, transmittable diseases etc. The impact is moderate to low adverse in nature. | ▪ Ensure proper maintenance of machinery and equipment;<br>▪ Proper storage and handling of generator fuel, chemicals, solvents and other hazardous substances;<br>▪ Ensure emergency prevention, preparedness and response arrangements;<br>▪ Emergency numbers should be clearly posted and communicated to the staff and community (where applicable);<br>▪ Fire extinguishing equipment should be installed at adequate and appropriate locations;<br>▪ Ensure provision of PPEs to the skilled and unskilled labors and visitors;<br>▪ Proper training should be given to workers on health and safety measures;<br>▪ Hazardous materials should be well labeled and stored in their original containers;<br>▪ Ensure that the site will be restricted for the entry of irrelevant people;<br>▪ Ensure health awareness; education initiatives; training heath workers in disease treatment and prevention; immunization program and providing health service; and<br>▪ Staff will strictly warned, not to involve in any unethical activities and to obey the local norms and cultural restrictions. | WAPDA | |



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## 9.8 ENVIRONMENTAL MONITORING PLAN

## 9.9 GENERAL

The Environmental Monitoring along with implementation of the various plans already highlighted during the construction and operation stages will be carried out to meet the following objectives:

- Monitor the actual Project impact on the physical, ecological and socio-economic indicators, in compliance with the provisions of the EIA/ EMP.
- Recommend mitigation measures for any unforeseen impact or where the impact level exceeds than those anticipated.
- Ensure compliance with legal and community obligations including safety at the construction and operation stages.
- Monitor the rehabilitation of borrow areas and the restoration of the construction camp site(s) as described in the EMP.
- To ensure the safe disposal of excessive construction materials, solid waste and effluents etc.

The main emphasis of monitoring during the operation phase will be as follows:

- Appraise the adequacy of the EIA with respect to the Project's predicted long-term impacts on the area's physical, biological and socio-economic environment.
- Evaluate the effectiveness of the mitigation measures proposed in the EMP and recommend any improvements in the EMP, if so required.
- Compile periodic incidents/accidents data to support analysis that will help in minimizing the future risks.
- Monitor the survival rate of the proposed plantations.

WAPDA through the EMMC/MC will ensure two types of monitoring during the execution of the Project activities.

- Compliance Monitoring: to ensure that the proposed measures in the EMP are adhered to as per applicable guidelines/ NEQS etc.
- Effects Monitoring: to establish baseline values for the environmental parameters such as air quality, water quality and noise levels etc.

## 9.10 MONITORING STRATEGY

All the compliance monitoring will be executed by the EPC Contractor during construction stage of the Project. Supervision of environmental monitoring will be carried out by the MC and WAPDA during the construction stage while compliance and effects monitoring at operational and maintenance stage will be carried out by WAPDA as internal monitoring agency. The staff working under the WAPDA will oversee all the activities of EPC contractor and MC in the field during the construction stage.


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## 9.11 IMPLEMENTATION AND MONITORING

### 9.11.1.1 EPC Contractor

Physical implementation of the EMP is the sole responsibility of the EPC Contractor during the construction stage. Contractor will be responsible for in-house monitoring to ensure that the construction activities are being carried out as specified in EMP.

### 9.11.1.2 Management Consultant (MC)

The MC will be responsible for supervision of the environmental monitoring and will perform the following activities:

- Monitoring of the environmental aspects of the Project during construction to ensure that the environmental requirements of the contract and the mitigation measures proposed in the EMP are implemented.
- Undertake critically important routine visual monitoring of construction, waste disposal and overall environmental management practices by the EPC Contractor and other contractor(s).
- A systematic check of the noise levels using a portable noise meter operated near major construction equipment and machinery.
- Visual checks of exhaust emissions from equipment and vehicles.
- Visual checks of airborne dust on temporary access roads, material stockpiles, disturbed soil, and haul tracks.
- Instrumental monitoring of water, ambient air and noise levels as per intensity and frequency specified in the environmental monitoring program.
- Maintaining the monitoring records and submit monthly reports to WAPDA, describing the details of environmental monitoring parameters, non-compliance (if any) by the Contractor and actions taken for rectification.

## 9.12 COMMUNICATION AND DOCUMENTATION (MONITORING PERIOD)

Communication and documentation is an essential feature of EMP. The key features of such mechanism are:

## 9.13 DATA RECORDING AND MAINTENANCE

All forms to be used for recording information during the environmental monitoring will follow a standard format which will correspond to the data base in to which all the gathered information will be placed. Check boxes will be used as much as possible to facilitate data entry. Tracking system will be developed for each form.

## 9.14 DATABASE

The database may include the following information:

- Training programs;
- Staff deployment;
- Non-compliances;
- Corrective actions
- List of environmental data; and
- List of environmental data to be maintained:


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- Soil and land pollution;
- Disposal of waste;
- Water resources;
- Fuel oil and chemical spills;
- Vegetation record;
- Noise and vibration pollution;
- Air and dust pollution;
- Socio-economic data; and
- Ecological sensitivities.

## 9.15 MEETINGS AND REPORTING

Monthly meetings will be held at site during the construction phase. The purpose of these meetings will be to discuss the routine activities, non-compliances and their remedial measures. Various reports will also be produced at periodic time intervals, as provided in **Table 9.2** along with information regarding persons responsible for report preparation and review process. Additionally, minutes of meeting will also be submitted as part of routine environmental reports.

**Table 9-2: Periodic Reporting Mechanism**

| Sr. No. | Report Category | Prepared by | Submitted to and Reviewed by |
|---|---|---|---|
| 1 | Monthly | EPC Contractor | EMMC of WAPDA/ MC |
| 2 | Quarterly | EPC Contractor | EMMC of WAPDA/ MC |
| 3 | Quarterly | MC | EMMC of WAPDA/GBEPA |
| 4 | Annual Report | EPC Contractor | EMMC of WAPDA/ MC |
| 5 | Completion Report | EPC Contractor | EMMC of WAPDA/ MC |

The system for monitoring compliance with environmental mitigation measures provides periodic inspection (at least biweekly), data compilation, and reporting of results. The MC will utilize a checklist to evaluate compliance with mitigation measures. Checklists serve primarily as guides for reviewing performance to determine general compliance with broad indicators, tentatively as follows:

- General conduct of work;
- Labor provisions and occupational / community health and safety;
- Noise and vibration control;
- Air quality, dust control and site cleanliness;
- Traffic management;
- Drainage and wastewater;
- Solid waste and spoil handling and disposal;
- Protection of community values; and
- Environmental monitoring and other indicators selected for the work at hand.


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The MC will prepare and submit quarterly reports to WAPDA (and to GB EPA as per the conditions mentioned in the NOC /environmental approval) as part of the periodic project performance reporting requirement. Monitoring reports also will summarize the status of complaints under the GRM, as well as results of air, water and noise monitoring conducted by the third party.

### 9.16 SOCIAL COMPLAINT REGISTER

The Contractor will maintain a register of complaints record from local communities and measures taken to mitigate these concerns.

### 9.17 PHOTOGRAPHIC RECORDS

Contractors will maintain photographic records during the implementation of the proposed Project. As a minimum, the photographic records will include the site photographs, all the roads, camp sites and monitoring activities, etc.

### 9.18 NON-COMPLIANCE OF THE EMP

The implementation of the proposed EMP involves inputs from various functionaries. The EPC Contractor will be primarily responsible for ensuring implementation of the mitigation measures proposed in the EMP, which will be part of the contract documents. The provision of the environmental mitigation cost will be made in the total cost of Project, for which the Contractor will be paid on the basis of monthly compliance reports. However, if the Contractor fails to comply with the implementation of EMP and submission of the monthly compliance reports, deductions will be made from the payments to the EPC Contractor claimed under the heads of environmental components.

### 9.19 REVIEW OF RECORDED DATA

All the data and communication recorded and maintained by the EPC Contractor will be periodically reviewed and checked by MC and EMMC, WAPDA and necessary action will be recommended to EPC Contractor to improve the recording and documentation. All the complaints in social complaint register shall be recorded in accordance with the Project GRM. Resident complaints will be responded to in a timely manner and action taken recorded in accordance with the GRM.

### 9.20 THIRD PARTY MONITORING

Third Party will be recruited by WAPDA to carry out independent monitoring regarding implementation of EMP. The Third Party shall carryout intermittent monitoring of the project. This will be done on bi-annual basis to evaluate the overall effectiveness of EMP implementation.

WAPDA will ensure the timely hiring and engaging a suitable consultant/firm. For this purpose, EMMC will be responsible for coordination; arranging site visits and providing necessary support to the Third Party. The objective of this Third Party will be to review the entire EMP implementation process and its effectiveness, to identify any environmental and/or social issues caused by the project that may exist at site, and to frame recommendations for course correction and to improve EMP for implementation.

### 9.21 OBJECTIVES

Following are the main objectives of the Environmental Audit:


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- To evaluate whether the monitoring done by MC is in compliance with the targets as set in the EIA/EMP.
- To determine the conformity of the environmental and social management plans with specified requirements and identify non-conformity in environmental and social parameters as per EIA/EMP.
- Meet regulatory requirements and commitments.

## 9.22 ENVIRONMENTAL TRAINING PROGRAM

## 9.23 TRAINING STRATEGY

An environmental training program needs to be conducted in order for capacity building of different key staff and the community's capacity as shown in **Table 9.3** to effectively implement the Project-specific EMP. Initially, the training program will be imparted to the key staff directly associated with the Project and subsequently, separate training program(s) will be run for the community and for the Contractor's staff. Past experience has shown that the exclusion of the community from the indirect benefits due to the Project interventions has largely produced socio-political issues that hinder the success of the Project; therefore, the involvement of the community seems to provide a great incentive for the environmental protection of the area, to win their support for the proposed Project and also for skill development purposes.

The MC will be obligated to provide training to the EPC Contractor's staff, WAPDA and the Community. In addition to the above training, additional training will be imparted as and when required. The criteria to assess the need for additional training are based on the following:

- For preventive O&M rather than only responding to accidents;
- Start of any new process/activity;
- When a specified percentage of staff is newly inducted in the Project;
- When any non-compliance is repeatedly reported, refresher training will be provided;
- When any incident/accident of minor or major nature occurs; and
- Arrival of new contractors/sub-contractors.

## 9.24 TRAINING OBJECTIVES

The overall objective of the training program is to create awareness and to train the concerned stakeholders to conserve and protect the ecological balance of the Project Area as much as possible at both the stages i.e. construction and operation and to ensure that the requirements of EMP are clearly understood and implemented throughout the Project life. The main training objectives can be summarized as follows:

- To implement the mitigation measure as given in the EMP.
- To train the supervisory staff for the protection of the health and safety of the workers/labour.
- To train the Project staff how to interact and involve the concerned communities.
- To define the roles and responsibilities of the concerned stakeholders according to this EMP.
- To train the stakeholders for the reporting mechanism.


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## 9.25 TRAINING MATERIAL

The MC will prepare and produce training materials/ manuals according to the training program, one for the key staff and the rest for the community and labor.

## 9.26 TRAINING PROGRAM

The detailed training program is given in **Table 9.3.**

**Table 9-3: Training Program**

| Sr. No. | Staff | Trainers | Contents | Timing/Frequency |
|---|---|---|---|---|
| 1. | Project Director, Construction, Chief Resident Engineer Resident Engineers, staff of the WAPDA Environmental Management/ Monitoring Cell. | MC | Introduction to GB Environmental Protection Act, 2014.<br>Introduction to the applicable national environmental laws and regulations.<br>Roles and responsibilities of various stakeholders especially the Construction Contractors/ staff and Consultants.<br>Introduction to EMP and its contents and provisions/ limitations.<br>Introduction to the Environmental Monitoring Plan.<br>Documentation mechanism<br>Use of laboratory equipment for testing and monitoring water and air quality parameters etc. | To be initiated soon after the start-up of the Project construction phase. |
| 2. | Construction Manager of the Contractor/ Contractor's staff. | MC | Mitigation measures included in the EMP<br>Good construction practices<br>Wildlife and vegetation issues in the Study Area<br>EMP communication, documentation and monitoring requirements<br>Workers/labour Health and Safety measures<br>Community participation and consultations | To be initiated at the start of the construction phase of the Project. |
| 3. | Operational / Managerial Staff of WAPDA | MC | Introduction to EMP<br>Related mitigation measures given in EMP<br>Safe handling, use and disposal of pesticides (fungicides, | Prior to the start of operation and at least one training session during the first year of operation |


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| Sr. No. | Staff | Trainers | Contents | Timing/Frequency |
|---|---|---|---|---|
| | | | insecticides) fertilizers and hazardous wastes etc.<br>Introduction to the Environmental Monitoring Plan and its relevant clauses. | |
| 4. | Camp Staff/ Support Staff (Drivers, in charge of workers/ labour, workshop force, kitchen staff etc.) | MC/<br>WAPDA EMMC | Road safety and restrictions<br>Proper Vehicle maintenance<br>Defensive driving<br>Waste disposal<br>Emergency handling<br>Fire fighting<br>Sanitation<br>Camp(s) operation<br>Housekeeping | Prior to the start of any construction activity and one training session during the operation stage. |
| 5. | Contractor's Restoration and Clean-up team for borrow materials and camp areas | MC | Site Restoration & Restoration requirements | Prior to the start of restoration activity (one training session) |
| 6. | Community | MC/<br>EMMC | Introduction to the Project features and operations<br>Interaction mechanism with the Project owner and Project's key staff<br>Introduction of any negative impacts on wildlife, vegetation, water etc. due to Project interventions & mitigation measures adopted.<br>Benefits to the community by the Project/Positive outcomes<br>Mechanism of community participation in the Project activities<br>Complaints/ Grievance handling procedures | To be initiated before the start-up of the Construction Activities under the Project. |
| 7. | Contractor's Staff/ Support Staff (Drivers, in charge of workers/ labour, workshop force, kitchen staff etc.) | MC | An "alleviation programme" with respect to HIV/AIDS and other infectious diseases.<br>Compulsory HIV/AIDS awareness and other infectious diseases prevention training. Educational campaigns to be conducted in the Project Area. | To be started immediately after the start of the construction activities. |


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## 9.27 MANAGEMENT PLANS

Prior to mobilization, within 30 days of commencement, the EPC Contractor will develop site Specific Environmental Management Plan (SSESMP) and Site Specific Health and Safety Management Plan (SSHSMP) which will be relevant to its chosen methodology and meet the requirement of this EMP. The Contract Agreement will have appropriate clauses to bind the EPC Contractor for the above obligations.

Various management plans have been prepared as a part of EMP for the better management and implementation of EMP during all phases of the proposed ALHPP. However, these plans will be updated by EPC Contractor and approval from MC should be sought before start of construction activities. These plans are listed below:

- Tree Plantation Plan;
- HSE Management Plan;
- Emergency Preparedness and Response Framework;
- Borrow Areas Management / Rehabilitation Plan;
- Restoration and Rehabilitation Plan;
- Waste Management Plan;
- Traffic Management Plan; and
- Change Management Plan.

## 9.28 TREE PLANTATION PLAN

The basic purpose of afforestation/plantation of suitable species in the project area is to reduce the risk been made due to cutting of trees for the proposed project and to enhance green cover and improve the overall environment of the area. Afforestation will not only reduce the risk been made but will also increase the carrying capacity of the area regarding many positive aspects.

Plantation will be done after the removal of trees during the construction work immediately. Plantation of indigenous trees species is highly important to maintain the biodiversity and ecological balance. It is also important to prevent global warming, soil erosion and pollution. Afforestation purifies the environment and helps in reducing the carbon dioxide level. A detailed Tree Plantation Plan has been provided as **Annex-II**.

## 9.29 HSE MANAGEMENT PLAN

Health risks and work safety problems may result at the workplace if the working conditions provide unsafe and/or unfavorable working environment due to storage, handling and transport of hazardous construction material. Workers should be provided with safe and healthy working environment taking into account risks inherent to the particular sector and specific classes of hazards in project area. During construction phase, EPC Contractor will be responsible for all HSE related issues and to comply with national laws and international standards for occupational health and safety. Guideline for EPC Contractor's Occupational Health and Safety Plan is attached as **Annex-IV**. The ultimate goal of the plan is to eliminate any injury to human and damage to facilities, materials and the environment.

The following measures are identified for health, safety, and environment protection during all activities of the proposed project to minimize risk of accidents, which could endanger the life


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of personnel, cause damage to properties and environment:

- All EPC contractor staff shall be well informed and trained on the HSE policies and guidelines;
- Contractor shall provide adequate health services as well as site first aid services for its workforce;
- The main priority of the contractor shall be to prevent accidents during mobilization, construction phase of the proposed Project. Prevention of workplace accidents during the construction activities will be achieved using approved work plan/instructions by the supervisors;
- Work safety measures and good workmanship practices shall be followed by the contractor to ensure no health risks for workers;
- Provision of adequate sanitation, washing, cooking and dormitory facilities;
- Proper maintenance of facilities for workers shall be monitored;
- Provision of protective clothing for laborers handling hazardous materials, e.g., helmet, adequate footwear for bituminous pavement works, protective goggles, etc. and contractor will ensure strict use of wearing these protective clothing during work activities;
- Elaboration of a contingency planning by the contractor at work site in case of major accidents shall be carried out;
- A site-specific fire-fighting plan also needs to be developed and implemented by EPC Contractor during construction phase;
- Accidents shall be reported to and investigated by the EPC Contractor. All personnel shall be encouraged to report all accidents/incidents and to cooperate in the investigation of such occurrence;
- Adequate signage, lightning devices, barriers, and persons with flags during construction to manage traffic at haulage and access roads shall be conducted;
- The communicable disease of most concern during construction phase, like sexually-transmitted diseases such as HIV/AIDS, should be prevented by successful initiative typically involving health awareness, education initiatives, training heath workers in disease treatment, immunization program and providing health service;
- Reducing the impacts of vector borne diseases on long-term health effect of workers should be accomplished through implementation of diverse interventions aimed at eliminating the factors that lead to disease;
- All construction activities shall be properly managed through careful planning and the applicable and relevant HSE policies.

## 9.30 EMERGENCY PREPAREDNESS AND RESPONSE FRAMEWORK

The framework provides an overview of the procedures to mitigate and control the impacts on community, on occupational health and safety, on the environment and on the Project in the event of emergency situations and to respond in life threatening situations usually occurring suddenly and unexpectedly during the construction and operational phases of the proposed project. This framework applies to all the processes of emergency responses to accidental calamities that can occur in an office, construction area and living area as well as first aids and emergency responses as per actual environmental situations during construction. This framework also provides a general reference and a basis for a detailed sub-plans and procedures that have to be developed by the Contractor before the initiation of the construction


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of the project and will be approved by the proponent. The framework needs to be developed with following objectives:

- Outline the applicable standards with regards to emergency preparedness and response;
- Define the emergency preparedness and response procedures utilized during the construction phase;
- Define persons and departments involved in emergency preparedness and their roles and responsibilities; and
- Define training requirements.

Various categories of risks can be envisaged in a working or construction environment. The response to each hazard will be different. A few types of emergencies/accidents will include the following:

- Natural risk: earthquake, flood, and other natural disaster;
- Political risk: civil strife, upheaval, riot, kidnap, and terrorist attack;
- Construction: fire, traffic accident, falling, hit and electric shock;
- Public health: dengue fever, malaria, food sanitation, high-temperature operation, insect sting, and
- Security: injury and property loss resulted from theft, robbery, and law case.

To minimize human suffering and financial losses, all personnel must know their responsibilities under the emergency preparedness and response plan. The plan should be used to set emergency procedures, implement and communicate the procedures and ensure that any required training has been completed. Planning for emergencies should include the following points:

- Hazard identification/assessment;
- Emergency resources;
- Communication systems;
- Administration of the plan;
- Emergency response procedure;
- Communication of the procedure; and
- Debriefing and post-traumatic stress procedure.

## 9.31 BORROW AREAS MANAGEMENT / REHABILITATION PLAN

There will be dire need to manage the borrow areas to avoid any environmental damage during the implementation phase of the Project. The EPC Contractor will develop a borrow area management/rehabilitation plan prior to start the extraction of material from each borrow area by using below guidelines.

- Site layout and boundaries with the following provisions:
  - Name, location and ownership of the borrow area;
  - Existing land use of the area;
  - Estimates of the resources to be extracted;


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- Stockpiling location;
- Dust and noise consideration; and
- Sequence of operation.

## 9.32 RESTORATION AND REHABILITATION PLAN

The implementation of the proposed Project would involve construction workers' camp for staff and laborers, establishment of fences around construction site, over usage of access roads for movement of heavy machinery/motor vehicles linking to various components of project, offices, borrow/quarry areas, etc. During construction, these activities could also result in accumulation of large amount of unused or spoil material at various sites such as at access roads, muck dumping sites, quarry sites, colonies, offices, etc. which will change the existing land cover in the project area. After completion of the construction work, it is required to restore the disturbed area to its original conditions wherever it is possible that is the sole responsibility of the Contractor. Various engineering and biological measures have been suggested for the restoration of these areas:

- Top soil should be stored at designated areas before performing excavation activities at quarry sites (if these are agriculture land) and after the completion of all the construction activities, quarry sites (if applicable) and construction sites should be covered with the top soil to support the growth of plant species;
- The area should be planted with indigenous vegetation that would require the initial establishment of fast growing grasses along with annuals and perennials, nitrogen fixing herbaceous legumes and non-legume shrubs to increase the soil conditioning and to stabilize the project site;
- Material stockpiles shall be removed as soon as the construction work will be completed;
- All the construction, toxic and hazardous chemicals/materials shall be completely removed from the site;
- All fencing and gates shall be removed and pits shall be backfilled;
- The reconstruction of interrupted drainage channels and pipes shall be carried out;
- Rehabilitation of affected roads should be carried out to avoid any inconvenience to the road commuters; and
- A clearance certificate from the consultant has to be taken by Contractor in this regard.

## 9.33 WASTE MANAGEMENT PLAN

Management of solid and hazardous waste is one of the most important issues during construction phase of the Project.

The major components of the workers' camp waste are garbage, putrescible waste, rubbish and small portion of ashes and residues, wastewater from camps toilets and washing yards, etc. The construction waste will include wastewater, oil spillage from machinery and solid waste (damaged or spoiled materials, temporary and expendable construction materials, etc.). Insecure and unhygienic disposal of the wastes may cause degradation of soil, land and water resources. However, a criterion has been developed for the solid and hazardous waste management at site. The criterion is as follows:


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- All the anticipated solid wastes should be collected through a properly designed solid waste management system. Enough number of containers should be placed inside the camps and within the construction area for the collection of various types of waste;
- These containers will help the component separation of various types of waste at source. Classification will be based on organic waste, recyclable waste, reusable waste (for resource and recovery) and waste for disposal site. Based on the conditions of the region, organic waste should be frequently collected to avoid odour problems;
- Recyclable, reusable and waste for disposal site should be collected twice a week and on alternate days and should be transferred to a properly designed disposal site;
- The sewage system for camps shall be properly designed (pit latrines or, as required, septic tanks) to receive all sanitary wastewaters;
- Lined wash areas shall be constructed within the camp site or at site, for the receipt of wash waters from construction machinery;
- Medical waste and construction waste should be handled with care.;
- Construction waste i.e. waste concrete, bricks, cement, etc. should be disposed of at the designated areas; and
- Construction workers and supervisory staff should be encouraged and educated to practice waste minimization, reuse and recycling to reduce quantity of the waste for disposal.

## 9.34 TRAFFIC MANAGEMENT PLAN

A comprehensive traffic management plan will be developed by EPC Contractor mentioning routes to be followed for transportation of construction machinery and materials e.g. cement, steel, gravels, sand, etc. Traffic management plan will comprise following contents necessarily:

- Goals and objectives of plan;
- Purpose & Scope;
- Project specific traffic;
- Roles & responsibilities of contractors' environmental personnel;
- Routes to be followed along with necessary maps;
- Transportation timing; and
- Mechanism to address road accidents (if occurs).

## 9.35 CHANGE MANAGEMENT PLAN

The EIA and EMP have been prepared at feasibility phase of the proposed Project. Both are living documents and it has been foreseen that during the detailed design phase the documents may be updated and the EMP has to be refined. The EMP will be refined in the light of updated results of ambient air quality, noise, drinking water and surface water/wastewater. It will further be updated in the light of possible adverse environmental impacts and if necessary then any additional mitigation and enhancement measures will also be added to the EMP. Any sort of change in EMP has to be informed to all concerned personnel/departments.


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## 9.36 CHANCE FIND PROCEDURE

In case of any chance find, the Contractor will immediately report through MC to Archaeology Department, GB and take further suitable action to preserve those antiques or sensitive remains. Representative of the Director will visit the site and observe the significance of the antique, artifact and cultural (religious) properties and significance of the Project. The report will be prepared by representative and will be given to the Director. The documentation will be completed and if required suitable action will be taken to preserve those antiques and sensitive remains. In case any artifact, antiques and sensitive remains are discovered, chance find procedures should be adopted by construction contractor workers as follows:

- Stop the construction activities in the areas of chance find;
- Delineate the discovered site or area;
- Consult with the local community and Archaeological Department, GB;
- The suggestion of the local communities and the concerned authorities will be incorporated during taking the preventive measures to conserved the antique, artefact and Cultural (religious) properties;
- Secure the site to prevent any damage or loss of removable objects. In case of removable antiquities or sensitive remain, a night guard shall be arranged until the responsible local authorities take over; and
- After stopping work, the Contractor must immediately report the discovery to the MC.

## 9.37 CODES OF PRACTICE

The EPC Contractor should seek to develop codes of practice for its staff and employees in order to ensure that the intrusion of workers in the project area does not result in any social and environmental and social issues between the workers and locals which can harm the project by causing unnecessary delays.

These codes should be based on the principles of environmental protection, occupational health and safety, good engineering practices, respect, integrity and sound ethical values. Each code should include, at minimum, the purpose and objectives, a policy statement from the in charge explaining the importance of this code for the success of the project, and examples of such conduct. Guidelines for the code of practices are discussed below.

## 9.38 GENERAL

General code of conduct should be developed for the project and should include, at minimum, the following practices:

- Rules and guidelines will be given to the workers regarding the use of common resources such as wood, plants, water sources etc. to ensure their sustainable use;
- The code should also include provisions of the solid waste management plan to address solid waste collection and disposal in order to prevent unhygienic conditions and contamination of soil and water;
- The EPC Contractor will be made arrangements to avoid accidental risks such as traffic signs board and speed control measures for the safety of locals;


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- In construction camps, amenities of life including clean food, water and sanitation facilities must be provided to these camps, and the workers should be provided with guidelines on how to dispose of their waste and maintain a sense of hygiene;
- The training of workers in the construction safety procedures, equipping all construction workers with Personnel Protective Equipment (PPEs) i.e., safety boots, helmets, gloves, ear plugs, and protective masks also and monitoring their proper and sustained usage;
- The Contractor should ensure that the construction labor is trained in safety procedures for all relevant aspects of construction;
- Formal emergency procedures should be developed for construction site in case of an accident. First aid kits and other necessary equipment should be kept available at site along with the list of emergency phone numbers at the construction site to be contacted in case of any accident; and
- The safety of the public at all stages of the construction and operation will be ensured by appropriate public education and safety measures such as use of sign boards, barriers and flags and use of proper illumination at night.

## 9.39 GOOD ENGINEERING PRACTICES

Good engineering practices should be developed for the project and should include, at minimum, the following practices;

- Standard Operating Procedures (SOP) for handling, storage and transportation of oil leakages, chemicals and other toxic materials should be strictly followed;
- Workers must be familiar with the Material Safety Data Sheets (MSDS) of each chemical used at site. MSDS are provided with each chemical drum. Chemicals will be stored as per their MSDS. Utmost care should be taken during the handling of these chemicals;
- Precautions should be taken to prevent spills and all workers should be trained in proper handling, storage and disposal of hazardous or toxic materials; and
- Proper disposal plans of excavated material.

## 9.40 CULTURAL NORMS

Cultural Code of Practice should be developed for the project and should include, at minimum, the following practices:

- Self-respect and sensitivity to insult is an important trait of the locals. The poorest among them has his own sense of dignity and honour and he vehemently refuses to submit to any insult. In fact, every inhabitant considers himself equal if not better than his fellow tribesmen and an insult is, therefore, taken as scurrilous reflection on his character. So, the contractor should be careful to avoid any unceremonious interaction with the locals and inform their staff to be humble and polite.
- The Contractor should also take care of the norms of local community and their sensitivity towards local customs and traditions;
- The Contractor should brief the staff about local culture and norms;
- As per local culture wearing of pant shirt, half shirts, and short trouser are considered inappropriate attire, therefore the contractor inform the staff to avoid wearing short trousers and short shirt;
- Contractor will strictly warn the staff not to involve in any unethical activities and to obey the local norms and cultural restrictions particularly with reference to women;


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- The Contractor will be required to maintain close liaison with the local elders and religious scholars of nearby local community to ensure that any potential conflicts related to common resource utilization for the project are resolved easily;
- Privacy of women is a major cause of concern for the communities of the project area. Due to the project activities local women may not be able to perform their daily outdoor chores. Women in the project are participate in other outdoor activities such as livestock rearing, bringing of potable water, collection of fire wood etc. that may be affected by the project activities;
- The EPC Contractor will have to select the specific timings for the construction activities so as to cause least disturbance to the local population particularly women considering their peak movement hours; and
- The EPC Contractor will warn the staff strictly not to indulge in any un-ethical activities and to obey the local norms and cultural restrictions particularly with reference to women.

## 9.41 ENVIRONMENTAL MITIGATION COST

Implementation of the recommendations of the EIA during the construction phase is the sole responsibility of the EPC Contractor and the monitoring activities will be carried out by the MC and WAPDA. Cost for environmental management and monitoring will be the part of the contract document with the Contractor.

The annual estimated cost for the implementation of environmental monitoring and management for the proposed Project is given in **Table 9-4.**

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**Table 9-4: Estimated Cost for the Implementation f Environmental Monitoring and Management**

| Sr. No. | Parameter | Mechanism | Frequency | Unit Rate (PKR) | Quantity | Cost (PKRs) | Remarks |
|---|---|---|---|---|---|---|---|
| **A** | **PRE- CONSTRUCTION PHASE** | | | | | | |
| **A-1** | **Environmental Monitoring Cost** | | | | | | |
| 1 | Drinking Water Quality | Discrete grab sampling and laboratory testing of water samples by EPA approved Laboratory for monitoring. | Once | 35,000 | 6 Nos. | 210,000 | One time monitoring shall be carried out before the mobilization of Contractor. |
| 2 | Surface/Wastewater Monitoring | Discrete grab sampling and laboratory testing of water samples by EPA approved Laboratory for monitoring. | Once | 35,000 | 4 Nos. | 140,000 | |
| 3 | Noise Levels | dBA Leq. as per NEQS 2010 | Once | 5,000 | 06 Nos | 30,000 | |
| 4 | Ambient Air Monitoring | Monitoring of CO, $CO_2$, SOx, $NO_x$, HC and $PM_{2.5}$ $PM_{10}$ by EPA approved Laboratory | Once | 50,000 | 06 Nos. | 300,000 | |
| | **Sub-Total (A-1)** | | | | | **680,000** | |
| **A-2** | **Tree Plantation Cost** | | | | | | |
| 1 | Tree Plantation Cost | The cost and maintenance of 5,750 plants for afforestation including cost of layout, digging, planting, carriage and watch and ward and its maintenance for five years | Lump Sum | 5,750 Nos. | | 11,109,000 | Refer **Annex-II** Tree Plantation/ Afforestation Plan |



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| Sr. No. | Parameter | Mechanism | Frequency | Unit Rate (PKR) | Quantity | Cost (PKRs) | Remarks |
|---|---|---|---|---|---|---|---|
| **Sub-Total (A-2)** | | | | | | 11,109,000 | |
| **Sub-Total A (A-1)+(A-2)** | | | | | | 11,789,000 | |
| **B** | **CONSTRUCTION PHASE** | | | | | | |
| **B-1** | **Environmental Monitoring Cost for one year** | | | | | | |
| 1 | Drinking Water Quality | Discrete grab sampling and laboratory testing of water samples by EPA approved Laboratory for monitoring. | Quarterly | 35,000 | 04 x 06 = 24Nos | 840,000 | Quarterly monitoring cost for the one year construction period and will be updated each year based on latest rates during construction timeline of the proposed Project. |
| | Surface/Wastewater Monitoring | Discrete grab sampling and laboratory testing of water samples by EPA approved Laboratory for monitoring. | Quarterly | 35,000 | 04 x 04 = 16Nos | 560,000 | |
| 2 | Noise Levels | dBA Leq. as per NEQS 2010 | Quarterly | 5,000 | 06x04=24 Nos. | 120,000 | |
| 3 | Ambient Air Monitoring | Monitoring of CO, $CO_2$, SOx, $NO_x$, HC and $PM_{2.5}$ $PM_{10}$ by EPA approved Laboratory | Quarterly | 50,000 | 06x04=24 Nos. | 1,200,000 | |
| **Sub-Total (B-1)** | | | | | | **2,720,000** | |
| | | | | | | | |
| **B-2** | **Environmental and Social Management Cost** | | | | | | |
| 1 | | Environment Personnel will monitor / conduct all HSE | Monthly | 500,000 per month | | 6,000,000 | This is the tentative monthly cost for one year period for |



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| Sr. No. | Parameter | Mechanism | Frequency | Unit Rate (PKR) | Quantity | Cost (PKRs) | Remarks |
|---|---|---|---|---|---|---|---|
| | HSE staff and Management Cost | related activities e.g. TBTs, PPEs, housekeeping, safety signage, emergency preparedness, etc. | | | | | Environment and HSE expert |
| | | | Breakup has been provided as **Annex-V** | | | 10,010,000 | Cost for PPEs, extinguishers, emergency lights, housekeeping equipment, safety signage and barricade, emergency preparedness kit, first aid kit, etc. |
| 2 | Ecological Monitoring & Management | Monitoring of disturbance due to construction activities. | Monthly | 200,000 per month | | 2,400,000 | This is the tentative monthly cost for one year period for one senior expert along with their monthly logistics. |
| 3 | Solid Waste Management | Collection, segregation, transportation, disposal and management of domestic, commercial, construction wastes | Monthly | 200,000 per month | | 2,400,000 | This is the tentative monthly cost for one year period for one senior expert along with their monthly logistics |
| | | | Lump sum | | | 1,000,000 | Cost for collection, segregation, transportation, disposal and management of domestic, commercial, construction wastes |
| 4 | Social Welfare Cost | Based on the regular consultations with stakeholders including affectees and nearby community, through basic need assessment by the EPC Contractor and verified by | Lump sum | | | 3,000,000 | Different social welfare Projects i.e. easy loans for affectees, rehabilitation of roads, tracks, etc. |



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| Sr. No. | Parameter | Mechanism | Frequency | Unit Rate (PKR) | Quantity | Cost (PKRs) | Remarks |
|---|---|---|---|---|---|---|---|
| | | WAPDA coordinating the district social welfare department. | | | | | |
| 5 | Training Cost | Literature preparation, printed material such as posters & pamphlets trainer(s), and venue, etc. | Monthly | 150,000 | | 1,800,000 | This is the tentative monthly cost for one year period |
| 6 | Third Party Monitoring | Checklists & proformas | Bi-annual | 750,000 | | 1,500,000 | This is the tentative biannual cost for one year period. |
| 7 | Communicable Diseases (as per advice of Environmental Specialist) | Tests should be performed by approved laboratory | Quarterly | 500,000 | | 2,000,000 | This is the tentative quarterly cost for one year period for medical tests of kitchen staff at each camp site. |
| **Sub-Total (B-2)** | | | | | | **30,110,000** | |
| **Sub-Total B ((B-1)+(B-2))** | | | | | | **32,830,000** | **Tentative Cost for One year Construction Period** |
| | | | | | | **98,490,000** | **Tentative for whole construction period i.e. 36 months. The cost shall be updated based on the current market prices during construction phase.** |
| **C** | **OPERATION & MAINTENANCE PHASE (One Year Cost)** | | | | | | |



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| Sr. No. | Parameter | Mechanism | Frequency | Unit Rate (PKR) | Quantity | Cost (PKRs) | Remarks |
|---|---|---|---|---|---|---|---|
| **C-1** | **Environmental Monitoring Cost** | | | | | | |
| 1 | Drinking Water Quality | Discrete grab sampling and laboratory testing of water samples by EPA approved Laboratory for monitoring. | Biannually for One Year | 35,000 | 06 Nos. | 480,000 | Biannually monitoring cost for the one year O&M Phase has been taken on current year basis, however, it will be reproduced for next years of O&M based on updated rates. |
| 2 | Surface/Wastewater Monitoring | Discrete grab sampling and laboratory testing of water samples by EPA approved Laboratory for monitoring. | Biannually for One Year | 35,000 | 04 Nos. | 280,000 | |
| 3 | Noise Levels | dBA Leq. as per NEQS 2010 | Biannually for One Year | 5,000 | 03 Nos. | 30,000 | |
| 4 | Ambient Air Monitoring | Monitoring of CO, $CO_2$, SOx, $NO_x$, HC and $PM_{2.5}$ $PM_{10}$ by EPA approved Laboratory | Biannually for One Year | 50,000 | 03 Nos. | 300,000 | |
| **Sub-Total (C-1)** | | | | | | **1,090,000** | |
| **C-2** | **Environmental and Social Management Cost** | | | | | | |
| 1 | HSE Activities | WAPDA | Monthly | 300,000 | | 3,600,000 | This is the tentative monthly cost for one year period for one senior HSE staff. |
| | **Sub-Total (C-2)** | | | | | **3,600,000** | |
| | **Sub-Total C ((C-1)+(C-2))** | | | | | **4,690,000** | **Tentative for (01) year project O&M phase. The cost shall be reproduced for next years of O&M** |



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| Sr. No. | Parameter | Mechanism | Frequency | Unit Rate (PKR) | Quantity | Cost (PKRs) | Remarks |
|---|---|---|---|---|---|---|---|
| | | | | | | | **Phase and updated based on the current market prices during O&M phase.** |
| | **Grand Total (A+B+C)** | | | | | **114,969,000** | |
| | **Contingency Charges** | | 10% of Grand Total | | | **11,496,900** | |
| | **Grand Total with Contingencies** | | | | | **126,465,900 (126.5 million)** | **Excluding Resettlement and Compensation Cost** |



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# 10 CONCLUSIONS AND RECOMMENDATIONS

## 10.1 CONCLUSIONS

Water and Power Development Authority (WAPDA) intends to develop 54 MW Attabad Lake Hydropower Project (ALHHP) on Attabad Lake situated in the Hunza Valley of GB, Pakistan. ALHPP (36º8'28.87"N and 74º49'19.44"E) has been identified on Hunza River on Attabad Lake. Attabad Lake was formed on January 4, 2010, when a huge mass from the right bank of Hunza River slided down near Attabad Village and blocked Hunza River. The inflow filled upstream valley created a reservoir 22 km long till the end of May 2010. Attabad Lake is about 15 km upstream of Ganish Bridge and about 111 km upstream from Gilgit. Therefore, ALHHP will utilize the Attabad Lake water and head for the generation of the Hydel Electricity. Therefore, due to the implementation of ALHPP, no major adverse impacts are anticipated.

Presently, there is a huge demand and supply gap of electricity in GB resulting in load shedding along with low voltage issues. Locals have no option for commercial and industrial demand to be partly fulfilled from diesel generators. Apart from the high cost of fuel, the use of these diesel generators is affecting the environment as well as tourism in the area.

This report has been prepared in accordance with the requirements of the GB Environmental Protection Act, 2014, Pakistan Environmental Protection Agency Review of Initial Environmental Examination and Environmental Impact Assessment Regulations, 2000; Guidelines for Environmental Assessment (Guidelines for the Preparation and Review of Environmental Reports, Pakistan Environmental Protection Agency, 1997, Guidelines for Sensitive and Critical Areas,1997, Guidelines for Public Consultation, Pakistan Environmental Protection Agency, May, 1997; and Sectoral Guidelines: Pakistan Environmental Assessment Procedures, Pakistan Environmental Protection Agency, October 1997). In addition, this EIA addresses the requirements defined in the national and local regulations. Thus, to fulfil local (GB EPA) legal requirements, an EIA study was conducted for the proposed project.

This EIA study has been updated based on the available information at this stage of the Project as an additional scope of work. The proposed project will be implemented in EPC Contractor mode therefore, Detailed Engineering Design including Final Design will be available after the selection of EPC Contractor.

Analysis of Alternatives such as No Project Option, Project Layout, Headrace, Penstock and Powerhouse Location have been considered during the preparation of EIA study.

During the field surveys, significant efforts were made to identify the main physical, ecological, social, cultural and environmental issues related to the construction and operation of the proposed project. Various stakeholders including government departments and agencies were also contacted for obtaining salient information in this regard along with that from area residents.

Following are the major anticipated positive impacts:

- The Project not only reduces or replaces equivalent electricity generation sources with all the associated environmental benefits but it will also help to avoid all associated pollution caused through extraction, processing, storage and transportation of conventional fuels required for fossil fuel power generation plants.


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- The sustainable power supply with the development of the proposed Project is likely to attract more tourists in the Project area and will increase the local business and recreational activities.
- The proposed Project will also provide skilled and unskilled jobs during the implementation phase and a limited number of jobs during operation and maintenance.
- Hunza and Nagar valleys have precious mineral resources which have remained unexploited. The availability of electricity will certainly develop a set up on large scale to preserve fruits and for exploration of minerals.
- The requirements of electricity have increased in homes, both public and private offices, education institutions, hospitals, and health care centers in towns and habitats in the remote rural areas of valleys in Gilgit-Baltistan region, the electricity shortfall can be decreased with commissioning of this Project.
- Access roads will be built as part of the Project and will facilitate the people for goods and services accessibility. After completion of the Project, these facilities and infrastructure will be available to the general public. Moreover, health facilities created during the construction phase will be available to local communities.

Following is the list of potential adverse impact:

- Permanent Land acquisition;
- Temporary Land on rental/lease basis
- Cutting of trees/bushes falling within the proposed Project Boundary.
- Disturbance due to field activities;
- Temporary Landslide Hazards;
- Disturbance to aquatic fauna;
- Disturbance to infrastructure and public utilities;
- Disturbance to the public movement during construction;
- Noise and air pollution due to the working of construction machinery during construction and traffic during O&M phases of the Project;
- Solid waste and wastewater generation during construction;
- Oil spillages from construction machinery, resulting in soil and water contamination;
- Occupational and community health and safety issues;
- Social and Cultural Conflicts;

Sedimentation, environmental flow, dam safety and emergencies etc. are the anticipated environmental impacts during operation and maintenance phase of the proposed project.

The impact assessment, revealed that with the help of appropriate mitigation and control measures provided in this EIA Study, most of these potential impacts will either be avoided altogether, or their likelihood of occurrence and severity will be reduced, thus making this project environmentally responsible and socially acceptable.

The environmental constraints will have to be monitored by concerned agencies, including Environment Specialist of Proponent and GB EPA. An EMP has been developed as part of the report which provides a detailed mitigation matrix that covers impacts, mitigation measures roles and responsibilities and timings to avoid, minimize or mitigate the adverse impacts of the


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project.

Project is socio-economically viable and environment friendly if EMP is implemented in true letter and spirit. The plantation will enhance the aesthetics; improve the landscape as well as the environmental conditions along the project area.

## 10.2 RECOMMENDATIONS

The EIA, EMP, mitigation and monitoring programs, contained herewith are recommended to include within the bidding documents for project works for all project components. The Bidding documents shall clearly state that the EPC Contractor will be responsible for the implementation of the requirements of the EMP through his own SSEMP and SSHSMP, based on the guidelines provided in the EIA report, which will adopt all of the conditions of the EMP and add site specific elements as per advice of Environmental Specialist. This will ensure that all potential bidders are aware of the environmental requirements of the project and its associated environmental costs.

Project affected persons must be compensated for their lost land, property or any other asset as per existing market rates. This step will reduce any future social impacts or political strains due to Project implementation. All personnel staff, employees and EPC Contractor should undertake appropriate training prior to construction works to ensure they are aware of the on-site responsibilities in respect of all environmental and social issues.

The EIA, EMP and all its requirements should be added to the EPC Contractor's Contract, thereby making implementation of the EMP a legal requirement according to the Contract. Therefore, EPC Contractor will prepare its SSEMP which will be approved and monitored by the Supervision Consultant. The Supervision Consultant shall note any non-conformance with the SSEMP and the conditions of environmental approval by GB EPA. The EPC Contractor should be held liable for breach of the contractual obligations of the EMP. In order ensure compliance with the SSEMP, the EPC Contractor will employ an Environmental Manager (or expert specified in EMP) to monitor and report project activities throughout the project construction phase.

The Project is found economically and financially feasible. The calculated economic internal rate of return (EIRR) is above 22.36% (the assumed opportunity cost of capital in Pakistan) and the financial internal rate of return (FIRR) comes out to be 19.17%. The proposed Project is found to be technically feasible, economically viable and environmentally acceptable and will fulfill electricity needs particularly for Hunza City and in general for Hunza, Gilgit and Ghizar Regions. It is suggested that the proposed Project should be implemented as soon as possible after all necessary approvals, design provisions and the implementation of EMP.

The tentative cost estimates to implement EMP is estimated as **PKR. 126.5 Million**. This tentative cost will be included in the overall project cost. This cost will be reviewed and firmed up periodically to ensure realism. The EPC Contractor however shall be paid against the actual execution with evidential proof of EMP activity.


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# ANNEXES

# ANNEX-I: LIST OF PARTICIPANTS-COMMUNITY CONSULTATIONS

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

## LIST OF PARTICIPANTS-COMMUNITY CONSULTATIONS

| Sr. No. | Name of Participants | Occupation |
|---|---|---|
| **1. Ganish Village** | | |
| 1 | Mubarak Hussain | President (Ganish Local Development Org.) |
| 2 | Sadaqat Hussain | Business |
| 3 | Tajir Hussain | Community Representative |
| 4 | Khadim Hussain | Advocate |
| 5 | Sherbaz | Govt. Employee |
| 6 | Ali | Shopkeeper |
| 7 | Akbar Hussain | Business |
| **2. Gulmit Village** | | |
| 1 | Shair Ullah Baig | Vice Chairman |
| 2 | Salman Kareem | Society Member |
| 3 | Hadayat Shah | Society Member |
| 4 | Sultan Ayub | Numberdar |
| 5 | Sikandar Ahmad | Finance Secretary |
| 6 | Ahmad Baig | Finance Secretary |
| **3. Attabad Village** | | |
| 1 | Dildar Khan | President Boat Association |
| 2 | Salman Ali | Vice President |
| 3 | Nawaz | Boat Owner |
| 4 | Naik Alam | Local Resident |
| 5 | Zafar Iqbal | Local Resident |
| 6 | Ahmad Khan | Boat Owner |
| 7 | Javed Iqbal | Supervisor |
| 8 | Agha Shahid | Shopkeeper |
| 9 | Ali Safdar | Shopkeeper |

| Sr. No. | Name of Participants | Occupation |
|---|---|---|
| 10 | Zakawat Ali | Labor |
| 11 | Jan Muhammad | Labor |
| **8. Passu Village** | | |
| 1 | Abdul Rasheed | Chairman PDO |
| 2 | Azeem Ali Shah | Community Stakeholder |
| 3 | Arman Ali | President Passu Conserving Committee |
| 4 | Salah Uddin | President Village Organization |
| 5 | M. Adab Khan | Community Stakeholder |
| 6 | Aman Ullah Khan | Social Activist |
| 7 | M. Ashraf Khan | Stakeholder |
| 8 | Mullah Walli | President Thrift Society |
| 9 | Ali Madad | President Water Supply |
| 10 | M. Sharif Khan | Stakeholder |
| 11 | M. Iqbal | Stakeholder |
| 12 | Wahid Murad | Head Agriculture Society |
| 13 | Babar Majeed | President CBES |
| 14 | Arman Ali | President Passu Conserving Committee |
| 15 | Salah Uddin | President Village Organization |
| 16 | M. Adab Khan | Community Stakeholder |
| 17 | Aman Ullah Khan | Social Activist |
| 18 | M. Ashraf Khan | Stakeholder |

# ANNEX-II: TREE PLANTATION PLAN

# TREE PLANTATION/ AFFORESTATION PLAN

The basic purpose of afforestation/plantation of suitable species in the project area is to reduce the risk been made due to cutting of trees for the proposed project and to enhance green cover and improve the overall environment of the area. Afforestation will not only reduce the risk been made but will also increase the carrying capacity of the area regarding many positive aspects.

Plantation will be done after the removal of trees during the construction work immediately. Plantation of indigenous trees species is highly important to maintain the biodiversity and ecological balance. It is also important to prevent global warming, soil erosion and pollution. Afforestation purifies the environment and helps in reducing the carbon dioxide level. The afforestation activity will further help in enhancing the socio-economic condition of the area and project sustainability.

**Importance of Tree Plantation**

- Trees contribute to their environment by providing oxygen, improving air quality, climate amelioration, conserving water, preserving soil, and supporting wildlife.
- Trees control climate by moderating the effects of the sun, rain and wind. Leaves absorb and filter the sun's radiant energy, keeping things cool in summer.
- Trees also preserve warmth by providing a screen from harsh wind.
- Trees also lower the air temperature and reduce the heat intensity of the greenhouse effect by maintaining low levels of carbon dioxide.
- Both above and below ground, trees are essential to the eco-systems in which they reside.
- Trees absorb and store rainwater which reduce runoff and sediment deposit after storms. This helps the ground water supply recharge, prevents the transport of chemicals into streams and prevents flooding.
- Trees, shrubs and turf also filter air by removing dust and absorbing other pollutants like carbon monoxide, sulfur dioxide and nitrogen dioxide.

**Objectives**

- To Restore native species
- To improve the quality of air and reduce its pollution
- To add color to the landscape and enhances the beauty of the environment
- To uplift the quality of our living environment through active planting, proper maintenance and preservation of trees together with other vegetation.
- To Protect and conserve flora and fauna of the project area.
- To attract rain which is a positive impact on the project area at all.
- To reduce sedimentation by plantation in the project area which will act as protection wall against wind born dust particles.

**Study Area Enhancement/Rehabilitation Plan**

The project area is not rich in natural vegetation but some of planted and natural trees may be damaged**.**

**In** the project area will be raised on available spaces, in the Project area. Distance from the outer boundary of the ROW and between two plants will be kept as 4 meters. A total of 5,750 plants shall be planted in lieu of expected 5**75** effected plants, which is equal to 1:10 of the effected plants.

**Plantation Technique**

Plantation of suitable broad leaved and pine species is to be carried out in the immediate vicinity of the project area. The project area can be afforested and vegetation cover can be improved by adopting standard afforestation technique of digging pits. The project area is suitable for plantation activities and can be managed thoroughly with care.

**Pits**

Pits should be dug in the project area at a spacing of 10' linearly. The pits should be of 1.5 feet dia at the top and 1 feet dia at the bottom with a depth of 1-3/4" ft. The earth taken out of the pits will be deposited below each pit in a crescent shape, so as to form a ridge with a clear berm of 9 inches in front. The consecutive crescents will be joined to catch the maximum quantity of moisture. Moreover, planting should be carried out in the pits and sowing on the berms, before or immediately after the first shower of rain. The choice of species (Forest Department may change as per actual requirement and suitability)

**Table: Recommended Species for Plantation in the Project Area**

| Sr. No. | Common Name | Scientific Name |
|---|---|---|
| 1 | Chinar | *Platanus orientalis* |
| 2 | Tooth/Mulberry | *Morus alba/Nigra* |
| 3 | Robenia | *Robinia pseudoacacia* |

**When to Plant**

Planting should be completed early in the rains in as short a time as possible. The trees must be given time to become well established prior to the dry season. A good rule of thumb is to start planting when the soil is moist to a depth of 15-25 cm or to the bottom of the planting hole. Failures because planting is too late are more common than failures because of planting too early. To obtain good results and avoid labor shortage in these areas considerable preparatory planning is needed. The size of the plantation might have to be adapted to the availability of labor. If dry sites cannot be planted in time, planting should be postponed until the next season.

**Cost**

The cost and maintenance of about 5,750 plants for afforestation in the project area has been estimated including cost of layout, digging, planting, carriage and watch and ward and its maintenance for four (04) years. **Table** shows the approximate cost of plantation including four (04) years' maintenance (Standard).

**Note:** *These all activates of plantation plan should be implemented by Forest Department and they may change/update the standards and choice of species as per rule and approved rates.*

Break-up of Expenditure per Avenue kilometer @ Rs. 1500/- per diem: Break-up of Expenditure per of 250 plants @ Rs. 1500/- per diem:

**FIRST YEAR**

| Sr. No. | Item | Quantity | Rate | Amount (Rs.) |
|---|---|---|---|---|
| 1. | Layout | 1 Av.km | 2 MD/Av.km | 3000.00 |
| 2. | Digging of Pits 2.5 ft. each 2.5x250 = 625 cft. | 625 cft. | 5 MD/Av.km | 7500.00 |

| | | | | |
|---|---|---|---|---|
| 3. | Cost of Plants including | 250 No. | Rs100/- plant | 25,000.00 |
| 4. | Cost of planting of plants | 250 No. | Rs. 25/- plant | 6250.00 |
| 5. | Carriage of plants from private nursery to site including loading/unloading | 250 No. | Rs. 10/- plant | 2500.00 |
| 6. | Cost of Manure and Bhall (silt) including carriage | 1 Av. Km | | 20,000.00 |
| 7. | H/watering 50 times 250x50 with water bowser, one driver and one coolie | 12500 no. | 5MD/per %0 | 100,000.00 |
| 8. | Weeding twice 250x2 | 500 no. | 2 MD/per % | 15,000.00 |
| 9. | Reopening of Pits twice (250x2)/cft/pit | 500 cft. | 2 MD/per % | 15,000.00 |
| 10. | Unforeseen | | | 5750.00 |
| Total | | | | 200,000.00 |

**SECOND YEAR**

| Sr. No. | Item | Quantity | Rate | Amount (Rs.) |
|---|---|---|---|---|
| 1. | Cost of Plants 20% Restocking | 50 No. | Rs.100/- plant | 5,000.00 |
| 2. | Cost of planting | 50 No. | Rs. 25/- plant | 1250.00 |
| 3. | Carriage of plants | 50 No. | Rs. 10/- plant | 500.00 |
| 4. | H/watering 50 times with water bowser, one driver and one coolie | 12500 no. | 5MD/per %0 | 100,000.00 |
| 5. | Reopening of Pits twice (250x2) | 500 cft. | 2 MD/per % | 1,5000.00 |
| 6. | Weeding twice 250x2 | 500 no. | 2 MD/per % | 1,5000.00 |
| 7. | Unforeseen | | | 1250.00 |
| Total | | | | 1,38,000.00 |

**THIRD YEAR**

| Sr. No. | Item | Quantity | Rate | Amount (Rs.) |
|---|---|---|---|---|
| 1. | Cost of Plants 10% Restocking 25 No. | 25 No. | Rs.100/- plant | 2500.00 |
| 2. | Cost of planting | 25 No. | Rs. 25/- plant | 625.00 |
| 3. | Carriage of plants | 25 No. | Rs. 10/- plant | 250.00 |
| 4. | H/watering 40 times x250 no. | 10,000 no. | 5MD/per %0 | 75000.00 |
| 5. | Reopening of Pits twice (250x2) | 500 | 5MD/per %0 | 3750.00 |
| 6. | Unforeseen | | | 2875.00 |
| Total | | | | 85,000.00 |

**FOURTH YEAR**

| Sr. No. | Item | Quantity | Rate | Amount (Rs.) |
|---|---|---|---|---|
| 1. | H/watering 30 times | 7500 no. | 5MD/per %0 | 56250.00 |
| 5. | Pruning and cleaning of plants | 250 no. | 5MD/per %0 | 1875.00 |
| 6. | Unforeseen | | | 1875.00 |
| Total | | | | 60,000.00 |

Cost for raising 250 plants: = **Rs.4,83,000/-**

For 4 years

Total cost for 5,**750** plants and their maintenance for four (4) years = **Rs. 11,109,000/-** or say

**Total Cost= 11.109 Million PKR**

***Note:*** *The above rates and calculations are approximate and tentative which will be updated according to the standard rates of concerned Forest and agriculture Departments/Implementing Agency, during implantation stage, as per updated and approved standards.*

**Expected Results**

**(1)** Extensive plantation, raised on both sides of the road will improve the ecological balance as both the flora and fauna are integral part of the ecosystem. Native tree species will be resorted which is playing pivotal role in carbon sequestration, which leads to reduce global warming and storing more carbon.

**(2)** Local people will also get direct benefits in terms of fodder for cattle's, shade, job opportunities during plantations and maintenance for four years, clean air, and balanced temperature. Improved Green cover in the area will also attract the faunal species which are scared away due to construction activities. This shall reduce the noise and air pollution as well.

**(3)** In many ways, fauna of a tract is dependent upon flora for its resting, nesting and roosting activities. With the improved flora of the project area, due to raising of large number of trees, the fauna and especially the avi-fauna shall be attracted to the area. The birds, which were scared away due to noise and degradation of their habitat, shall return to the area.

**(4)** Plantation on both sides of the road shall not only reduce the noise and air pollution but will also be a source of attraction for the humans, and Wildlife like mammals, reptiles' birds and other dependents.

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

# ANNEX-III: CHANCE FIND PROCEDURE

**CHANCE FIND PROCEDURE**

In case of any chance find procedure, the EPC Contractor will immediately report through supervision consultant to Archaeology Department of Astor and take further suitable action to preserve those antiques or sensitive remains. Representative of the Director will visit the site and observed the significance of the antique, arte fact and Cultural (religious) properties and significance of the Project. The report will be prepared by representative and will be given to the Director. The documentation will be completed and if required suitable action will be taken to preserved those antiques and sensitive remains.

In case any artifact antiques and sensitive remains are discovered, chance find procedures should be adopted by construction contractor workers as follows:

- Stop the construction activities in the areas of chance find procedure;
- Delineate the discovered site or area;
- Consult with the local community and Archaeological Department;
- The suggestion of the local communities and the concerned authorities will be incorporated during taking the preventive measures to conserved the antique, arte fact and Cultural (religious) properties;
- Secure the site to prevent any damage or loss of removable objects. In case of removable antiquities or sensitive remain, a night guard shall be arranged until the responsible local authorities take over; and
- After stopping work, The EPC Contractor must immediately report the discovery to the Supervision Consultant Expert.

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

# ANNEX-IV: GUIDELINE OCCUPATIONAL HEALTH AND SAFETY PLAN

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

# GUIDELINE OCCUPATIONAL HEALTH AND SAFETY PLAN

Occupational Health and Safety covers all personnel working under the project and will be in line with the World Bank EHS guidelines on health and safety.

The Occupational Health and Safety program will aim to ensure that the workplace is safe and healthy by: addressing the hazards and risks at the workplace; outlining the procedures and responsibilities for preventing, eliminating and minimizing the effects of those hazards and risks; identifying the emergency management plans for the workplace or workplaces; and, specifying how consultation, training and information are to be provided to employees at various workplaces.

Some of the risks/hazards associated with workplaces are due to working close to or at sites associated with the various project construction activities. Other risks associated with the project construction phase include risk of increase of vector borne and other different diseases.

The following sections will be implemented during the construction phase to address and ensure workers' health and safety.

## SCREENING AND REGULAR UNANNOUNCED CHECKING OF WORKERS

As per the procedure for hiring workers, all contractors and labor agencies are required to make all prospective workers undergo medical tests to screen for diseases and sicknesses, prior to selection and employment of any worker. The contractor is also responsible for ensuring that no worker who has a criminal record is employed at the project site. It will be ensured that all workers undergo medical tests to screen diseases at source and at sites in consultation with the designated Health Officer.

In addition to this, the Project Management will also undertake sudden, unannounced checks on workers to look for diseases such as COVID-19, HIV, STDs, and hepatitis and take necessary steps as mandated by the Contractual agreement between the Contractor and the Worker(s).

## MINIMIZING HAZARDS AND RISKS AT THE WORKPLACE

To ensure safety at all work sites, the following will be carried out:

i. Installation of signboards and symbols in risky and hazardous areas, to inform workers to be careful.
ii. Construction of barricades around construction sites and deep excavated pits, to cordon off and deter entry of unauthorized personnel and workers into these areas.
iii. Providing a safe storage site/area for large equipment such as power tools and chains, to prevent misuse and loss.
iv. Proper Housekeeping: Ensuring that materials are all stacked, racked, blocked, interlocked, or otherwise secured to prevent sliding, falling, or collapse. Brick stacks will not be more than 7 feet in height and for concrete blocks they will not be more than 6 feet high.
v. Removing all scrap timber, waste material and rubbish from the immediate work area as the work progresses.
vi. Where scaffolds are required, ensuring that each scaffold or its components shall be capable of supporting its own weight and at least 4 times the maximum intended load applied or transmitted to it. The platform/scaffold plank shall be at least 15 inches wide and 1.5 inches thick. The rope should be capable of supporting at least 6 times the maximum intended load applied or transmitted to that rope. Pole scaffolds over 60 feet in height shall be designed by a registered professional engineer and shall be constructed and loaded in accordance with that design. Where scaffolds are not provided, safety belts/safety nets shall be provided;
vii. Ensure that all ramps or walkways are at least 6 feet wide, having slip resistance threads

and not inclined at more than a slope of 1 vertical and 3 horizontal.

viii. Stacking away all excavated earth at least 2 feet from the pit to avoid material such as loose rocks from falling back into the excavated area and injuring those working inside excavated sites.

ix. Constructing support systems, such as bracing to adjoining structures that may be endangered by excavation works nearby.

x. Only a trained electrician to construct, install and repair all electrical equipment to prevent risks of electrical shocks and electrocution.

xi. Install fire extinguishers and/or other fire-fighting equipment at every work site to prepare for any accidental fire hazards.

**PROVISION OF PERSONAL PROTECTIVE EQUIPMENT**

Risks to the health and safety of workers can be prevented by provision of Personal Protective Equipment (PPEs) to all workers. This will be included in the construction cost for each Contractor. Depending on the nature of work and the risks involved, contractors must provide without any cost to the workers, the following protective equipment:

i. High visibility clothing for all personnel during road works must be mandatory.

ii. Helmet shall be provided to all workers, or visitors visiting the site, for protection of the head against impact or penetration of falling or flying objects.

iii. Safety belt shall be provided to workers working at heights (more than 20 ft) such as roofing, painting, and plastering.

iv. Safety boots shall be provided to all workers for protection of feet from impact or penetration of falling objects on feet.

v. Ear protecting devices shall be provided to all workers and will be used during the occurrence of extensive noise.

vi. Eye and face protection equipment shall be provided to all welders to protect against sparks.

vii. Respiratory protection devices shall be provided to all workers during occurrence of fumes, dusts, or toxic gas/vapor.

viii. Safety nets shall be provided when workplaces are more than 25 feet (7.5 m) above the ground or other surfaces where the use of ladders, scaffolds, catch platforms, temporary floors or safety belts is impractical.

The specific PPE requirements for each type of work are summarized below.

**Table 1: PPE Requirement List**

| Type of Work | PPE |
|---|---|
| Elevated work | Safety helmet, safety belt (height greater than 20 ft), footwear for elevated work. |
| Handling work safety | Helmet, leather safety shoes, work gloves. |
| Welding and cutting work | Eye protectors, shield and helmet, protective gloves. |
| Grinding work | Dust respirator, earplugs, eye protectors. |
| Work involving handling of chemical substances | Dust respirator, gas mask, chemical-proof gloves. Chemical proof clothing, air-lined mask, eye protectors. |
| Wood working | Hard hat, eye protectors, hearing protection, safety footwear, leather gloves and dust respirator. |

| Type of Work | PPE |
|---|---|
| Blasting | Hard hat, eye and hearing protection. |
| Concrete and masonry work | Hard hat, eye protectors, hearing protection, safety footwear, leather gloves and dust respirator. |
| Excavation, heavy equipment, motor graders, and bulldozer operation | Hard hat, safety boots, gloves, hearing protection. |
| Quarries | Hard hat, eye protectors, hearing protection, safety footwear, leather gloves and dust respirator. |

**PROCEDURES TO DEAL WITH EMERGENCIES SUCH AS ACCIDENTS, SUDDEN ILLNESS AND DEATH OF WORKERS**

First aid kits will be made available at all times throughout the entire construction period by the respective contractors. This is very important, because most work sites will be at some distance from the nearest hospital. In addition to the first aid kits, the following measures should be in place:

i. Provision of dispensaries by the individual EPC contractor.
ii. A vehicle shall be on standby from the Project Office so that emergency transportation can be arranged to take severely injured/sick workers to the nearest hospital for immediate medical attention.
iii. A designated Health Officer/worker for the Project will be identified as a focal person to attend to all health and safety related issues. This employee's contact number will be posted at all work sites for speedy delivery of emergency services. The focal person shall be well versed with the medical system and facilities available at the hospital.
iv. Communication arrangements, such a provision of radios or mobile communication for all work sites, for efficient handling of emergencies, will be made.

**RECORD MAINTENANCE AND REMEDIAL ACTION**

The Project Management will maintain a record of all accidents and injuries that occur at the work site. This work will be delegated by the contractor to the site supervisor and regularly reviewed every quarter by project management. Reports prepared by the contractor shall include information on the place, date and time of the incident, name of persons involved, cause of incident, witnesses present and their statements. Based on such reports, the management can jointly identify any unsafe conditions, acts or procedures and recommend for the contractor to undertake certain mitigative actions to change any unsafe or harmful conditions.

**COMPENSATION FOR INJURIES AND DEATH**

Any casualty or injury resulting from occupational activities should be compensated as per the local labor laws of Pakistan. Where compensation is sought by the injured party, proper procedures for documentation of the case will be followed, including a detailed report on the accident, written reports from witnesses, report of the examining doctor and his/her recommendation for treatment. Each individual contractor will be responsible for ensuring compensation for the respective workers.

**AWARENESS PROGRAMS**

The Project management will undertake awareness programs through posters, talks, and meetings with the contractors to undertake the following activities:

i. Dissemination sessions will clarify the rights and responsibilities of the workers regarding interactions with local people (including communicable disease risks, such as HIV/AIDS, COVID-19), work site health and safety, waste management (waste separation, recycling, and composting), and the illegality of poaching.
ii. Make workers aware of procedures to be followed in case of emergencies such as informing the focal health person who in turn will arrange the necessary emergency transportation or treatment.

**NOMINATION OF A HEALTH AND SAFETY FOCAL PERSON**

Within each site (especially if different sites are being implemented by different contractors), a Health and Safety Focal Person will be appointed. The Terms of Reference for the focal person will mainly be as follows:

i. Function as the focal person/representative for all health and safety matters at the workplace;
ii. Responsible for maintaining records of all accidents and all health and safety issues at each site, the number of accidents and its cause, actions taken and remedial measures undertaken in case of safety issues;
iii. Be the link between the contractor and all workers and submit grievances of the workers to the contractor and instructions/directives on proper health care and safety from the contractors back to the workers;
iv. Ensure that all workers are adequately informed on the requirement to use Personal Protective Equipment and its correct use;
v. Also responsible for the first aid kit and making sure that the basic immediate medicines are readily available.

**SUGGESTED CONTENTS OF OCCUPATIONAL HEALTH AND SAFETY PLAN**

The suggested contents of Occupational Health and Safety Plan to be developed by the Contractor(s) are described below:

a Purpose

b Scope of Application

c Complying Basis

d Occupational Health and Safety Objectives

e Organization and Responsibility

- Contractor’s Project Manager
- HSE Management Department of the Contractor(s)
- Medical Treatment Room of the Contractor(s)
- Subcontractor’s Project Manager
- Subcontractor’s HSE Managers
- Occupational Health and Safety
- Community Health and Safety

f Health Plan

- Labour Protection
- Sanitary Epidemic Prevention

g Safety Plan

- Summary

- Qualification Review
- Safety Training
- Construction Plans and Documents
- Control Measures
- Monitoring Measures
- Management of the Key Safety Accidents

h Public Security Plan

i Local Community Health and Safety

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# ANNEX-V: BREAKUP OF HEALTH AND SAFETY COST

## BREAKUP OF HEALTH AND SAFETY COST

| Items | Quantity | Cost / Item (Rs.) | Total Cost (Rs.) | Rationale |
|---|---|---|---|---|
| **(A) Personal Protective Equipment PPEs** | | | | |
| Dust masks | 16,800 | 200 | 3,360,000 | One dust mask per person to be used in a week by 350 labourer for 12 months the quantity will be 16,800 dust masks. |
| Safety Shoes | 350 | 7,500 | 2,625,000 | One safety shoe per person is supposed to be used for 12 months by 350 labourers. |
| Gloves | 4,200 | 200 | 840,000 | One pair of gloves is to be used per month per person and for 350 labourer for 12 months, 4,200 gloves are estimated |
| First Aid Box | 6 | 10,000 | 60,000 | Six First Aid Boxes are proposed for 12 months. The cost includes refilling expenses. |
| Ear Plugs | 4,200 | 100 | 420,000 | One set of ear plug is to be used per month per person and for 350 labourer for 12 months, 4,200 ear plugs are estimated |
| Safety Helmets | 350 | 3,000 | 1,050,000 | One safety helmet to be used by each of 350 labourer for 12 months. |

| Items | Quantity | Cost / Item (Rs.) | Total Cost (Rs.) | Rationale |
|---|---|---|---|---|
| Safety Jackets (Hi Vis) | 700 | 1,500 | 1,050,000 | Two safety Jacket (Hi Vis) to be used by each of 350 labourers for 12 months and total 700 safety jackets are required |
| ***Sub-Total (A)*** | | | ***9,405,000*** | |
| **(B) Others** | | | | |
| Provision of Dust Bins | 30 | 1,000 | 30,000 | Thirty dust bins are proposed to be placed at construction site. |
| Warning Tape | 50 | 500 | 25,000 | --- |
| Safety Cones | 50 | 1000 | 50,000 | Fifty safety cones are estimated to be placed at active construction site. |
| Safety Sign Boards | 50 | 10,000 | 500,000 | Fifty safety sign boards are proposed to be placed at active construction site. |
| ***Sub-Total (B)*** | | | ***605,000*** | |
| ***Grand Total (A + B)*** | | | ***10,010,000*** | |

***Cost is estimated for 12 Months**

**No. of labour required during construction = 350**

# ANNEX-V: GENDER ACTION PLAN

# GENDER ACTION PLAN (GAP)

## Introduction

This Gender Action Plan (GAP) has been developed for the 54 MW Attabad Lake Hydropower Project to ensure gender equality, social inclusion, and equitable benefit-sharing throughout the project lifecycle.

The GAP draws upon findings from the Environmental Impact Assessment (EIA), feasibility studies, and community consultations conducted in the Hunza region. It reflects local socio-cultural conditions, high female literacy rates, strong women's participation in agriculture and home-based enterprises, and the differentiated impacts of energy shortages on women, particularly during prolonged winter months.

## Project Context and Gender Profile

The Hunza region exhibits high female literacy (approximately 98%) and strong participation of women in household management, agriculture (around 80%), and home-based enterprises (over 50%). Despite this, prolonged winter electricity shortages disproportionately affect women by increasing domestic workload, limiting productivity, and elevating exposure to indoor air pollution from diesel generators and traditional fuels.

The project's provision of reliable and clean electricity is expected to significantly reduce women's physical burden through improved heating and lighting, enhance indoor air quality, enable income-generating activities such as food processing and handicrafts, support digital access and home-based enterprises, and improve safety and comfort within domestic spaces. Vulnerable groups including low-income households, elderly persons, students, and patients will also benefit through improved access to education, healthcare, and essential services.

## Project Components

- Weir and associated structures
- Sediment Flushing Tunnel
- Headrace Tunnel
- Surge Tank
- Penstock
- Powerhouse
- Tailrace
- Switchyard

## Objectives of the Gender Action Plan

The objective of the GAP is to mainstream gender considerations into project planning, construction, and operation to ensure inclusive development outcomes. The specific objectives are to:

- Enhance women's access to and benefits from reliable and clean electricity;
- Promote women's participation in project-related employment and livelihood opportunities;
- Prevent and mitigate gender-based violence (GBV), sexual exploitation and abuse (SEA), and sexual harassment (SH);
- Ensure women's meaningful participation in consultations, decision-making, and grievance redress;

- Establish clear institutional responsibilities and monitoring mechanisms for gender actions.

**Gender Action Plan Framework**

Community institutions such as Village Organizations (VOs) and Women's Organizations (WOs), supported by AKRSP and AKDN, will play a critical role in consultation, outreach, monitoring, and feedback. Their continued engagement will help ensure meaningful participation of women and marginalized groups in project planning, implementation, and monitoring.

**Table 1: Key Gender Actions and Measures**

| Activity | Gender Risks / Issues | Mitigation / Actions | Measurement Indicators | Responsibility | Timeframe |
|---|---|---|---|---|---|
| Institutional Strengthening | Weak implementation of gender commitments | Appoint Gender Specialist; integrate sex-disaggregated indicators; regular gender monitoring reports | Gender Specialist appointed; sex-disaggregated data included in reports | EMMC / WAPDA / MC | Design & Implementation |
| Community Consultation | Limited awareness of women regarding project impacts and entitlements | Inclusive consultations; female representation in PAP Committees; information disclosure | Number of women consultations; %percentage of female representation in committees | EMMC / WAPDA | Throughout Project |
| Electricity Access Benefits | High domestic workload and indoor air pollution for women | Reliable power for heating, lighting, clean cooking support, and home enterprises | Reduction in generator use; reported reduction in domestic workload | WAPDA / Operator | Operation Phase |
| Employment & Livelihoods | Limited female participation in project-related jobs | Minimum 10% female workforce; skills training; support home-based businesses | Percentage women employed/trained; number of women-led enterprises supported | Contractor / EMMC | Construction Phase |
| GBV / SEA / SH Risk Management | Labor influx related social risks | Code of Conduct; awareness sessions; referral mechanisms; | Code of Conduct signed; trainings conducted | Contractor / EMMC | Construction Phase |

| Activity | Gender Risks / Issues | Mitigation / Actions | Measurement Indicators | Responsibility | Timeframe |
|---|---|---|---|---|---|
| | | gender-sensitive GRM | | | |
| Facilities & Safety | Lack of women-friendly facilities | Separate toilets, waiting areas, lighting, and privacy barriers near institutions | Facilities provided and functional | Contractor | Construction Phase |
| **Gender-Sensitive Grievance Redress** | Barriers for women in reporting complaints | Establish accessible, confidential, and gender-responsive GRM; engage Women's Organizations in outreach | GRM operational; number of grievances resolved | WAPDA / EMMC | WAPDA / EMMC |
| **Monitoring & Reporting** | Limited accountability for gender outcomes | Quarterly monitoring using sex-disaggregated indicators; participatory monitoring with Women's and Village Organizations | Quarterly GAP monitoring reports | EMMC / MC | EMMC / MC |

**Monitoring and Reporting**

Implementation of the GAP will be monitored through quarterly progress reports incorporating sex-disaggregated data against the indicators defined in Table 1. Women's Organizations (WO) and Village Organizations (VO), and other active civil society organizations such as Agha Khan Rural Support Program (AKRSP) or Agha Khan Development Network (AKDN) where relevant will be engaged in participatory monitoring to ensure transparency, accountability, and equitable outcomes.

Institutional responsibilities are summarized as follows:

- WAPDA: Overall oversight and compliance with gender commitments.
- Environmental and Monitoring Management Consultant (EMMC) / Management Consultant (MC): Day-to-day supervision of GAP implementation, monitoring, and reporting.
- Contractors: Implementation of construction-phase gender actions, including employment targets, facilities, and GBV risk mitigation.
- Operator (Operation Phase): Ensuring sustained electricity benefits and monitoring gender-related outcomes during operation.

Corrective actions will be initiated where gaps are identified, and the GAP may be updated as necessary to respond to emerging issues during implementation.

# ANNEX-VI: KEY PERFORMANCE INDICATORS

## KEY PERFORMANCE INDICATORS

| Indicator Category | Example Indicator | Unit / Target |
|---|---|---|
| Energy Efficiency | Reduction in grid losses | % reduction |
| Pollution Prevention | Compliance with emission/discharge standards (NEQS) | % compliance |
| Pollution Prevention | Number of pollution incidents reported and addressed | No. |
| Pollution Prevention | Levels of key pollutants (BOD, COD, heavy metals) in effluent | mg/L |
| Pollution Prevention | Concentration of particulate matter (PM2.5, PM10) at project sites | µg/m³ |
| Pollution Prevention | Reduction in greenhouse gas (GHG) emissions | tons $CO_2$ equivalent/year |
| Occupational Health & Safety (OHS) | Lost Time Injury Frequency Rate (LTIFR) | No. / million man-hours |
| Occupational Health & Safety (OHS) | Workers trained in OHS | % |
| Occupational Health & Safety (OHS) | Workplace accidents/incidents reported | No. |
| Waste Management | Solid and hazardous waste generated, treated, or recycled | tons/year |
| Waste Management | Project waste disposed of in compliance with regulations | % |
| Community Health and Safety | Community health and safety incidents (traffic accidents, hazardous exposure) | No. |
| Community Health and Safety | Community members reached through health and safety awareness campaigns | No. |
| Community Engagement | Community consultations held | No. |
| Community Engagement | Project-affected people who feel adequately consulted | % |
| Grievance Redress | Workers trained on Code of Conduct (including SEA/SH prevention) | No. |
| Grievance Redress | Project beneficiaries from vulnerable or disadvantaged groups | No. |
| Grievance Redress | Grievances received and resolved through the Grievance Redress Mechanism (GRM) | No. |
| Grievance Redress | Grievances resolved within stipulated timeframe | % |
| Labor and Working Conditions | Workers with signed contracts and access to grievance mechanisms | % |

| | | |
|---|---|---|
| Labor and Working Conditions | Unskilled labor sourced locally | % |
| Labor and Working Conditions | Project activities accessible to women, indigenous peoples, or persons with disabilities | % |
| Land Use | People affected by land use or acquisition | No. (Target: zero) |
| Biodiversity | Area of natural habitat restored or protected | Hectares |
| Biodiversity | Species (flora/fauna) monitored or protected | No. |

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**Photolog**

*Photograph 1: Attabad Lake*

*Photograph 2: Attabad Land Slide Information*

*Photograph 3: Shamshal Nullah*

*Photograph 4: Fine Sediment Deposits near Passu*

**Photograph 5: Powerhouse Site**

**Photograph 6: Hunza River D/S of PH Site**

**Photograph 7: Hunza and Nagar Rivers Confluence Point near Ganish**

**Photograph 8: Civil Dispensary Gulmit**

**Photograph 9: Meeting with Director EPA Gilgit**

**Photograph 10: Meeting with Director KIU Hunza Campus**

**Photograph 11: Meeting with Assistant Commissionaire Gojal Hunza**

**Photograph 12: Meeting with Representative of Water & Power Dept. of GB**

**Photograph 13: Meeting with President Local Ismaili Council Gulmit**

**Photograph 14: Meeting with Director Forrest and Wildlife Department Hunza**

**Photograph 15: Meeting District Health Officer Hunza**

**Photograph 16: Meeting with Director Agricultural Department**

**Photograph 17: Meeting with District Education Office Hunza**

**Photograph 18: Meeting with Principal Al-Amin Model School Gulmit**

**Photograph 19: Visit of Bulbulik Music School Gojal**

**Photograph 20: Socio-Economic Survey of Local Cummunity Gulmit**

**Photograph 21: Bulbulik Music School Gojal**

**Photograph 22: Socio-Economic Survey of Locals near Attabad Lake Site**

**Photograph 23: Socio-Economic Survey of Local Community Shishkat**

**Photograph 24: Socio-Economic Survey of Locals Gulkhin**

**Photograph 25: Socio-Economic Survey of Locals Sarat**

**Photograph 26: Socio-Economic Survey of Locals Salman Abad**

**Photograph 27: Socio-Economic Survey of Locals Gulmit**

**Photograph 28: Socio-Economic Survey of Locals Gulmit**

**Photograph 29: Socio-Economic Survey of Locals near Attabad Lake Site Shishkat**

**Photograph 30: Environmental & Socio-Economic Survey Team**

**Photograph 31: Collection of Water Sample from Attabad Lake**

**Photograph 32: Collection of Water Sample from Gulmit Glacier Melt**

**Photograph 33: Agriculture Seed Farm/Nursery Shishkat Gojal**

**Photograph 34: Government Middle School Shishkat Gojal Hunza**

**Photograph 35: Testing of Lake Water with Portable TDS Meter**

**Photograph 36: Testing of Lake Water with Portable PH Meter**

| | |
|---|---|
| | |
| **Consultation in process with Forest Department** | **Consultation in process with Agriculture Department** |
| | |
| **View of Departmental Consultation with Fisheries Department** | **Meeting with Fisheries Department** |

**View of Public Consultations**

## ADDENDUM NO. 01

**Amendments to RFP/EPC Bidding Document for**
**Engineering, Procurement and Construction (EPC) of**
**Attabad Lake Hydropower Project (54 MW)**
**Package-III: Electro-Mechanical Works**

This Addendum No. 01 to RFP/EPC Bidding Document containing the following amendments to the EPC Bidding Document for Engineering, Procurement and Construction (EPC) of Attabad Lake Hydropower Project (54 MW) Package-III: Electro-Mechanical Works is issued pursuant to ITP 8.1 of Volume-I of RFP/EPC Bidding Document.

| **Volume I, Section II - Proposal Data Sheet (PDS), ITP 23.1 (Deadline for Submission of Proposals)** | | |
|---|---|---|
| **ITP No.** | **Instruction to Proposer** | **Amendment** |
| **ITP 22.1(b)** | The original Proposal shall be submitted/uploaded on EPADS v2.0 at (www.vendors.epads.gov.pk/)<br><br>Original Proposal Security / Proposal Security instrument amounting to Rs.120 Million shall be submitted to the address provided in PDS to ITP 23.1 on or before last date of submission or submission in person before the Proposal date and submission time.<br><br>The Proposer shall provide complete searchable PDF version. | The original Proposal shall be submitted/uploaded on EPADS v2.0 at (www.vendors.epads.gov.pk/). Proposals not submitted / uploaded on EPADS v2.0 shall not be considered.<br>In addition to the Proposals submitted/uploaded on EPADS v2.0, the Proposer shall submit **three (03) hard copies of** Technical proposal only, in strict accordance with the procedure set forth in ITP Clause 22.1(b). In case of discrepancy between files uploaded on EPADS v2.0 and hard copies, the content of files uploaded on EPADS v2.0 shall prevail.<br>Original Proposal Security Instrument amounting to Rs.120 million shall be submitted to the address provided in PDS to ITP 23.1 on or before last date of submission or submission in person before the Proposal date and submission time.<br>The Proposer shall provide complete searchable PDF version. |

| **Volume I, Section II - Proposal Data Sheet (PDS), ITP 23.1 (Deadline for Submission of Proposals)** | | |
|---|---|---|
| **ITP No.** | **Instruction to Proposer** | **Amendment** |
| **ITP 23.1** | The Proposal/Bids shall be submitted/uploaded on EPADS v2.0 at https://vendors.epads.gov.pk/<br>Proposal/Bids not submitted/uploaded on EPADS v2.0 shall not be accepted.<br><br>For **Proposal Submission Purposes (Original Bid Security)** only, the Employer's address is: | The Proposal/Bids shall be submitted/uploaded on EPADS v2.0 at https://vendors.epads.gov.pk/<br>Proposal/Bids not submitted/uploaded on EPADS v2.0 shall not be accepted.<br><br>For **Proposal Submission Purposes (Technical Part and Original** |



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| | | |
|---|---|---|
| | **Water and Power Development Authority (WAPDA),**<br>WAPDA Auditorium, WAPDA House, Sharah-e-Quaid-e-Azam Lahore, Punjab, Pakistan<br>**Telephone:** 0092-42-99204981 0092-42-3334481116<br>**Electronic Mail Address:** gmpna01@gmail.com, pdalhpp@gmail.com<br>**Date:** May 14, 2026<br>**Time:** 1100 hrs. | **Proposal Security)** only, the Employer's address is:<br>**Water and Power Development Authority (WAPDA),**<br>WAPDA Auditorium, WAPDA House, Sharah-e-Quaid-e-Azam Lahore, Punjab, Pakistan<br>**Telephone:** 0092-42-99204981 0092-42-3334481116<br>**Electronic Mail Address:** gmpna01@gmail.com, pdalhpp@gmail.com<br>**Date:** June 16, 2026<br>**Time:** 1100 hrs. |
| **Volume I, Section II - Proposal Data Sheet (PDS), ITP 26.1 (Opening of Technical Parts of Proposal)** | | |
| **ITP 26.1** | The **Electronic Bids/Proposal Opening on EPADS v2.0** shall take place on:<br>**Date:** May 14, 2026<br>**Time:** 1130 hrs.<br>**Venue:** WAPDA Auditorium, WAPDA House, Sharah-e-Quaid-e-Azam Lahore, Punjab, Pakistan | The **Electronic Bids/Proposal Opening on EPADS v2.0** shall take place on:<br>**Date:** June 16, 2026<br>**Time:** 1130 hrs.<br>**Venue:** WAPDA Auditorium, WAPDA House, Sharah-e-Quaid-e-Azam Lahore, Punjab, Pakistan |

| **Volume I, Section IV - Proposal Forms, Table of Adjustment Data, Table Foreign Currency** |
|---|
| The table referred to above shall be replaced with the table provided in **Annexure A**. |

| **Volume I, Section IV - Proposal Forms, Table B: Summary of Payment Currencies** |
|---|
| The table referred to above shall be replaced with the table provided in **Annexure B**. |

| **Volume I, Section IV - Proposal Forms, Schedule of Payment for E&M Works, Price Schedule No. 01, Price Schedule No. 02 & Price Schedule No. 04** |
|---|
| Activity No. 18 "132 kV Remote End Line Bays including Bus Bars and Civil Works" shall stand deleted in its entirety from the above-referred Price Schedules. The updated Price Schedules tables have been provided in **Annexure C**. |



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| **Volume I, Section IV - Proposal Forms, Method Statement for Key Construction Activities** |
|---|
| The Key activity “33 kV Switchgear” in the above referred section shall stand deleted in its entirety. |

| **Volume I, Section VIII- Particular Conditions of Contract, Part B - Special Provisions,** | |
|---|---|
| The following sub-clause is added after sub-clause 1.1.84 Milestones : | |
| **Sub-Clause 1.1.85 Accepted Contract Amount** | **“Accepted Contract Amount**” means the proposal price, excluding provisional sums and the provision, if any for contingencies in the Schedule of Rates and Prices (if any), but including Daywork items. |

| **Volume I, Section VIII- Particular Conditions of Contract, Part B - Special Provisions, Sub-Clause 4.2.1 Performance Security** |
|---|
| The referred Sub-Clause shall be substituted with the following:<br><br>Sub-Clause 4.2.1 “EPC Contractor’s Obligations”<br><br>The first paragraph has been substituted with the following:<br><br>“The EPC Contractor shall deliver the Performance Security to the Employer within 28 days after receipt of the Letter of Acceptance. The Performance Security shall be in the form of a Bank Guarantee issued by, at the option of the EPC Contractor, either (a) any Scheduled Bank in Pakistan or (b) a bank located outside Pakistan duly counter-guaranteed by a Scheduled Bank in Pakistan and shall be in the prescribed form.” |

| **Volume I, Section VIII - Particular Conditions, Part B - Special Provision, Sub-Clause 10.1 Taking Over the Works and Sections** |
|---|
| The table referred to above Sub-Clause shall be substituted in its entirety with the table provided in **Annexure D**. |

| **Volume I, Section VIII - Particular Conditions of Contract, Part B - Special Provisions, Sub-Clause 14.2.1 Advance Payment Guarantee and 14.2.3 Re-payment of Advance Payment** |
|---|
| The referred Sub-Clauses shall stand deleted in its entirety and be replaced with the following:<br><br>Sub-Clause 14.2.1 “Advance Payment Guarantee” |



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- In the First paragraph delete the words "equal to the advance payment" from the first sentence and replace with : "equal to the total amount of advance"
- In the second paragraph before "the advance payment has been repaid" add the words : "the total amount of"
- In the third paragraph before "the advance payment has been repaid" add the words : "the total amount of"
- In sub-paragraph (a) before "the advance payment has been repaid" add the words: "the total amount of"
- In the last sentence, before "the advance payment", at the very end of sentence, add the words: "the first installment of"

The entity issuing the Advance Payment Guarantee and its form shall be as follows:

"The Advance Payment Guarantee shall be in the form of Bank Guarantee issued by (a) a Scheduled Bank in Pakistan or (b) a foreign bank duly counter-guaranteed by a Scheduled Bank in Pakistan. In case of Joint Venture, the Advance Payment Guarantee(s) shall be in the name of the Joint Venture or in the name of the Lead / Either firm of the JV or in ratio of shares of the individual JV Partners.

Sub-Clause 14.2.3 "Re-payment of Advance Payment"

Replace the text with the following:

"The Advance Payment shall be recovered in equal installments; first installment at the expiry of 4th month after the date of payment of Advance and last installment before the issuance of TOC of the Works as per Sub-Clause 10.1. The Advance Bank Guarantee may be reduced in proportion to the value of the Plant and Equipment delivered to the site, as evidenced in the shipping and delivery documents.

**Volume I, Section VIII - Particular Conditions of Contract, Part B - Special Provisions, Sub-Clause 14.4 Schedule of Payments Advance Payment**

This Sub-Clause shall be substituted with following:
The Foreign Currency Component Will be Paid in Equivalent Pak Rupee / Local Currency. The amount in Equivalent PKR / Local Currency shall be determined by applying TT&OD composite selling exchange rate published / authorized by State Bank of Pakistan (SBP) for the day 28 days prior to Contractor's IPC / FPC submission date.

Schedule No. 01: Supply of Plant from Abroad (Pre-Engineered Structures) including Fixtures and other Materials, Goods and Spare Parts (if any) (Schedule of Price Basis)

In respect of Plant and Equipment supplied from Abroad, the following Payments shall be made:

- Sixty five Percent (65%) of the total or Pro Rata CIP Amount (Quoted Amount) upon incoterm "CIP" upon Delivery to the Carrier within Forty-Five (45) Days after successful Factory Acceptance Tests (FAT) and Certificate by Employer's Representative and Receipt of Interim Payment Certificate and Shipping Document.
- Thirty Percent (30%) of the Total or Pro Rate CIP Amount (Quoted Amount) upon Incoterm "CIP (including all Costs of Logistics to site etc.)" after Delivery to Site (Attabad Lake HPP, District Hunza) within Forty-Five (45) days after receipt of Interim Payment Certificate mentioned.



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- Two and a half Percent (2.5%) of the Total or Pro Rate CIP Amount (Quoted Amount), upon Issuance of the Taking Over Certificate, within Forty-Five (45) days after receipt of Interim Payment Certificate mentioned.
- Two and a half Percent (2.5%) of the Total or Pro Rate CIP Amount (Quoted Amount), upon Issuance of the Performance Certificate, within Forty-Five (45) days after receipt of Interim Payment Certificate mentioned.

Schedule No. 02: Supply of Plant from within the Employer's Country (Pre-Engineered Structures) including Fixtures and other Materials, Goods and Spare Parts (if any) (Schedule of Price Basis)

In respect of Plant and Equipment supplied from within the Employer's country, the following Payments shall be made:

- Sixty Five Percent (65%) of the Total or Pro Rate Quoted Amount upon Incoterm "EXW", after successful Factory Acceptance Tests (FAT) and Certificate by Employer's Representative, within Forty-Five (45) days after receipt of Interim Payment Certificate mentioned.
- Thirty Percent (30%) of the Total or Pro Rate Quoted Amount upon after Delivery to Site (Attabad Lake HPP, District Hunza) within Forty-Five (45) days after receipt of Interim Payment Certificate mentioned.
- Two and a half Percent (2.5%) of the Total or Pro Rate Quoted Amount, upon Issuance of the Taking Over Certificate, within Forty-Five (45) days after receipt of Interim Payment Certificate mentioned.
- Two and a half Percent (2.5%) of the Total or Pro Rate Quoted Amount, upon Issuance of the Performance Certificate, within Forty-Five (45) days after receipt of Interim Payment Certificate mentioned.

Price Schedule No. 03: Design Services

The following payments shall be made:

- Twenty Five Percent (25%) of the Measured Value of Work performed by the Contractor, as identified in the said Program Level-I Design and other approved submittals, during the preceding month, as evidenced by the Employer's Authorization of the Contractor's Application, will be made Monthly within Forty-Five (45) days after receipt of Interim Payment Certificate mentioned.
- Seventy Percent (70%) of the Measured Value of Work performed by the Contractor, as identified in the said Program Level-II Design and other approved submittals, during the preceding month, as evidenced by the Employer's Authorization of the Contractor's Application, will be made Monthly within Forty-Five (45) days after receipt of Interim Payment Certificate mentioned.
- Two and a half Percent (2.5%) of the Total or Pro Rata Value of Design Services performed by the Contractor as evidenced by the Employer's Authorization of the Contractor's Monthly Applications, upon Issue of the Taking Over Certificate, within Forty-Five (45) days after receipt of Interim Payment Certificate mentioned.
- Two and a half Percent (2.5%) of the Total or Pro Rata value of Design Services performed by the Contractor as evidenced by the Employer's Authorization of the Contractor's Monthly Applications, upon Issue of the Performance Certificate, within Forty-Five (45) days after receipt of Interim Payment Certificate mentioned.



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Price Schedule No. 04: Installation and All Other Services

The following payments shall be made:

- Ninety Five Percent (95%) of the Measured or Pro Rata Value of Work performed by the Contractor, as identified in the Said Program of Performance, during the Preceding Month, as evidenced by the Employer's Authorization of the Contractor's Application, will be made Monthly within Forty-Five (45) days after receipt of Interim Payment Certificate mentioned.
- Two and a half Percent (2.5%) of the Total or Pro Rata Value of Installation Services Performed by the Contractor as evidenced by the Employer's Authorization of the Contractor's Monthly Applications, upon Issue of the Taking Over Certificate, within Forty-Five (45) days after receipt of Interim Payment Certificate mentioned.
- Two and a half Percent (2.5%) of the Total or Pro Rata Value of Installation Services performed by the Contractor as evidenced by the Employer's Authorization of the Contractor's Monthly Applications, upon Issue of the Performance Certificate, within Forty-Five (45) days after receipt of Interim Payment Certificate mentioned.

| **Volume I, Section VIII - Particular Conditions, Part A - Contract Data** | | | | |
|---|---|---|---|---|
| **Sr. No.** | **Data required** | **Sub-Clause** | **Provision of RFP/EPC Bidding Document** | **Amendment** |
| 41 | Proportions or amounts of Local and Foreign Currencies are:<br>Local:<br>Foreign: | 14.15(a)(i) | Table B - Summary of Payment Currencies. | Table C - Summary of Payment Currencies. |

| **Volume I, Section VIII - Particular Conditions, Part A - Contract Data** | | | | |
|---|---|---|---|---|
| **Sr. No.** | **Data required** | **Sub-Clause** | **Provision of RFP/EPC Bidding Document** | **Amendment** |
| 42 | Currencies and Proportions for Payment of Delay Damages | 14.15(c) | Currency: PKR<br>Proportions: Table B - Summary of Payment Currencies | Currency: PKR<br>Proportions: Table C - Summary of Payment Currencies |

| **Volume II, Part-I, Specific Provisions** |
|---|
| Sub-Clause 1.1.1, Sub-Clause 1.2.1.6 |



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| |
|---|
| All referred Sub Clauses pertaining to the **Remote End Line Bays** as discussed in the RFP / EPC Bidding Document shall stand deleted in their entirety.<br><br>In addition to the above, any other reference, requirement, Provision, Drawing, Specification, Schedule, Testing and Commissioning requirement, or scope related to the Remote End Line Bays mentioned anywhere else in the RFP / EPC Bidding Document shall be deemed deleted in their entirety and shall no longer form part of the scope under this Package. |
| **Volume II, Part-I, Specific Provisions** |
| Wherever the words “WAPDA” and/or “NGC” mentioned in the aforesaid document, the same shall be read and construed as “Employer” and/or “Employer’s Representative”, respectively. |

| **Volume II, Part-I, Specific Provisions Sub-Clauses 1.14.4, 1.16.2.1.1 and 1.16.2.3.10** |
|---|
| The above Sub-Clauses has been modified in the RFP / EPC Bidding Document. |

| **Volume II, Part-I, Specific Provisions, Section 1, Scope of Work, Sub-Clause 1.2.1.5 132kV AIS Switchyard** | |
|---|---|
| **Original (Data)** | **Amendment (Data)** |
| a. 132 kV AIS Switchyard shall consist of Three (03) Transformer Bays (Generator Step Up Transformers), One (01) Power Transformer Bay and Two (02) 132 kV Transmission Line Bays. The 132 kV Transmission Line Bays shall be arranged in a One-and-a-Half Circuit Breaker Scheme.<br><br>b. One (01) 132/33 kV Power Transformer with a Rating of 10/13 MVA.<br><br>c. One (01) 33/11 kV Power Transformer with a Rating of 6.3 MVA.<br><br>d. One (01) Emergency Diesel Generator Set with a Rating of 200 kVA.<br><br>e. One (01) set of 110V DC System and UPS system complete with Batteries and Chargers.<br><br>f. 33 kV Switchgear<br><br>g. MV/LV Switchgear.<br><br>h. Protection System. | a. 132 kV AIS Switchyard shall consist of Three (03) Transformer Bays (Generator Step Up Transformers), One (01) Power Transformer Bay and Three (03) 132 kV Transmission Line Bays. The 132 kV Transmission Line Bays shall be arranged in a One-and-a-Half Circuit Breaker Scheme.<br><br>b. One (01) 132/11.5 kV Power Transformer with a Rating of 10/13 MVA.<br><br>c. One (01) Emergency Diesel Generator Set with a Rating of 200 kVA.<br><br>d. One (01) set of 110V DC System and UPS system complete with Batteries and Chargers.<br><br>e. MV/LV Switchgear.<br><br>f. Protection System.<br><br>g. Substation Automation System (SAS) |



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| | |
|---|---|
| i. Substation Automation System (SAS)<br>j. SCADA and Telecommunication System.<br>k. Equipment Protective Earthing connections, complete in all respect.<br>l. The specifications mentioned in the Employer's Requirements in respect of goods and materials to be provided and considered in the Works shall be new, unused, of the most recent or current models and shall incorporate all recent improvements in design and materials. | h. SCADA and Telecommunication System.<br>i. Equipment Protective Earthing connections, complete in all respect.<br>j. The specifications mentioned in the Employer's Requirements in respect of goods and materials to be provided and considered in the Works shall be new, unused, of the most recent or current models and shall incorporate all recent improvements in design and materials. |

| **Volume II, Part-I, Specific Provisions, Section 1, Scope of Work, Sub-Clause 1.16.2.3.10 132 kV Switchyard and 132 kV Line End Bays at Remote End** | |
|---|---|
| **Original (Data)** | **Amendment (Data)** |
| The 132 kV Switchyard shall be constructed nearby the plant which consist of three Transformer Bays, one Power Transformer Bay and two 132 kV Transmission Line Bays. The 132 kV Transmission Line Bays shall be arranged in breaker & half scheme. The Attabad Lake HPP will be interconnected to the proposed 132/66 kV Regional Grid Station at Aliabad and existing 11/33 kV Existing Grid Station at Sost. Two (2) 132 kV Remote End Line Bays shall be constructed at 132/66 kV Regional Grid Station, Aliabad.<br><br>The interconnection with 132 kV switchyard and Power Plant shall be through 11kV Segregated Phase Bus. AC Auxiliary supply be fed from Power Plant through One (01) No. feeder and another feeder from 132 kV Switchyard Power Transformer (6.3 MVA). A complete DC system shall be installed in 132 kV Switchyard Control House Building. | The 132 kV Switchyard shall be constructed nearby the Power Plant which consist of three (03) Transformer Bays (Generator Step Up Transformers), one (01) Power Transformer Bay and three (03) 132 kV Transmission Line Bays. The 132 kV Transmission Line Bays shall be arranged in one and a half breaker scheme. The Attabad Lake HPP shall be interconnected to the proposed 132/66 kV Regional Grid Station at Aliabad and 132/11 kV Grid Station at Sost. The scope of Remote end bays including 132kV transmission lines shall be covered in separate package.<br><br>The interconnection with 132 kV Switchyard and Power Plant shall be through 11kV Segregated Phase Bus (SPB). AC Auxiliary supply shall be fed from Power Plant through One (01) feeder and another feeder from 132 kV Switchyard Power Transformer (10/13 MVA). A complete DC system shall be installed in 132 kV Switchyard Control House Building. |



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| **Volume II, Part-II, Technical Provisions** |
|---|
| Sub-Clause 6.3.3, Annexure-I: Technical Schedules (E&M Works) Point-6, 132 kV Switchyard and Remote End Line Bays. |
| The scope mentioned in the referred Sub-Clause pertaining to the **Remote End Line Bays** in the RFP / EPC Bidding Document shall stand deleted in their entirety.<br><br>In addition to the above, any other reference, requirement, provision, drawing, specification, schedule, testing and commissioning requirement, or scope related to the Remote End Line Bays mentioned anywhere else in the RFP / EPC Bidding Document shall also be deemed deleted and shall no longer form part of the scope under this Package. |

| **Volume II, Part-II, Technical Provisions, Section 2: Hydraulic Steel Structures** |
|---|
| The table provided in **Annexure E** shall be substituted under the referred section above as Sub-Clause 2.5 “Painting Schedule HSS Works” as Table 2-3 “Paint Schedule”. |

| **Volume II, Part-II, Technical Provisions, Section 3 Electrical Plant Equipment, Sub-Clause 3.5 Medium Voltage Switchgear, Sub-Clause 3.5.1 “Scope”** | |
|---|---|
| **Original (Data)** | **Amendment (Data)** |
| The Generator Circuit Breakers shall be of vacuum type as insulating and interrupting medium and complying with IEC 62271-100 standard and IEC 62271-200 standard. The Generator Circuit Breakers shall be suitable for synchronizing duties and provided with interlocks to avoid incorrect operation of the disconnector or the earth switches. | The 11 kV Switchgear shall be SF6 Gas type for generating units. All other except generating units shall be vacuum type as insulating and interrupting medium and complying with IEC 62271-100 standard and IEC 62271-200 Standard. The Generator Circuit Breakers shall be suitable for synchronizing duties and provided with interlocks to avoid incorrect operation of the Disconnector or the Earth Switches. |

| **Volume II, Part-II, Technical Provisions, Section 6: 132 kV Switchyard and 132 KV Remote End Line Bays, Sub-Clause 6.1 “Scope of Work”** |
|---|
| The title of the above referred Section 6 shall be substituted with **“132 kV Switchyard”,** and the contents under Sub-Clause 6.1 “Scope of Work” shall stand replaced in their entirety with the text provided in **Annexure F**. |



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| **Volume II, Part-II, Technical Provisions, Section 6: 132 kV Switchyard and 132 KV Remote End Line Bays, Sub-Clause 6.7.2 "Ratings"** |
|---|
| The value of "Minimum Creepage Distance, mm" under Sub-Clause 6.7.2 'Ratings' contained a typographical error and shall be corrected as 4495 mm. |

| **Volume II, Part-II, Technical Provisions, Sub-Clause 6.18 "Power Transformer (10/13 MVA, 132/33 KV)"** |
|---|
| The title of the above referred Sub-Clause 6.18 has been changed to **"Power Transformer (10/13 MVA, 132/11.5 kV)"**. Also, the contents under Sub-Clause 6.18 " Power Transformer" shall be substituted. |

| **Volume II, Part-II, Technical Provisions, Sub-Clause 6.19 - "Power Transformer (6.3 MVA, 33/11 KV)"** |
|---|
| The above referred Sub-Clause 6.19 shall stand deleted in its entirety. |

| **Volume II, Part-II, Technical Provisions, Sub-Clause 6.20 - "35 KV Metal-Clad Switchgear"** |
|---|
| The above referred Sub-Clause 6.20 shall stand deleted in its entirety. |
| **Volume II, Part-II, Technical Provisions, Sub-Clause 6.22.3 "Mandatory Spare Parts for Remote End Line Bays (Aliabad)"** |
| The above referred Sub-Clause 6.22.3 shall stand deleted in its entirety. |

| **Volume II, Part-II, Technical Provisions, Sub-Clause 6.3 "Switchyard and Remote End Line Bays Design" & Sub-Clause 6.3.1 "General"** |
|---|
| The title of the above referred Sub-Clause 6.3 shall be substituted with **"132 kV Switchyard Design",** and the contents under Sub-Clause 6.3.1 "General" shall stand replaced in its entirety with the text provided below:<br><br>These Specifications cover the requirements for Design, Supply, Installation, Testing and Commissioning of Plant and Equipment for 132 kV Switchyard Attabad Lake HPP. The design of Civil Engineering Facilities associated with this Contract (Cable Trenches, Equipment Foundations, Earthwork, Control House Building, Guard Rooms, Metering Room, Boundary Walls, Drainage etc.) shall be the responsibility of Civil EPC Contractor and included in separate Package-I. The Single Line Diagram (SLD) and Equipment Arrangement Plans indicate the Details of Facilities to be carried out. |



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| |
|---|
| The EPC Contractor shall prepare detailed design drawings on the basis of information provided in the Employer's Requirements listed herein. |

| **Volume II, Part-II, Technical Provisions, Sub-Clause 6.3.3 "Electrical Design Parameters"** |
|---|
| In the paragraph of the above-referred Sub-Clause 6.3.3, the words "Remote End Line Bays" shall stand deleted in its entirety. |

| **Volume II, Part-II, Technical Provisions, Sub-Clause 6.12.1 General, Serial No. 15** | |
|---|---|
| **Original (Data)** | **Amendment (Data)** |
| 15. The numerical devices offered under this contract shall be of latest version, of proven design, having minimum of Five (05) years' operating experience in a well reputed power utility power systems of voltage level 132kV and above. | 15. The numerical devices offered under this contract shall be of latest version, of proven design, having minimum of Five (05) years' operating experience in a well reputed power utility power systems of voltage level 132kV and above.<br><br>However, the latest version of the same shall be offered/quoted along with valid type test reports for the relays, in accordance with the applicable IEC standards and the DISCO's type test policy. The relays shall be compatible with and meet the requirements for integration with the National Power Control Center. |

| **Volume II, Part-II, Technical Provisions, Section 6: 132 kV Switchyard, Sub-Clause 6.14.4 Equipment Requirements at 132 kV Attabad Lake HPP Substation** |
|---|
| The Sub-clause 6.14.4.1.2 & Sub-clause 6.14.4.2.2 shall be included under the above referred Sub-Clause 6.14.4 with the text provided in **Annexure G**. |

| **Volume II, Part-II, Technical Provisions, Sub-Clause 6.14 Telecommunication and Scada System** |
|---|
| The Sub-clause 6.14.5 & Sub-clause 6.14.6 shall stand deleted in their entirety under the above referred Sub-Clause6.14. |



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| **Volume II, Part-II, Technical Provisions, Annexure-I: Technical Schedules (E&M Works), Section 6. 132 kV Switchyard and 132 kV Remote End Line Bays** |
|---|
| The title of the above referred Section 6 shall be substituted with **"132 kV Switchyard"**. |

| **Volume II, Part-II, Technical Provisions, Annexure-I: Technical Schedules (E&M Works), Section 3. Electrical Plant Equipment, Sub-Clause 3.5 Switchyard Power Transformer (10/13 MVA, 132/11.5 kV)** |
|---|
| The title of the above referred Sub-clause shall be substituted with **"Switchyard Power Transformer (10/13 MVA, 132/11.5 kV)"**. |

| **Volume II, Part-II, Technical Provisions, Sub-Clause 3.1.14, Fire Protection System** | |
|---|---|
| **Original (Data)** | **Amendment (Data)** |
| Generators shall be provided with a fire extinguishing system of inert gas and water spray type. | Generators shall be provided with a fire extinguishing system comprising $CO_2$ inert gas and water spray type. |

| **Volume II, Part-II, Technical Provisions, Section 1: Hydro-Mechanical Equipment, Sub-Clause 1.5.1, Cooling Water System** |
|---|
| The above-referred Sub-Clause 1.5.1 "Cooling water system" shall be substituted with the text provided in the Annexure-H. |

| **Volume II, Part-II, Technical Provisions, Sub-Clause 3.5.14.11-Table 3-9 Spare Parts and Tools** |
|---|
| The Table 3-9 provided under the above referred Sub-Clause 3.5.14.11 "Spare Parts and Tools" shall be substituted with Table provided in Annexure-I. |

| **Volume II, Part III, Conceptual Drawings** |
|---|
| Drawing No. ALHPP-PPE-0501 |
| Drawing No. ALHPP-PPE-0502 |
| Drawing No. ALHPP-SY-0601 |
| Drawing No. ALHPP-SY-0602 |
| Drawing No. ALHPP-SY-0603 |



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| |
|---|
| Drawing No. ALHPP-SY-0605<br>Drawing No. ALHPP-SY-0606<br>Drawing No. ALHPP-SY-0607<br>Drawing No. ALHPP-TC-0702<br>Drawing No. ALHPP-TC-0704<br>The above-mentioned Conceptual Drawings shall be substituted after deleting in their entirety of 132 kV Remote End Line Bays Conceptual Drawings in accordance with the Original Scope and shall be attached as **Annexure J**. |
| **Drawing No. ALHPP-SY-0608** shall stand deleted in its entirety. |

Other terms and conditions of the RFP/EPC Bidding Document shall remain unchanged.

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**ANNEXURE A**

## Table of Adjustment Data

### Table B: Foreign Currency

| Index code | Index description | Source of index* | Base value and Date* | Proposer's related source currency in Type / Amount | Equivalent in FC1 | Proposer's Proposed Weighting |
|---|---|---|---|---|---|---|
| a | **Non-Adjustable (50%)** | — | — | — | | a : 0.5* |
| | **Labor:** | | | | | |
| b | Expatriates | | | | | b: 0.03-0.05* |
| c | Local | | | | | c: 0.12-0.15* |
| d | **Material :** | | | | | d: 0.25-0.3 |
| d-1 | *Material (1)* | | | | | d-1: * |
| d-2 | *Material (2)* | | | | | d-2: * |
| e | **Machinery & Equipment** | | | | | e: 0.05-0.07* |
| | | | | **Total** | | **1.00** |

* To be specified by the Proposers. Whereas "a" is a fixed percentage, while the Proposer should specify range within maximum percentage allowed for material and labour for b, c, d, e, f, g & h such that the total weighting = 1.00.



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**ANNEXURE B**

## Table C: Summary of Payment Currencies

**Table: Alternative A**

Foreign currency requirement shall be in the portion of Proposal Price (excluding Provisional Sum) for such that Foreign Currency requirement shall not be more than 80%.

For _____ [*insert name of Section of the Works]*

| **Name of payment currency** | **A**<br>**Amount of currency** | **B**<br>**Rate of exchange**<br>**(local currency per unit of foreign)** | **C**<br>**Local currency equivalent**<br>**C = A x B** | **D**<br>**Percentage of Proposal Price (PP)**<br>**100xC**<br>**PP** |
|---|---|---|---|---|
| Local currency | | 1.00 | | 20% or greater |
| Foreign currency | | * | | 80% or less |
| Proposal Price (excluding provisional sums) | | | | 100.00 |

**Note:**

*The Conversion for Proposal evaluation shall be made on TT&OD composite selling exchange rate published / authorized by State Bank of Pakistan (SBP) for the day of deadline for submission of Proposals.



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**ANNEXURE C**

## Schedule of Payment for E&M Works

### Price Schedule No. 01: Supply of Plant from Abroad (Pre-Engineered Structures) including Fixtures and other Materials, Goods and Spare Parts (if any) (Schedule of Price basis)

*[**Note:** To be completed / updated by the Proposer.]*

| Activity No. | Description of Activity | Unit Price (US$) | Qty | Total CIP (US$) Excluding Sales Tax | Custom Duty (PKR) |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5=3x4 | 6 |
| .1 | Vertical Francis Turbines | | | | |
| 2 | Governors | | | | |
| 3 | Main Inlet Valves | | | | |
| 4 | Powerhouse Overhead Cranes | | | | |
| 5 | Gantry and Mobiles Cranes | | | | |
| 6 | Mechanical Auxiliaries | | | | |
| 7 | Mechanical Workshop Equipment | | | | |
| 8 | Generators & Auxiliaries | | | | |
| 9 | Excitation System | | | | |
| 10 | Generator Step up Transformers | | | | |
| 11 | Power Transformer | | | | |
| 12 | Auxiliary Transformers | | | | |
| 13 | Segregated Phase Bus | | | | |
| 14 | Power and Control Cables | | | | |
| 15 | Medium Voltage Switchgear | | | | |
| 16 | Low Voltage Switchgear | | | | |
| 17 | 132 kV Switchyard / Equipment | | | | |
| 18 | SCADA System | | | | |
| 19 | DC and UPS system | | | | |
| 20 | Emergency Diesel Generators | | | | |
| 21 | Plant Control and Instrumentation System | | | | |
| 22 | Telecommunication System | | | | |
| 23 | Protection System | | | | |
| 24 | Grounding System | | | | |
| 25 | Mandatory Spare Parts | | | | |



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| Activity No. | Description of Activity | Unit Price (US$) | Qty | Total CIP (US$) Excluding Sales Tax | Custom Duty (PKR) |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5=3x4 | 6 |
| **Total Price of Activities carried forward to Schedule No. 5 Summary (excluding Custom Duty), Page ____** | | | | | |
| **Total Custom duties** | | | | | |

Name of Proposer _____

Signature of Proposer _____

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## Schedule of Payment for E&M Works

**Price Schedule No. 02: Supply of Plant from within the Employer's Country (Pre-Engineered Structures) including Fixtures and other Materials, Goods and Spare Parts (if any) (Schedule of Price basis)**

*[**Note:** To be completed / updated by the Proposer.]*

| Activity No. | Description of Activity | Unit Price (PKR) | Qty | Total PKR |
|---|---|---|---|---|
| **1** | **2** | **3** | **4** | **5=3x4** |
| 1 | Vertical Francis Turbines | | | |
| 2 | Governors | | | |
| 3 | Main Inlet Valves | | | |
| 4 | Powerhouse Overhead Cranes | | | |
| 5 | Gantry and Mobiles Cranes | | | |
| 6 | Mechanical Auxiliaries | | | |
| 7 | Mechanical Workshop Equipment | | | |
| 8 | Generators & Auxiliaries | | | |
| 9 | Excitation System | | | |
| 10 | Generator Step up Transformers | | | |
| 11 | Power Transformer | | | |
| 12 | Auxiliary Transformers | | | |
| 13 | Segregated Phase Bus | | | |
| 14 | Power and Control Cables | | | |
| 15 | Medium Voltage Switchgear | | | |
| 16 | Low Voltage Switchgear | | | |
| 17 | 132 kV Switchyard/Equipment | | | |
| 18 | SCADA System | | | |
| 19 | DC and UPS system | | | |
| 20 | Emergency Diesel Generators | | | |
| 21 | Plant Control and Instrumentation System | | | |
| 22 | Telecommunication System | | | |
| 23 | Protection System | | | |
| 24 | Grounding System | | | |
| 25 | Mandatory Spare Parts | | | |
| **Total Price of Activities carried forward to Schedule No. 5 Summary, Page ____** | | | | |

**Note 1:** The scope mentioned above shall be read in conjunction with the applicable Employer's Requirements, missing items can be added in the schedules 1 & 2 as per employer's requirements.



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**Note 2:** Weightages in %age to Contract Price excluding Provisional Sums for all Activities put together shall be 100%.

**Note 3:** The Proposer shall quote/ include the price of FAT (Factory Acceptance Tests) in the above Price Schedules 1 & 2.

Name of Proposer _____

Signature of Proposer _____

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## Schedule of Payment for E&M Works

### Price Schedule No. 04: Installation and All other Services

*[**Note:** To be completed / updated by the Proposer.]*

| Activity No. | Description of Activity | Unit Price (PKR) | Qty | Total PKR |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5=3x4 |
| 1 | Vertical Francis Turbines | | | |
| 2 | Governors | | | |
| 3 | Main Inlet Valves | | | |
| 4 | Powerhouse Overhead Cranes | | | |
| 5 | Gantry and Mobiles Cranes | | | |
| 6 | Mechanical Auxiliaries | | | |
| 7 | Mechanical Workshop Equipment | | | |
| 8 | Generators & Auxiliaries | | | |
| 9 | Excitation System | | | |
| 10 | Generator Step up Transformers | | | |
| 11 | Power Transformer | | | |
| 12 | Auxiliary Transformers | | | |
| 13 | Segregated Phase Bus | | | |
| 14 | Power and Control Cables | | | |
| 15 | Medium Voltage Switchgear | | | |
| 16 | Low Voltage Switchgear | | | |
| 17 | 132 kV Switchyard/Equipment | | | |
| 18 | | | | |
| 19 | SCADA System | | | |
| 20 | DC and UPS system | | | |
| 21 | Emergency Diesel Generators | | | |
| 22 | Plant Control and Instrumentation System | | | |
| 23 | Telecommunication System | | | |
| 24 | Protection System | | | |



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| Activity No. | Description of Activity | Unit Price (PKR) | Qty | Total PKR |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5=3x4 |
| 25 | Grounding System | | | |
| 26 | Testing and Commissioning | | | |
| 27 | Employer's Staff Trainings | | | |
| 28 | Operation and Maintenance for DNP | | | |
| **Total Price of Activities carried forward to Schedule No. 05 Summary, Page ____** | | | | |

Name of Proposer _____

Signature of Proposer _____



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**ANNEXURE D**

**Sub-Clause 10.1**

**Taking Over the Works and Sections**

The following text has been included as Sub Paragraph (iii)

The Works shall be divided into Five (05) Sections. One Unit consist complete turbine Generator Unit (s) including all associated Systems.

In order to render the Unit (s) fit for its purpose and capable to generate Electrical Output that can be dispatched through the Interconnection and Transmission Facilities to the Regional Grid/Load Centers.

| Section No. | E&M Works | Time for Completion |
|---|---|---|
| 1 | Execution of Successful Completion of First Unit and all Auxiliaries necessary, 132 kV Switchyard, fit for intended / Commercial Purpose. The Tests on Completion have also been satisfactorily completed | 37 Months from the Date of Commencement |
| 2 | Execution of Successful Completion of Second Unit and all Auxiliaries necessary, 132 kV Switchyard, fit for Intended/ Commercial Purpose. The Tests on Completion have also been Satisfactorily Completed. | 39 Months from the Date of Commencement |



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| | | | |
|---|---|---|---|
| | 3 | Execution of Successful Completion of the Third Unit and all Auxiliaries necessary, 132 kV Switchyard, fit for Intended/ Commercial Purpose. The Tests on Completion have also been Satisfactorily Completed. | 41 Months from the Date of Commencement |
| | 4 | Power Intake and Sediment Flushing Intake Hydraulic Gates, Trash Racks, Stoplogs and their Associated Equipment, HSS and Gantry Crane | 36 Months from the Date of Commencement |
| | 5 | Execution of successful Completion of remaining Balance Of Plant Mechanical Works including Bridge Cranes, Workshops, Fire Detection and Fire Fighting system (For Generators), Drainage and Dewatering system, Oil Filtration system, Compressed Air system, Complete 132 kV Switchyard and Balance of Plant for Electrical Works, SCADA System, | 42 Months from the Date of Commencement |



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| | | | |
|---|---|---|---|
| | | Telecommunication System, DG Set and other Whole of the Works mentioned in Employer's Requirement. The Tests on Completion have also been Satisfactorily Completed on these Systems. | |

**Note:**

All the Prerequisites / Activities outlined in each Section for Powerhouse Electro-Mechanical Works shall be completed prior to the Issuance of the TOC (Taking Over Certificate) in accordance with the provisions of Sub-Clause 10.1 of GCC.



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## 2.5 Painting Schedule for HSS Works

**Table 2-3 Paint Schedule**

| Type | Item / Part | Surface Preparation | Paint System | Dry Film Thickness µm |
|---|---|---|---|---|
| A | Steel Structures which are constantly in contact with water and not exposed to UV-rays; e.g., Gates incl. Armatures, Interior Surfaces of Steel Lining, Valves and Trash Racks | Sa 2.5 | **Prime Coat:**<br>1x Zinc-Rich Epoxy Primer<br>**Intermediate and Finish Coat:**<br>3x High Build-Epoxy Paint | min. 60, max. 120 **µm**<br>3 x 150 = 450 **µm**<br>**Total Min. 510 µm** |
| B | Exterior Surfaces of Equipment exposed to UV-rays including:<br>Gates, Stoplogs, Hoisting Equipment, Valves, Cranes, Piping, Electric Motors and all other Steel Structures | Sa 2.5 | **Prime Coat:**<br>1x Zinc-Rich Epoxy Primer<br>**Intermediate Coat:**<br>2x Epoxy Micaceous Iron Oxide Paint<br>**Finish Coat:**<br>1x Epoxy Micaceous Iron Oxide Paint of different color | min. 60, max. 120 **µm**<br>2 x 80 = 160 **µm**<br>80 **µm**<br>**Total Min. 300 µm** |
| C | Indoor Steel Structures like Exterior Surfaces of Valves and Piping, Cranes and Electric Motors etc. | Sa 2.5 | **Prime Coat:**<br>1x Zinc-Rich Epoxy Primer<br>**Intermediate Coat:**<br>1x Epoxy Micaceous Iron Oxide Paint<br>**Finish Coat:**<br>1x 2-Pack Polyurethane or Epoxy Paint | Min. 60 **µm**, Max. 120 **µm**<br>80 **µm**<br>80 **µm**<br>**Total Min. 220 µm** |
| D | Control Boards, Panels, Cubicles | Sa 3 | **Prime Coat:** | |



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| Type | Item / Part | Surface Preparation | Paint System | Dry Film Thickness µm |
|---|---|---|---|---|
| | | | 2x Epoxy Zinc-Phosphate Primer<br>**Finish Coat:**<br>2x Epoxy Paint | 2 x 40 = 80 **µm**<br>2 x 60 = 120<br>**Total Min. 200 µm** |
| E | Surfaces of Steel Structures to be Embedded in Concrete | Degreasing | **Primer Coat:**<br>1x Zinc-Rich Epoxy Primer | Min. 60 **µm** |

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**ANNEXURE F**

## SECTION 6 132 kV SWITCHYARD

### 6.1 SCOPE OF WORK

The Design, Supply, Installation, Testing and Commissioning of Plant & Equipment for 132 kV switchyard at Attabad Lake HPP which consist of Three (03) Transformer Bays ( Generator Step Up Transformers), One (01) Power Transformer Bay and Three (03) 132 kV Transmission Line Bays. The 132 Kv Transmission Line bays shall be arranged in One-and-a-Half Circuit Breaker Scheme . The Attabad Lake Hydropower Project (54 MW) shall be interconnected to the proposed 132/66 kV Regional Grid Station at Aliabad and 132/11 kV Grid Station at Sost. One Double Circuit 132 kV Transmission Line about 14.5 km long from 132 kV Switchyard of Attabad Lake HPP to proposed 132/66 kV Regional Grid Station Aliabad and one 132 kV Single Circuit Transmission Line about 70 km long from 132 kV Switchyard of Attabad Lake HPP to 132/11 kV Grid Station at Sost have been proposed for dispersal of energy generated at Attabad Lake HPP. The synchronization with the Gilgit Regional Grid system is proposed to be carried out in the Attabad Lake HPP Powerhouse Control Room. The scope of Remote end bays including 132kV transmission lines shall be covered in separate package.

The interconnection with 132 kV Switchyard and Power Plant of Attabad Lake HPP shall be through 11 kV Segregated Phase Bus in underground trench. The AC auxiliary supply shall be fed from Power Plant through One (01) feeder and the other feeder shall be taken from 132 kV Switchyard. The complete DC Supply System shall be installed in 132 kV Switchyard Control House Building.

The scope of Facilities includes Design, Manufacture, Supply, Insurance to Site, Delivery to wharf at Sea Port in Pakistan, unloading and loading at Sea Port, Transportation to the 132 kV Switchyard site, Unloading and Storage at Site, Installation, Testing and Commissioning of Plant & Equipment for 132 kV Switchyard as specified in the Employer's Requirements.

All Materials, Tools, Equipment and Services, necessary for the reliable and safe operation of the 132 kV Switchyard, whether specified in the Document or not, shall be included in the Proposal except items specifically excluded from the scope of Facilities as listed in this Section.

The Type Tests Reports for all the specified Equipment including Circuit Breakers, Disconnectors & Earthing Switches, Current Transformers, CCVTs, Surge Arresters, Protection System, Line Traps, Line Matching Units, Power Line Carrier and Protection Signaling Equipment from any of the specified Independent Authority/Independent Laboratory pursuant to Employer's Requirement shall be provided for all the specified Type Tests specific to the offered Equipment. In case the Type Test Reports are not available, these tests shall be carried out in accordance with the relevant Employer's Requirement in the presence of the Employer and Employer's Representative at no additional cost to the Employer, at the time of routine tests at the Manufacturer's Workshop. If facilities for type tests are not available at manufacturer's premises, these tests shall be got carried out from one of the Independent Laboratories specified in the Employer's Requirement.

The Facilities shall also include provision of Spare Parts, Erection and Testing Equipment and Maintenance Tools, and Training of the Employer's Staff in accordance with the requirements listed in the Employer's Requirement.



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The Facilities have been provided in Specifications, Drawings and indicated in the Single Line Diagram, 132 kV Switchyard Layout and other relevant Drawings, shall also help in understanding the scope of work for 132 kV Switchyard.

a) The 132 kV Switchyard Equipment to be provided, Installed, Tested and Commissioned at the 132 kV Switchyard includes but is not limited to the following:

1. Circuit Breakers.
2. Disconnectors.
3. Disconnectors with Earthing Switches.
4. Current Transformers.
5. Capacitor Voltage Transformers.
6. Surge Arresters.
7. Line Traps/Fiber.
8. High voltage Bus Work.
9. Steel Structures.
10. Switchyard Grounding System (Only Equipment Protective Earthing Connection).
11. Paging System.
12. Secure Metering System.
13. Relay Boards and Protective Relaying Systems.
14. Control and Small Power Cables.
15. AC Auxiliary Supply Board and DC Supply System.
16. Telecommunication and SCADA Systems.
17. Testing and Maintenance Equipment.
18. CCTV System and PAS System as per specifications mentioned in the Section 5 of this Document.
19. All other Auxiliary items for the completion of work including testing Devices, Equipment and Spare Parts as listed in the Specifications.
20. Cable Trays, Ladders, Conduits and Accessories inside the 132 kV Switchyard and Control House Building/Generator Room.
21. Any other item which is not included here but is necessary for integrated operation of the Plant as advised by the Employer

The Civil Works required for all the above-mentioned facilities shall not be a part of E&M EPC Contractor's Scope. The Civil Works Scope for above mentioned facilities shall be provided by Civil EPC Contractor (Package-I)

The Technical Provisions of various Equipment have been given in the relevant sections.



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### 16.14.4.1.2 Attabad Lake HPP Substation - 132 kV Sost Substation

a. Redundant (Two Units) Digital Power Line Carrier (DPLC) terminal (≥ 40W) and Digital Protection Signaling Equipment (DPSE) installed in Swing Rack cabinet at 132 kV Attabad Lake HPP Substation.

b. One Set (Each Set comprising Two Units) of Line Traps for Phase-Phase Coupling.

c. One set (Each Set comprising Two Units) of LMUs for Phase-Phase Coupling with Coupling Filters, hybrid Transformer, Protection Circuits, Interface for through connection of existing PLC Channels and all Materials required for a Complete Installation.

d. One Length of Coaxial Cable to connect LMU with associated DPLC terminals and between both LMUs.

e. Teleprotection interconnection cables between DPSE and the relay panels and terminated at both ends.

f. All other ancillary material comprising Cables, Connectors, MDF Modules, Iumpers, Harnesses, Mounting Frames, Fuses, Relays, nuts, Bolts etc. required for complete installation and fully functional DPLC and PSE links.

### 16.14.4.2.2 Attabad Lake HPP Substation - 132kV Sost Substation

a) OLTE Equipment in (1+1) configuration with Equipment Rack and installed in a Swing Rack Cabinet.

b) The Digital Access Multiplexer ((DAM) & CC/Add-Drop Multiplexer ADM) equipped with specified user interfaces and installed in OLTE cabinet.

c) DPSE for Transmission over OLTE and installed in OLTE/separate swing rack cabinet for tele-protection.

d) One length approach Fiber Optic Cable (FOC) with 24 fibers.

e) Optical Distribution Frame (ODF) for termination of 48 fibers.

f) Teleprotection interconnection cables between DPSE and the relay panels and terminated at each end.

g) Amplifies/Repeater (if required)

h) All other ancillary material comprising Cables, Connectors, MDF Modules, Jumpers, Harnesses, Mounting Frames, Fuses, Relays, Nuts, Bolts etc. required for complete installation and fully functional fiber optic link.



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### 1.5.1 Cooling Water System

#### 1.5.1.1 General

This specifies the requirements for the design, engineering, manufacture, works testing, packing, transport, storage at site, install, test and commission, acceptance testing, warranty and other services specified or required in these specifications for the supply of cooling water system for the turbine and generator units.

#### 1.5.1.2 Description

The cooling water system shall be provided for the following components:

- Generator ir coolers.
- Oil coolers of turbine and generator bearings.
- Turbine shaft seal (if applicable).
- Governor oil cooler (if applicable).

The close loop cooling system shall be provided for each unit of the power plant; however, the EPC Contractor must carried out his own water, petrographic and sedimentation analysis where necessary for verification and confirmation of contractual guarantees. The EPC Contractor shall be required to take sedimentation into consideration in the design of the cooling water system. The Contractor shall determine the flow requirements for cooling water system of each unit and size all associated equipment accordingly

For safe and steady operation, standby arrangement for pump for redundancy shall be provided. The Contractor shall design the complete cooling water system for ease of cleaning and maintenance.

The cooling water systems shall be complete in all respects and include but not be limited to: heat exchangers, horizontal shaft centrifugal pumps with electric motors (1 working + 1 standby) for each unit, air and oil coolers, duplex filters motor operated control valves, flow meters, makeup water tanks, expansion vessels, checks valves, discharge valves, all interconnected piping, instrumentation with cabling, wiring, panels, etc.

The P&ID, system description, detailed arrangement and specifications of cooling water equipment shall be submitted by the Contractor for Employer's approval during design phase.

Based on the requirements, the Proposer shall develop and detail the cooling water system in his Proposal.

Cooling clean water connections shall be such that refilling can be provided through direct couplings to the water supply storage tank provided by the Contractor using fixed pipes. The material size and location of storage tank shall be finalized in detail design after getting approval from the Employer.

#### 1.5.1.3 Tubular Heat Exchanger

The tubular heat exchangers shall be arranged in the tailrace pond. The heat exchanging elements, tubes and water boxes shall be of corrosion resistant metal



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Provisions shall be made to allow easy cleaning of the primary circuit side of the heat exchanger. Drain sockets with valves and pipe connections through to the drainage gallery shall be foreseen.

A temperature indicator and remote temperature detector shall be provided. The heat exchangers shall be designed and tested according to an approved pressure vessel code.

Two sets of special cleaning brushes and of all other necessary equipment to carry out effective cleaning shall be included in the scope of supply.

#### 1.5.1.4 Pumps

The operating range of cooling water pump shall also cover the required cooling water demand in the case only one turbine is in operation. The delivery head of the pump shall be designed to allow for a safety margin to all cooling water consumers.

The pump shall be standard units of a reputable manufacturer and shall conform to the requirements of the standards as prescribed in these specifications. Pump performance curves shall be submitted during basic design.

#### 1.5.1.5 Expansion Vessel

In order to compensate for the pressure fluctuation during operation, the closed loop circuit shall be provided with a pressurized closed expansion vessel of bladder type or piston type with suitable capacity at the selected pressure. The vessel or the filling system shall be provided with automatic filling valve and safety valve, and a volume meter in the filling line for monitoring of the volume of water introduced in the closed loop circuits. Pressure gauge and pressure switch for remote alarm indication shall be provided at the expansion vessel.

#### 1.5.1.6 Piping and Valves

The design of the piping shall ensure that the water flow velocity under normal operating conditions does not exceed 2 m/s. Welding of pipe joints and painting of the pipes shall be done in the shop as far as practicable. A sufficient quantity of flanged connections and threaded unions shall be provided to allow dismantling and replacement of piping without welding work. The connecting pipes of each unit of equipment shall be equipped with shut-off valves. The pipes shall be so arranged that no excessive vibrations or forces can occur and provisions shall be made to prevent pulsations.

#### 1.5.1.7 Tests

The Contractor shall submit detailed testing and commissioning plan / protocol including factory acceptance tests (FATs), site testing & commissioning in accordance with following requirement and latest applicable international standards for approval of the Employer. Testing shall be carried out as per the approved plan.

**a) Assembly and Tests in the Workshop**

The Contractor shell prepare a table, listing all components to be tested and the tests to be performed. The Employer reserves the right to request additional tests if necessary. Test certificates for materials and equipment shall be provided in triplicate to the Employer.

Shop tests shall include the following:

- Hydraulic pressure tests on all components under internal pressure. The test pressure shall be 1.5 of the design pressures.



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- Routine tests on purchased equipment.
- Insulation tests, operating tests, heating tests, load tests, etc. on electric motors, and other electrical and mechanical components.

All plant shall be assembled for the inspection of functional tests. Exceptions may be permitted if approved by the Employer. All parts shall be correctly doweled and matchmarked to facilitate assembly at the Site. The Contractor shall intimate the Employer Requirements in writing of the date and place of inspection and testing not less than two weeks before the parts are ready, and give the Employer full facilities for conducting or witnessing the tests. Three copies of the test reports shall be provided to the Employer.

At least the following components shall be assembled and presented to the Employer:

- Pump sets.
- Automatic strainers.
- Control valves.
- Non-return valves.
- Safety valves.
- Local control board.
- Heat exchangers.

The tests shall include the following:

- Check of conformity with approved documents.
- Operation of electric motors, limit switches, etc.
- Hydraulic pressure test.
- Setting and calibration of safety valves.
- Seal leakage check.

When the plant has passed the tests to the Employer satisfaction, he will confirm that it is satisfactory, and that it can be disassembled, painted and packed for shipment.

**b) Tests at Site**

**i. Commissioning Tests**

The Contractor shall conduct the following commissioning tests to ensure that the equipment has been correctly installed, all necessary adjustments and settings been made, and that it is in sound condition to operate. The site tests are subdivided in preliminary tests, and operation and performance tests.

**ii. Preliminary Tests**

- Electrical check of correct wiring and cabling
- Testing and setting of pressure switches, pressure transmitters and limit switches
- Measuring of insulation level on electrical plant



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- Functional tests of the valves
- Ultrasonic testing of cooling water pipelines

iii. Operation and Performance Tests

- Leakage test
- Final adjustment of pressure switches, indication instruments and interlocking devices.
- Pump performance tests

#### 1.5.1.8 Trial Operation

After successful completion of all commissioning tests, the cooling water systems shall be subject to a Trial Run. Trial Run Operation shall be carried out under the supervision and responsibility of the Contractor.

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**ANNEXURE I**

**Table 3-9 Spare Parts and Tools**

| Description | Unit | QTY |
|---|---|---|
| **Mandatory spare parts (for each type used)** | | |
| Main contacts for three poles complete with springs, bolts, nuts etc. | Sets | 4 |
| Closing and opening trip coils of each type used | Sets | 4 |
| Drive motor of each type used | Sets | 4 |
| Breaker ON/OFF control switches | Sets | 4 |
| Miniature circuit breakers (MCBs) used in control/interlock circuits of each type/rating | Sets | 5 |
| Single-phase current transformer of each type used | Sets | 3 |
| Single-phase voltage transformer of each type used | Sets | 3 |
| Single-phase lightning arrester of each type used | Sets | 3 |
| Trip units (LSIG) of each type used | Sets | 5 |
| Indicating and measuring instruments each type i.e., voltmeters, ammeters and indication lights etc. | Sets | 2 |
| Anti-condensation heaters of each type and rating. | Sets | 1 |
| **Maintenance Equipment** | | |
| Intelligent Instrument Transformer check device | Sets | 1 |
| Testing equipment for circuit breakers characteristics | Sets | 1 |
| Ratio automatic measuring instrument | Sets | 1 |
| Phase shifter | Sets | 1 |
| SF6 gas leakage test set luma sense Model 3434i complète sets with all accessoires | Sets | 1 |
| Circuit Breaker test set omicron model cibano 500 advanced package VE000901 (complete with all connection cables, registered software's, modules etc) | Sets | 1 |
| **Tools** | | |
| Circuit breaker handling truck/trolley of each type used | Sets | 1 |
| Feeder grounding trucks/trollies with VTs of each type used | Sets | 2 |
| Remote controlled racking assembly as per requirement cord and control station of each type used | Sets | 1 |



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| Description | Unit | QTY |
|---|---|---|
| Temporary earthing sticks with accessories of each type used | Sets | 2 |
| Special tools for dismantling and maintenance | Lot | 1 |

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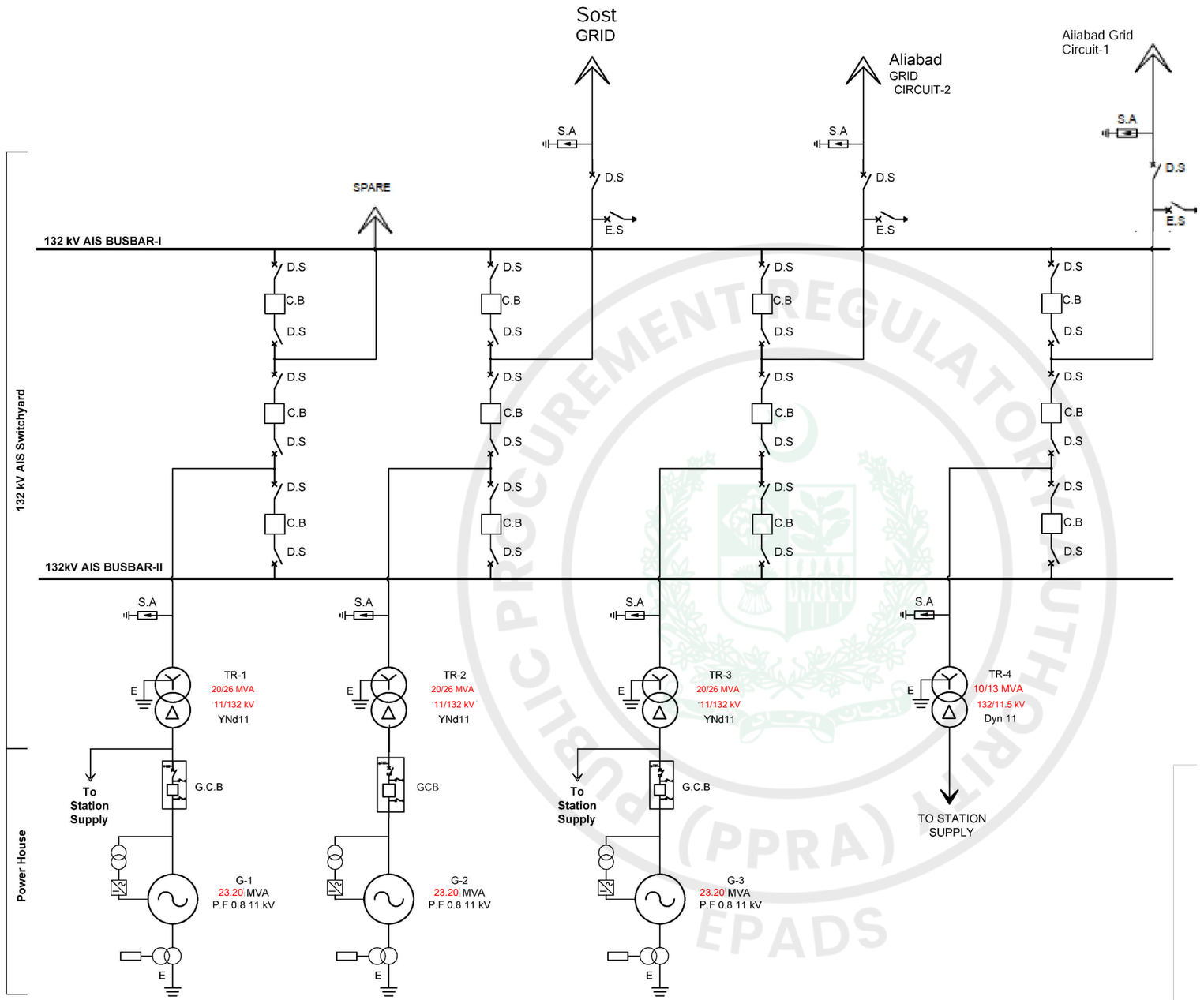


| LEGEND: | |
|---|---|
| SYMBOL | DESCRIPTION |
| | 3~ GENERATOR |
| | 132 kV CIRCUIT BREAKER |
| | TRANSFORMER |
| | TRANSMISSION LINE |
| | SURGE ARRESTER |
| | EARTH/GROUND |
| | NEUTRAL GROUND RESISTOR |
| | EARTHING SWITCH |
| | DISCONNECTOR SWITCH |
| | 11 kV GENERATOR C.B |

**DISCLAIMER:**

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NOTES:

1. DRAWING SHOWS THE BASIC CONCEPT OF ELECTRICAL SYSTEM. FINAL DESIGN SHALL BE DEVELOPED BY CONTRACTOR DURING DETAIL DESIGN STAGE.
2. FINAL RATINGS OF VARIOUS EQUIPMENT SHALL BE DETERMINED ON DETAILED DESIGN STAGE.
3. THIS DRAWING IS PREPARED BASED ON FEASIBILITY DRAWING NO. AFS-EM-451.

CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF:
NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)
ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD.
PAKISTAN ENGINEERING SERVICES (PVT.) LTD.
BARQAAB CONSULTING SERVICES (PVT.) LTD.
DOLSAR ENGINEERING INC.CO.

| REV. | DATE | DESCRIPTION | APPROVED |
|---|---|---|---|
| 04 | | | |
| 03 | | | |
| 02 | | | |
| 01 | | | |

| | |
|---|---|
| DRAWN | ASIF SAMI |
| RECOMMENDED | - |
| CHD./VER. | - |
| APPROVED | - |

**MAIN SINGLE LINE DIAGRAM**

SCALE: AS SHOWN

DATE : MARCH, 2026

DRAWING No. ALHPP-PPE-0501

REV. 0

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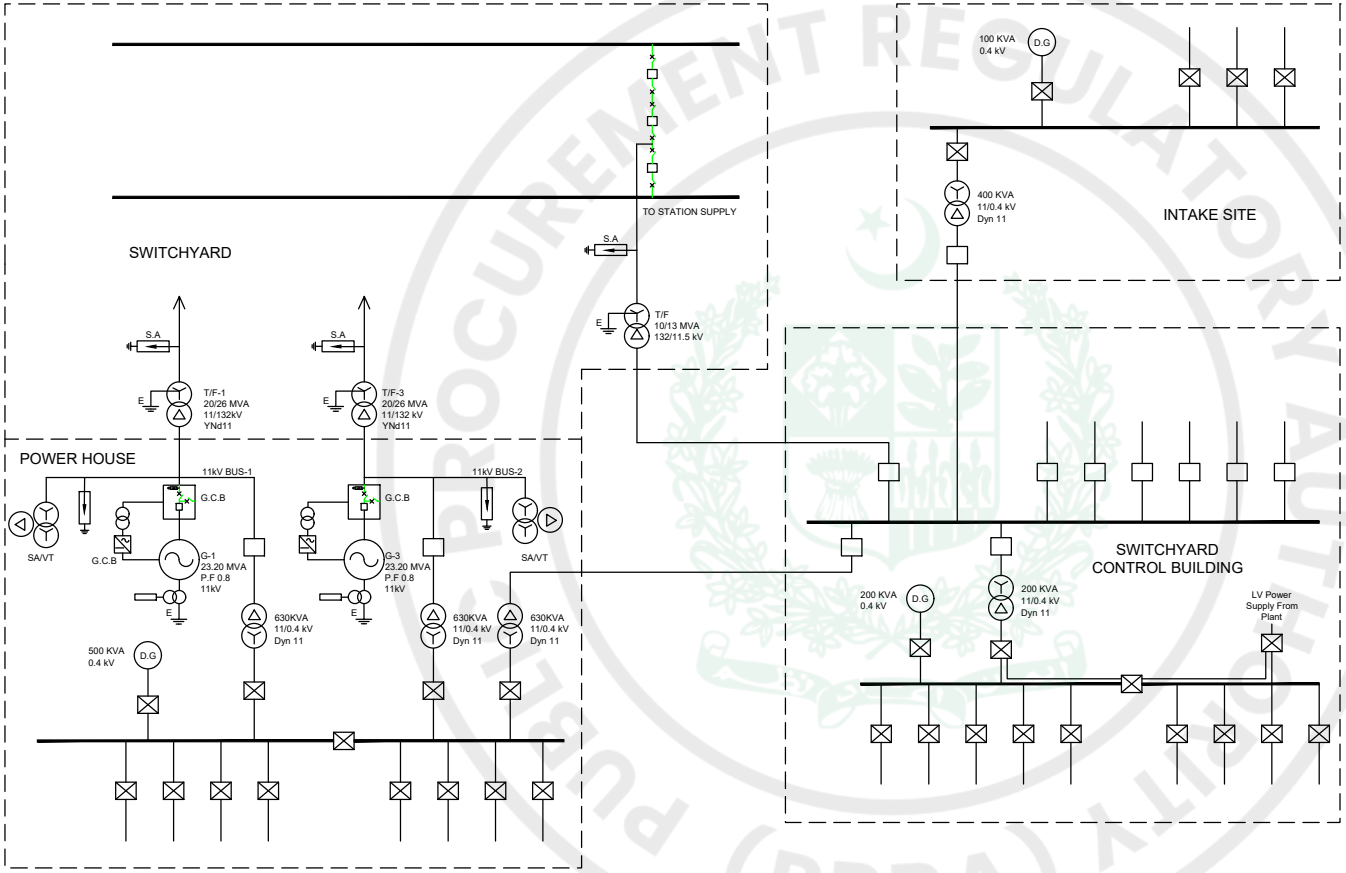


| LEGEND: | |
|---|---|
| SYMBOL | DESCRIPTION |
| | MV CIRCUIT BREAKER |
| | LV CIRCUIT BREAKER |
| | TRANSFORMER |
| | DIESEL GENERATOR |
| N.C | NORMALLY CLOSE |
| N.O | NORMALLY OPEN |

**DISCLAIMER:**

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NOTES:

1. DRAWING SHOWS THE BASIC CONCEPT OF ELECTRICAL SYSTEM. FINAL DESIGN SHALL BE DEVELOPED BY CONTRACTOR DURING DETAIL DESIGN STAGE.
2. FINAL RATINGS OF VARIOUS EQUIPMENT SHALL BE DETERMINED ON DETAILED DESIGN STAGE.
3. THE NUMBER OF CIRCUITS FOR 11kV & 400V SUPPLY SHALL BE DETERMINED BY THE ENGINEER/CONTRACTOR BASED ON THE AUXILIARY LOAD OF THE PLANT.
4. THIS DRAWING IS PREPARED BASED ON FEASIBILITY DRAWING NO. AFS-EM-452.

CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: AHMC ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF: NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)

ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD. | BARQAAB CONSULTING SERVICES (PVT.) LTD.

PAKISTAN ENGINEERING SERVICES (PVT.) LTD. | DOLSAR ENGINEERING INC.CO.

| REV. | DATE | DESCRIPTION | APPROVED |
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| DRAWN | ASIF SAMI |
| RECOMMENDED | - |
| CHD./VER. | - |
| APPROVED | - |

**AC SUPPLY SYSTEM ( OVERALL SCHEME )**

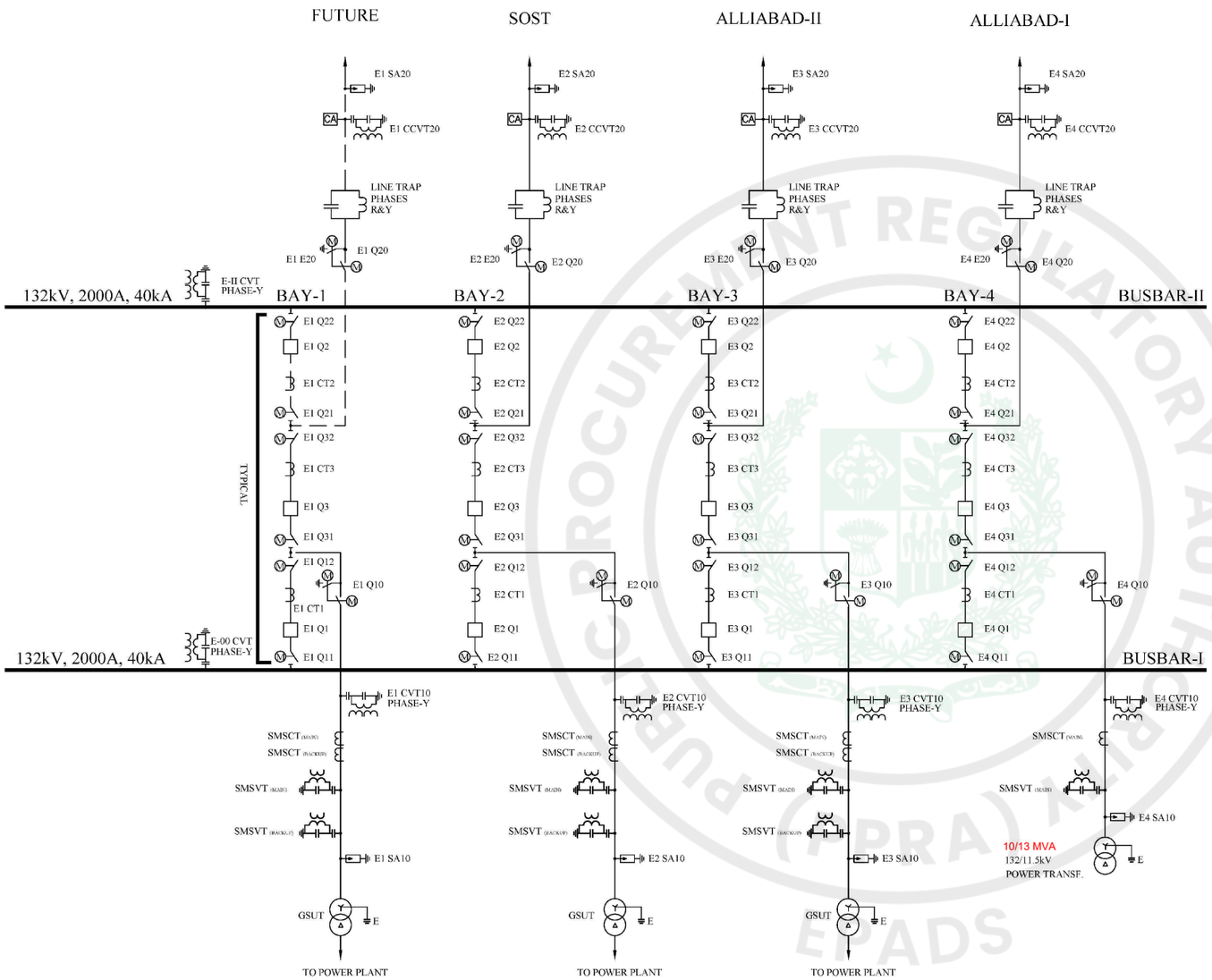
SCALE: AS SHOWN

DATE : MARCH, 2026

DRAWING No. ALHPP-PPE-0502

REV. 0

PROCUREMENT REGULATORY AUTHORITY PUBLIC (PPRA) EPADS




**LEGEND:-**

| SYMEOLS | DESCRIPTION | 132kV |
|---|---|---|
| | POWER TRANSFORMER (PTR), STATION AUXILIRAY TRANSFORMER (PMT) | 10/13 MVA |
| | CIRCUIT BREAKER | 2000A, 40kA |
| | MOTOR OPERATED DISCONNECTOR | 2000A, 40kA |
| | DISCONNECTOR WITH EARTHING SWITCH (MOTOR OPERATED) | 2000A, 40kA |
| | CURRENT TRANSFORMER | FOR CB SIDE CT 1600/800/400/150/1A<br>FOR PTR SIDE CT 1600/800/400/150/1A<br>SMS CT 1600/400/150/1A |
| | CAPACITOR VOLTAGE TRANSFORMER (CVT) SMS | 132kV/$\sqrt{3}$/ 110/$\sqrt{3}$ V,/110V 0.2 + 3P, 3P |
| | CURRENT TRANSFORMER (CT) SMS | |
| | SURGE ARRESTER | 120kV, 98kV |
| | LINE TRAP | - |
| | SECURE METERING SYSTEM VOLTAGE TRANSFORMER (SMSVT) | 132kV/$\sqrt{3}$/ 110/$\sqrt{3}$ V,/110V 0.2 |
| CA | COUPLING CAPACITOR VOLTAGE TRANSFORMER (CCVT) WITH CARRIER FREQUANCY FACILITY | 132kV/$\sqrt{3}$/ 110/$\sqrt{3}$ V,/110V 0.2 + 3P, 3P |

**LEGEND:-**

SCOPE OF WORK

FOR FUTURE

**NOTES:**

1. **ALL 5P20 CLASS CTs SHALL EE AS PER IEC 61869-2.**
2. **132kV BAY EQUIPMENT ARE RATED 2000A, 40kA.**

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CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF:
NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)
ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD.
BARQAAB CONSULTING SERVICES (PVT.) LTD.
PAKISTAN ENGINEERING SERVICES (PVT.) LTD.
DOLSAR ENGINEERING INC.CO.

| REV. | DATE | DESCRIPTION | APPROVED |
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| 04 | | | |
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| 01 | | | |

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|---|---|
| DRAWN | ASIF SAMI |
| RECOMMENDED | - |
| CHD./VER. | - |
| APPROVED | - |

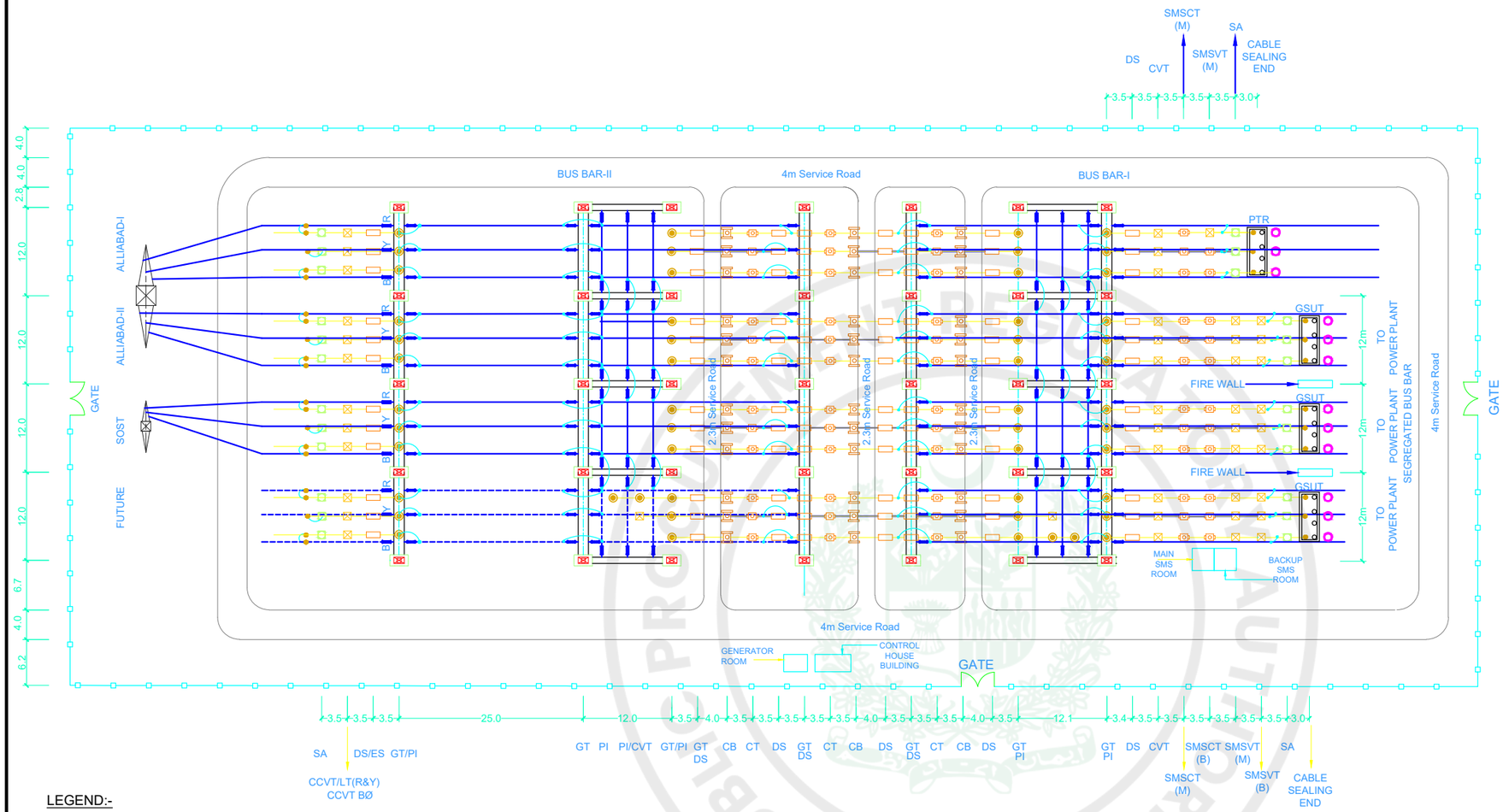
**132 kV SWITCHYARD SINGLE LINE DIAGRAM**

SCALE: AS SHOWN

DATE : MARCH, 2023

DRAWING No. ALHPP-SY-0601

REV. 0




LEGEND:-

| SYMBOLS | DESCRIPTION |
|---|---|
| | SURGE ARRESTER (SA) |
| | CAPACITOR VOLTAGE TRANSFORMER (CVT) |
| | LINE TRAP (LT) |
| | GANTRY TOWER (GT) |
| | SHIELD WIRE |
| | CREOPISES/TUBULOR CONDUCTOR |
| | POST INSULATOR (PI) |
| | INSULATOR STRING (TENSION) |
| | MARSHALLING KIOSK (M.K) |
| | DISCONNECTOR SWITCH (DS) |
| | CIRCUIT BREAKER (CB) |
| | CURRENT TRANSFORMER (CT) |

## NOTES:

1. SPANS BETWEEN SUBSTATION GANTRIES AND THE RELEVANT TRANSMISSION LINE TOWERS SHALL BE FURNISHED BY OTHERS. HOWEVER, THE CONTRACTOR SHALL SUPPLY AND INSTALL ALL NECESSARY JUMPERS/DROPPERS AND HARDWARE FOR CONNECTIONS BETWEEN TRANSMISSION LINES AND THE SUBSTATION EQUIPMENT.
2. INSTALL ALUMINIUM ALLOY CONDUCTOR INSIDE THE ALLUMINIUM TUBULAR CONDUCTOR TO PREVENT VIBRATION AND TACK-WELDING TO PREVENT ARCING OF THIS PARALLEL CONDUCTOR AT THE ENDS.
3. CORROSION INHIBITING COMPOUNDS SHALL BE USED FOR ALL ELECTRICAL CONNECTIONS AND SHALL BE APPLIED TO CONTACT GROOVES AND ON CONDUCTORS PRIOR TO ASSEMBLY.
4. BUS SUPPORT CLAMPS SHALL BE DESIGNED TO ALLOW FOR THERMAL EXPANSION.
5. SPECIAL CARE SHALL BE EXERCISED IN HANDLING ALL TUBING, CABLE AND FITTINGS TO PREVENT SCRATCHES ON THEIR SURFACES. TO PREVENT CORONA, ALL WELDS MADE ON CONDUCTORS OR FITTINGS SHALL BE MADE WITH A SMOOTH BEAD WHICH SHALL BE FILED AND SANDED.
6. LAYOUT SHALL BE ADJUSTED DURING DETAIL DESIGN STAGE
7. ALL DIMENSIONS SHALL BE MEASURED FROM TOP OF FOUNDATIONS.
8. INTERCONNECTION BETWEEN POWER HOUSE AND 132kV SWITCHYARD WILL BE THROUGH SEGREGATED BUS BAR AS SPECIFIED IN POWER PLANT SPECIFICATION.

**DISCLAIMER:**

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CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF: NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)

ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD. | BARQAAB CONSULTING SERVICES (PVT.) LTD.

PAKISTAN ENGINEERING SERVICES (PVT.) LTD. | DOLSAR ENGINEERING INC.CO.

| REV. | DATE | DESCRIPTION | APPROVED |
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| DRAWN | ASIF SAMI |
| RECOMMENDED | - |
| CHD./VER. | - |
| APPROVED | - |

**132 kV SWITCHYARD EQUIPMENT ARRANGEMENT PLAN**

SCALE: AS SHOWN

DATE : MARCH, 2023

DRAWING No. ALHPP-SY-0602

REV. 0

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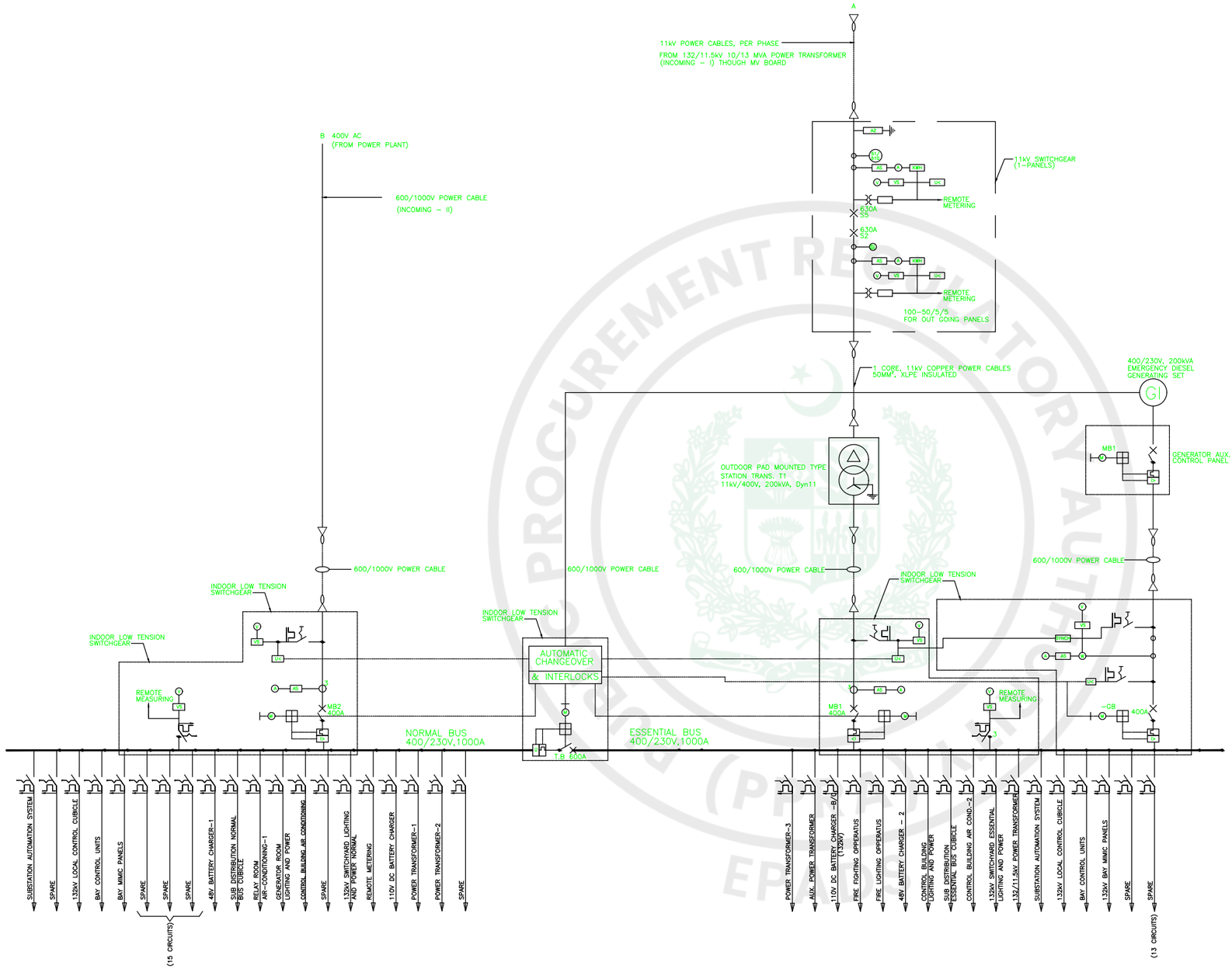


LEGEND:-

| SYMBOL | DESCRIPTION |
|---|---|
| M | MOTOR OPERATED CONTROL |
| | MOLDED CASE CIRCUIT BREAKER |
| G1 | DIESEL GENERATING SET |
| 50 | DEFINITE TIME OVER CURRENT RELAY |
| 50/G | GROUND FAULT RELAY |
| 87 | POWER TRANSFORMER DIFFERENTIAL CURRENT PROTECTION |
| | STATION AUXILIARY TRANSFORMER |
| SYNH | SYNCHROSCOPE |
| W | WATT - METER |
| VS | VOLT METER SELECTOR SWITCH |
| AS | AMMETER SELECTOR SWITCH |
| KWH | KILOWATT - HOUR METER |
| VH | VAR - HOUR METER |
| U< | UNDER VOLTAGE RELAY |
| | RESISTOR |
| SA | SURGE ARRESTOR |
| | AIR CIRCUIT BREAKER (MOTOR OPERATED) |
| | CURRENT TRANSFORMER |
| A | AMMETER |
| V | VOLTMETER |
| | VACUUM CIRCUIT BREAKER (11kV) |
| | POTENTIAL TRANSFORMER |
| G.B | GENERATOR BREAKER |
| M.B | MAIN BREAKER |
| T.B | TIE BREAKER |

NOTES:

1. THIS DRAWING SHOWS ONLY TYPICAL AC OUTGOING CIRCUITS.
2. EMERGENCY DIESEL GENERATING SET SHALL BE SUPPLIED COMPLETE WITH CONTROL, PROTECTION, METERING, INDICATION AND ANNUNCIATION SYSTEMS AS SPECIFIED.
3. FOLLOWING REMOTE CONTROLS OF THE DIESEL GENERATOR/DIESEL ENGINE SHALL BE PROVIDED ON THE DIESEL GENERATOR PANEL IN CONTROL ROOM:
   A) DIESEL GENERATOR START.
   B) GENERATOR STOP.
   C) VOLTAGE AND CURRENT INDICATION.
   D) FREQUENCY INDICATION.
4. DETAILS FOR CONTROL, METERING, INDICATIONS AND OTHER INSTRUMENTS RELEVANT TO AC SYSTEM SHALL BE FINALIZED AT THE DETAIL DESIGN STAGE.
5. THE SIZES OF THE CABLES ON THIS DRAWING ARE APPROXIMATE SIZES. THE CONTRACTOR SHALL SUBMIT CALCULATIONS FOR APPROVAL OF THE EMPLOYER'S REPRSENTATIVE FOR THE SELECTION OF CABLES STAGE.
6. THE CONTRACTOR SHALL PROVIDE SUB-DISTRIBUTION BOARDS AS SPECIFIED / REQUIRED BY THE EMPLOYER'S REPRESENTATIVE.
7. THE SIZE OF BUSBAR AND MCBs SHALL BE DETERMINED BY THE CONTRACTOR AND SHALL BE SUBJECT TO APPROVAL BY THE EMPLOYER'S REPRESENTATIVE. FRAME SIZES OF MCBs SHALL BE 250A MINIMUM.
8. BCU SHALL BE PROVIDED TO COVER ALL 11kV SWGR SIGNALS TO SAS.
9. ENERGY METERS FOR 400V SHALL BE HOUSED IN EACH PAD MOUNTED TRANSFORMER.

**DISCLAIMER:**

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CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF:
NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)
ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD.
PAKISTAN ENGINEERING SERVICES (PVT.) LTD.
BARQAAB CONSULTING SERVICES (PVT.) LTD.
DOLSAR ENGINEERING INC.CO.

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| RECOMMENDED | - |
| CHD./VER. | - |
| APPROVED | - |

**132 kV SWITCHYARD AC AUXILIARY SERVICES SYSTEM (TYPICAL)**

SCALE: AS SHOWN

DATE : MARCH, 2023

DRAWING No. ALHPP-SY-0603

REV. 0

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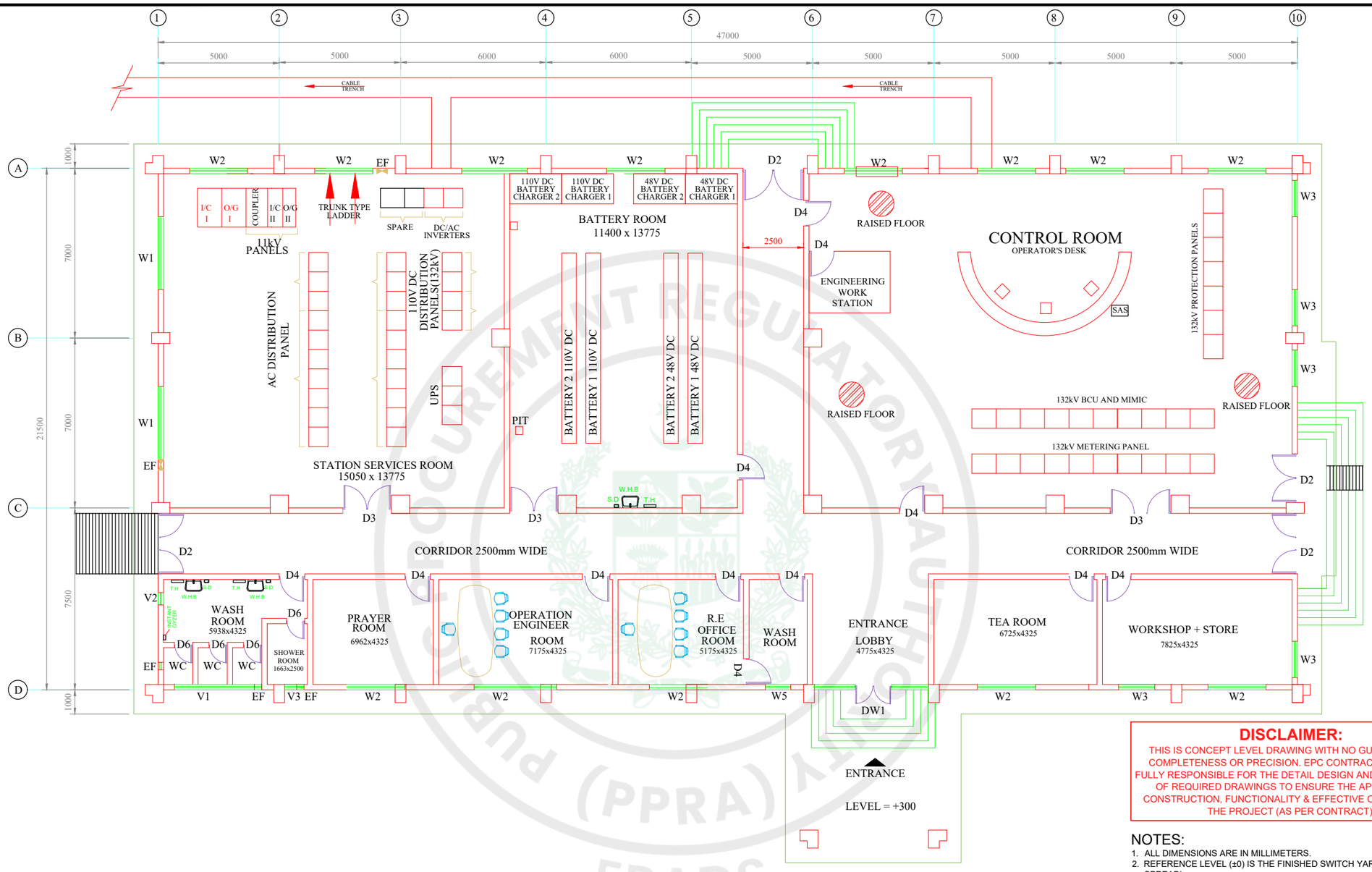


**DISCLAIMER:**

THIS IS CONCEPT LEVEL DRAWING WITH NO GUARANTEE OF COMPLETENESS OR PRECISION. EPC CONTRACTOR WILL BE FULLY RESPONSIBLE FOR THE DETAIL DESIGN AND PREPARATION OF REQUIRED DRAWINGS TO ENSURE THE APPROPRIATE CONSTRUCTION, FUNCTIONALITY & EFFECTIVE OPERATION OF THE PROJECT (AS PER CONTRACT).

## NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. REFERENCE LEVEL (±0) IS THE FINISHED SWITCH YARD LEVEL (TOP OF GRAVEL SPREAD).
3. PVC (EMBEDDED) PIPES OF APPROPRIATE SIZES CONSIDERING FUTURE REQUIREMENTS, SHALL BE PROVIDED FOR CABLES BETWEEN BATTERY BANK, BATTERY CHARGERS AND AC/DC PANELS WHERE EVER NEEDED.
4. LAYOUT PLAN FOR THE BATTERY BANKS IN THE BATTERY ROOM SHALL BE FINALIZED AT THE DETAIL DESIGN STAGE.
5. THE SPACE OF CABLE TRENCH OR OPENING IN THE CONTROL HOUSE BUILDING ,NOT USED FOR PANELS, SHALL BE PROVIDED WITH STEEL CHECKERED PLATE COVERS WITH PROPER STIFFENERS AND LIFTING ARRANGEMENT.
6. AT THE POINT OF ENTRY OF CABLE TRENCHES IN CONTROL HOUSE BUILDING, PROPER BLOCKING OF RAIN WATER AND RATS ETC. SHALL BE PROVIDED. BOTTOM ENTRY PLATES OF PANELS SHALL BE PROVIDED WITH PROPER CABLE GLANDS & SPARE HOLES BE TEMPORARILY BLOCK FOR FUTURE USE.
7. ADEQUATE NUMBER OF R.C.C. PIPES SHALL BE PROVIDED AT 11kV CABLE ENTRY INTO STATION SERVICES ROOM. TRENCH AND SPARE PIPES SHALL BE TEMPORARILY BLOCKED FOR FUTURE USE.
8. FALSE CIELING SHALL BE PROVIDED IN COMPLETE C.H.B.

| | | | |
|---|---|---|---|
| CLIENT: | PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY | CONSULTANT: | ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS<br>JOINT VENTURE OF:<br>NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD(LEAD FIRM)<br>ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD.<br>BARQAAR CONSULTING SERVICES (PVT.) LTD.<br>PAKISTAN ENGINEERING SERVICES (PVT.) LTD.<br>DOLSAR ENGINEERING INC.CO. |
| PROJECT: | ATTABAD LAKE HYDROPOWER PROJECT (54 MW) | | |

| REV. | DATE | DESCRIPTION | APPROVED |
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| RECOMMENDED | - |
| CHD./VER. | - |
| APPROVED | - |

**132 kV SWITCHYARD CONTROL HOUSE BUILDING LAYOUT PLAN**

SCALE: AS SHOWN

DATE : MARCH, 2023

DRAWING No. ALHPP-SY-0605

REV. 0

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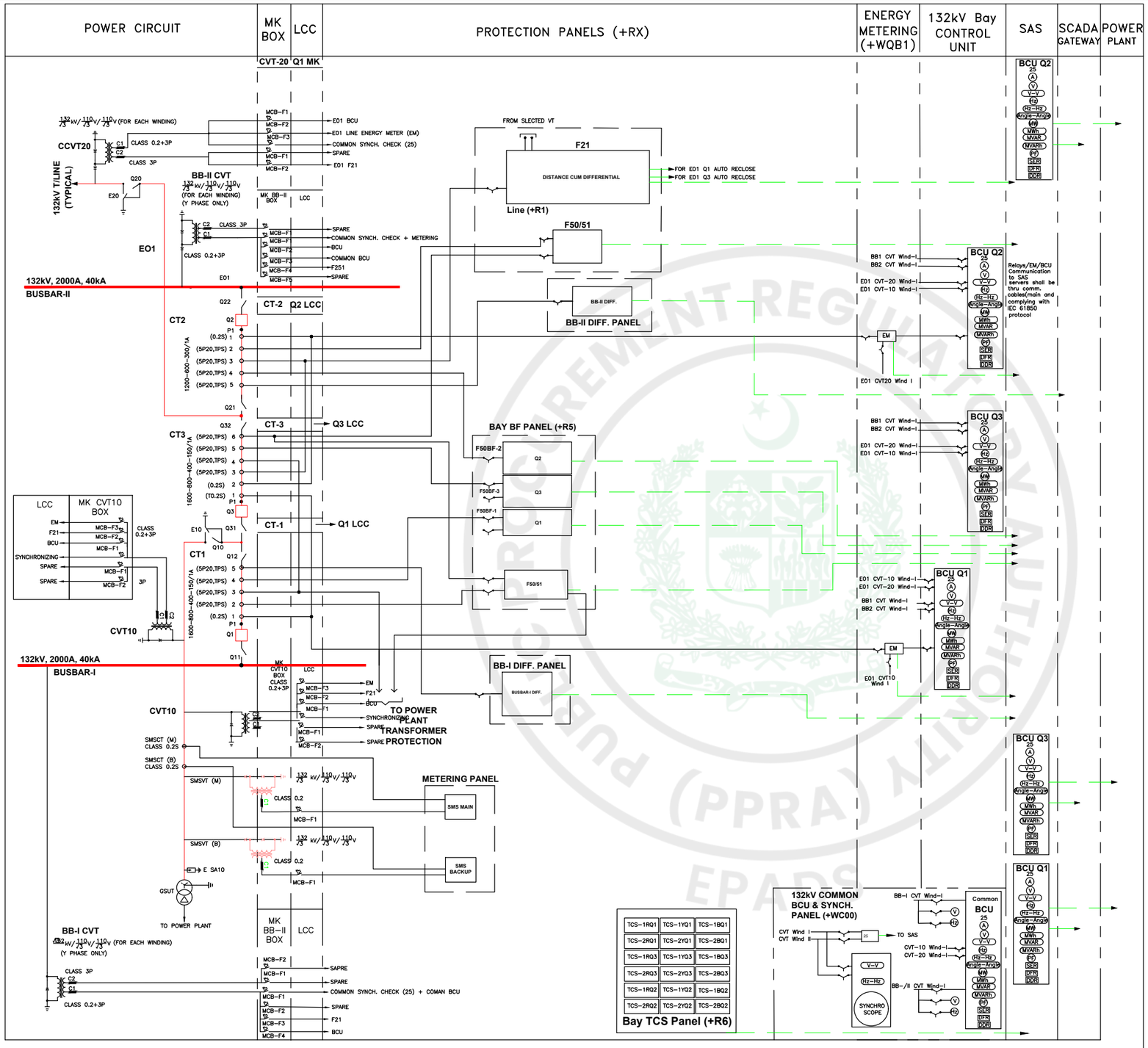


## LEGEND :-

| ITEM | DESCRIPTION | ITEM | DESCRIPTION |
|---|---|---|---|
| 21 | Distance cum differential relay | 95 | CT Supervision Relay |
| 24 | Volts per hertz/Over excitation | Angle | Phase Angle Meter/Angle measurement |
| 25 | Synchronism-check device | A | Ammeter/Ampere Measurement |
| 50 | Instantaneous Overcurrent Relay | Hz | Frequency Meter/Frequency measurement |
| 50N | Neutral Instantaneous Overcurrent | Hz-Hz | Double Frequency Meter/Double Frequency measurement |
| 50BF | Breaker Failure Relay | MW | Megawatt Meter/MW Power measurement |
| 50EF | End Fault Protection | MWh | Megawatthour Meter/MWh Energy Measurement |
| 51 | AC Time Overcurrent Relay | MVAR | Megavar Meter/MVAR Power measurement |
| 51N | Neutral Time Overcurrent | MVARh | Megawatthour Meter/MVARh Energy measurement |
| 67 | AC Directional Overcurrent | PF | Power Factor Meter/PF Measurement |
| 67N | Neutral Directional Overcurrent | V | Voltmeter/Voltage Measurement |
| 68 | Power Swing Blocking | V-V | Double Voltmeter |
| 74 | Alarm Relay | BCU | Bay Controller Unit |
| 79 | Auto Reclose | DDR | Dynamic Disturbance Recorder |
| 81 | Frequency | DFR | Digital Fault Recorder |
| 86 | Lock-out Relay | EM | Energy Meter |
| 87B | Busbar Differential Relay | FL | Distance Fault Locator |
| 94 | Self Reset/Tripping Relay | PQM | Power Quality Monitor |
| FR | Fault Recorder | SER | Sequence of Events Recorder |
| -.-.- | Panel | SOTF | Switch On To Fault |
| ..... | Status/Control/Metering To SAS/SCADA | TCS | Trip Circuit Supervision Relay |
| | Test Switch | VTFF | VT Fuse Fail |

## DISCLAIMER:

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## NOTES.

1. POSITION SCHEMES ARE BASED ON MULTIFUNCTION RELAYS. HOWEVER IF SOME FUNCTIONS ARE NOT POSSIBLE TO ACCOMODATE WITHIN RELAY SEPARATE RELAY SHALL BE PROVIDED.
2. ALL FOUR CVTs SHALL BE PROVIDED TO BCU FOR SYNCHROCHECK AND FOR SPECIFIC BREAKER VT SELECTION SHALL BE WITHIN BCU.
3. CVT MCB SHALL BE PROVIDED BEFORE BCU, RELAY & ENERGY METER.
4. BCU SHALL BE PROVIDED PER CIRCUIT BREAKER.
5. E01, E02 & E03 ARE TYPICAL.

SHEET NO. 1 OF 2

CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF:
NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)
ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD.
BARQAAB CONSULTING SERVICES (PVT.) LTD.
PAKISTAN ENGINEERING SERVICES (PVT.) LTD.
DOLSAR ENGINEERING INC.CO.

| REV. | DATE | DESCRIPTION | APPROVED |
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| CHD./VER. | - |
| APPROVED | - |

PROTECTION & METERING SYSTEM
132kV SINGLE LINE DIAGRAM

SCALE: AS SHOWN

DATE : MARCH, 2023

DRAWING No. ALHPP-SY-0606

REV. 0

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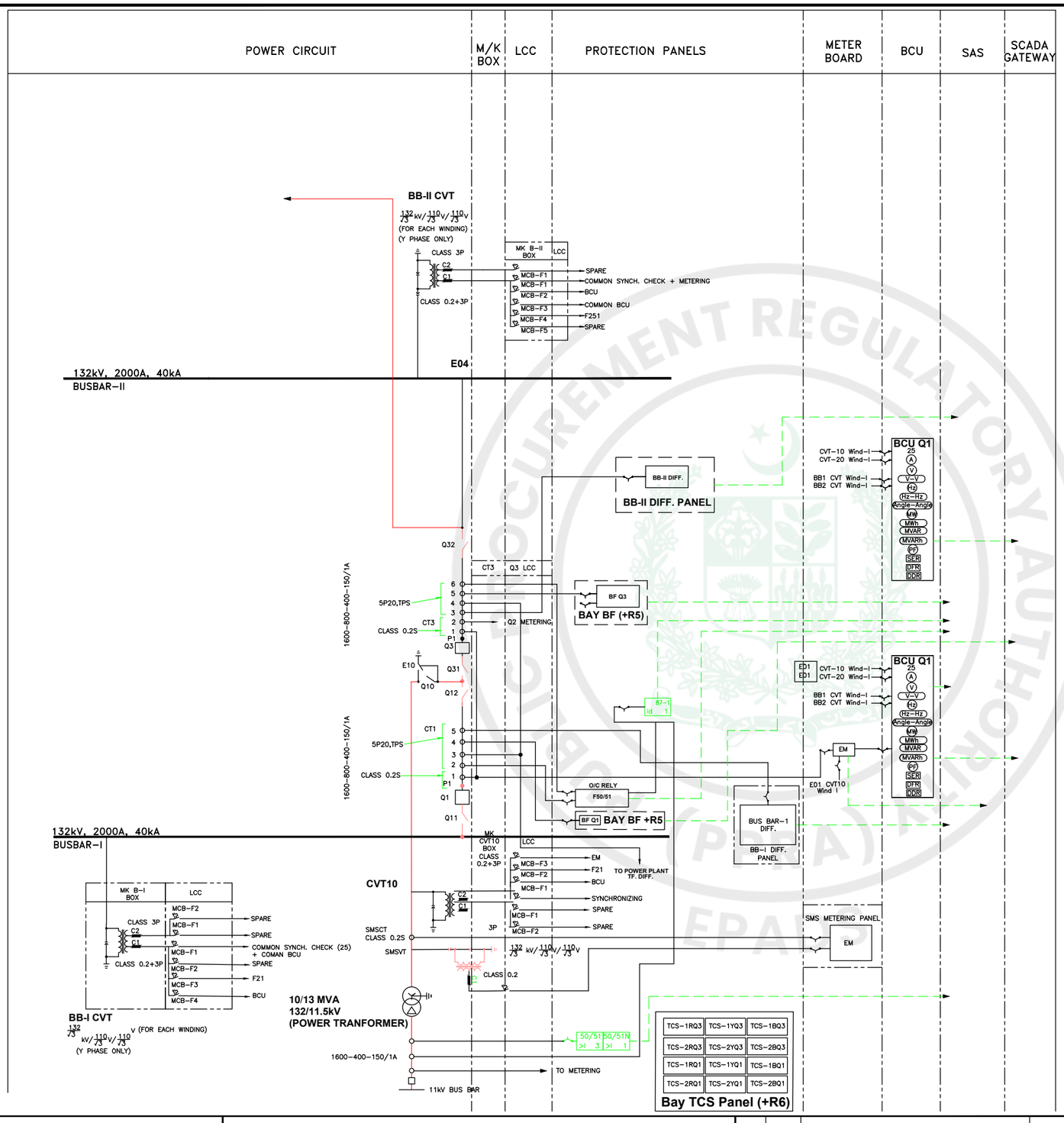


LEGEND :-

| ITEM | DESCRIPTION |
|---|---|
| 21 | Distance cum differential relay |
| 24 | Volts per hertz/Over excitation |
| 25 | Synchronism-check device |
| 50 | Instantaneous Overcurrent Relay |
| 50N | Neutral Instantaneous Overcurrent |
| 50BF | Breaker Failure Relay |
| 50EF | End Fault Protection |
| 51 | AC Time Overcurrent Relay |
| 51N | Neutral Time Overcurrent |
| 67 | AC Directional Overcurrent |
| 67N | Neutral Directional Overcurrent |
| 68 | Power Swing Blocking |
| 74 | Alarm Relay |
| 79 | Auto Reclose |
| 81 | Frequency |
| 86 | Lock-out Relay |
| 87B | Busbar Differential Relay |
| 94 | Self Reset/Tripping Relay |
| FR | Fault Recorder |
| -.-.- | Panel |
| ..... | Status/Control/Metering To SAS/SCADA |
| | Test Switch |

LEGEND :-

| ITEM | DESCRIPTION |
|---|---|
| 95 | CT Supervision Relay |
| Angle | Phase Angle Meter/Angle measurement |
| A | Ammeter/Ampere Measurement |
| Hz | Frequency Meter/Frequency measurement |
| Hz-Hz | Double Frequency Meter/Double Frequency measurement |
| MW | Megawatt Meter/MW Power measurement |
| MWh | Megawatthour Meter/MWh Energy Measurement |
| MVAR | Megavar Meter/MVAR Power measurement |
| MVARh | Megawatthour Meter/MVARh Energy measurement |
| PF | Power Factor Meter/PF Measurement |
| V | Voltmeter/Voltage Measurement |
| V-V | Double Voltmeter |
| BCU | Bay Controller Unit |
| DDR | Dynamic Disturbance Recorder |
| DFR | Digital Fault Recorder |
| EM | Energy Meter |
| FL | Distance Fault Locator |
| PQM | Power Quality Monitor |
| SER | Sequence of Events Recorder |
| SOTF | Switch On To Fault |
| TCS | Trip Circuit Supervision Relay |
| VTFF | VT Fuse Fail |

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NOTES :-

1. POSITION SCHEMES ARE BASED ON MULTIFUNCTION RELAYS. HOWEVER IF SOME FUNCTIONS ARE NOT POSSIBLE TO ACCOMODATE WITHIN RELAY SEPARATE RELAY SHALL BE PROVIDED.
2. ALL CVTs SHALL BE PROVIDED TO BCU FOR SYNCHROCHECK AND FOR SPECIFIC BREAKER VT SELECTION SHALL BE WITHIN BCU.
3. CVT MCB SHALL BE PROVIDED BEFORE BCU, RELAY & ENERGY METER.
4. BCU SHALL BE PROVIDED PER CIRCUIT BREAKER.

SHEET NO. 2 OF 2

CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF: NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)

ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD. | BARQAAB CONSULTING SERVICES (PVT.) LTD. | PAKISTAN ENGINEERING SERVICES (PVT.) LTD. | DOLSAR ENGINEERING INC.CO.

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| DRAWN | ASIF SAMI |
| RECOMMENDED | - |
| CHD./VER. | - |
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**PROTECTION & METERING SYSTEM 132kV POWER TRANSFORMER SINGLE LINE DIAGRAM**

SCALE: AS SHOWN

DATE : MARCH, 2023

DRAWING No. ALHPP-SY-0607

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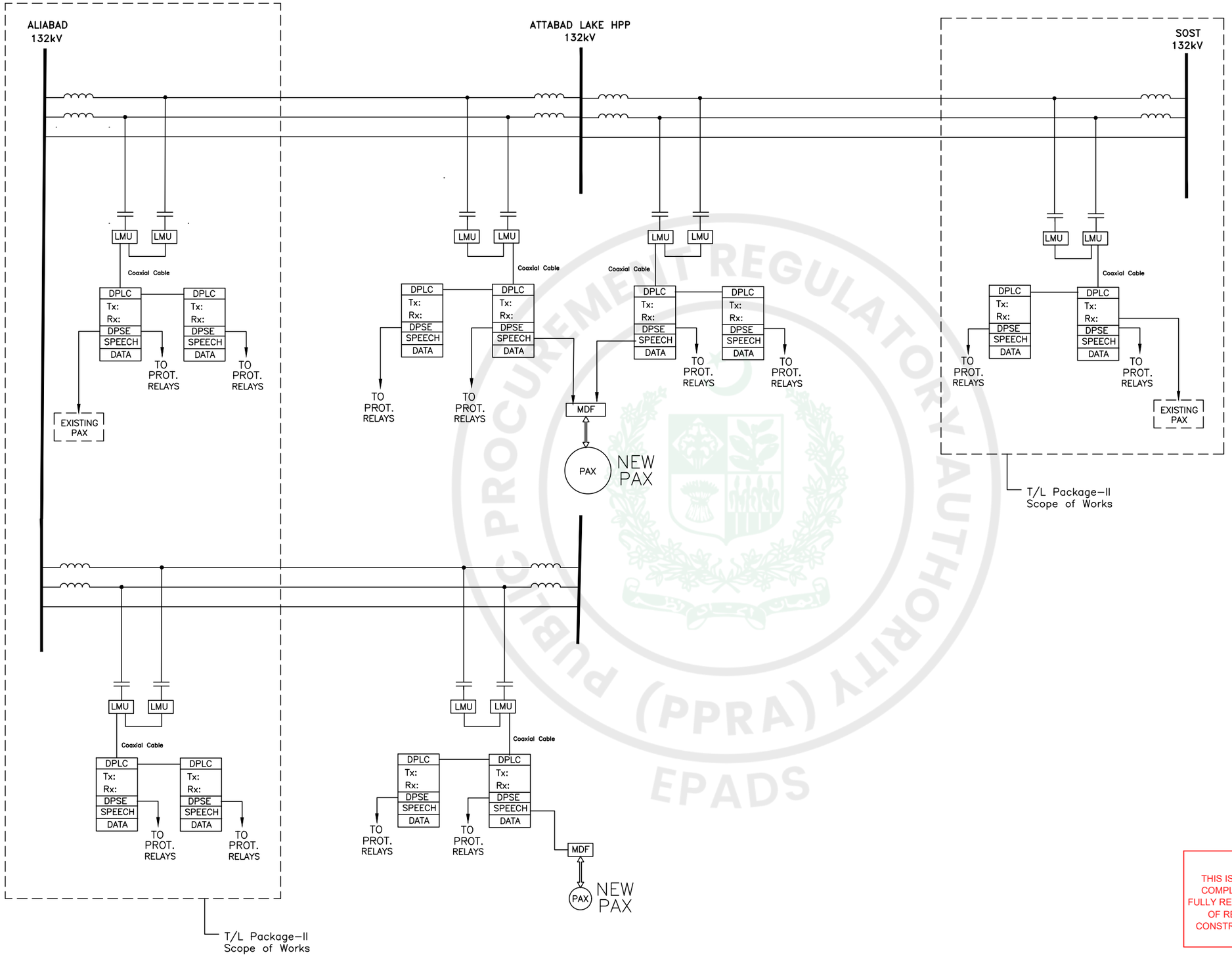


LEGEND:

| SYMBOL | DESCRIPTION |
|---|---|
| ~~~ | LINE TRAP |
| ⊣⊢ | CCVT/CVT |
| LMU | LINE MATCHING UNIT |
| SSB–SC<br>Tx: f2<br>Rx: f1<br>PSE<br>SPEECH<br>DATA | DIGITAL PLC TERMINAL<br>TRANSMIT FREQUENCY (f2 KHz)<br>RECEIVE FREQUENCY (f1 KHz)<br>PROTECTION SIGNALLING INTERFACE<br>VOICE INTERFACE<br>DATA INTERFACE |
| MDF | MAIN DISTRIBUTION FRAME |
| PAX | PRIVATE AUTOMATIC EXCHANGE |
| ⟺ | VF CHANNELS |
| – – – | EXISTING EQUIPMENT |

**DISCLAIMER:**

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CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF:
NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)
ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD.
PAKISTAN ENGINEERING SERVICES (PVT.) LTD.
BARQAAB CONSULTING SERVICES (PVT.) LTD.
DOLSAR ENGINEERING INC.CO.

| REV. | DATE | DESCRIPTION | APPROVED |
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| DRAWN | ASIF SAMI |
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**132 kV SWITCHYARD TELECOMMUNICATION NETWORK LAYOUT**

SCALE: AS SHOWN

DATE : MARCH, 2026

DRAWING No. ALHPP-TC-0702

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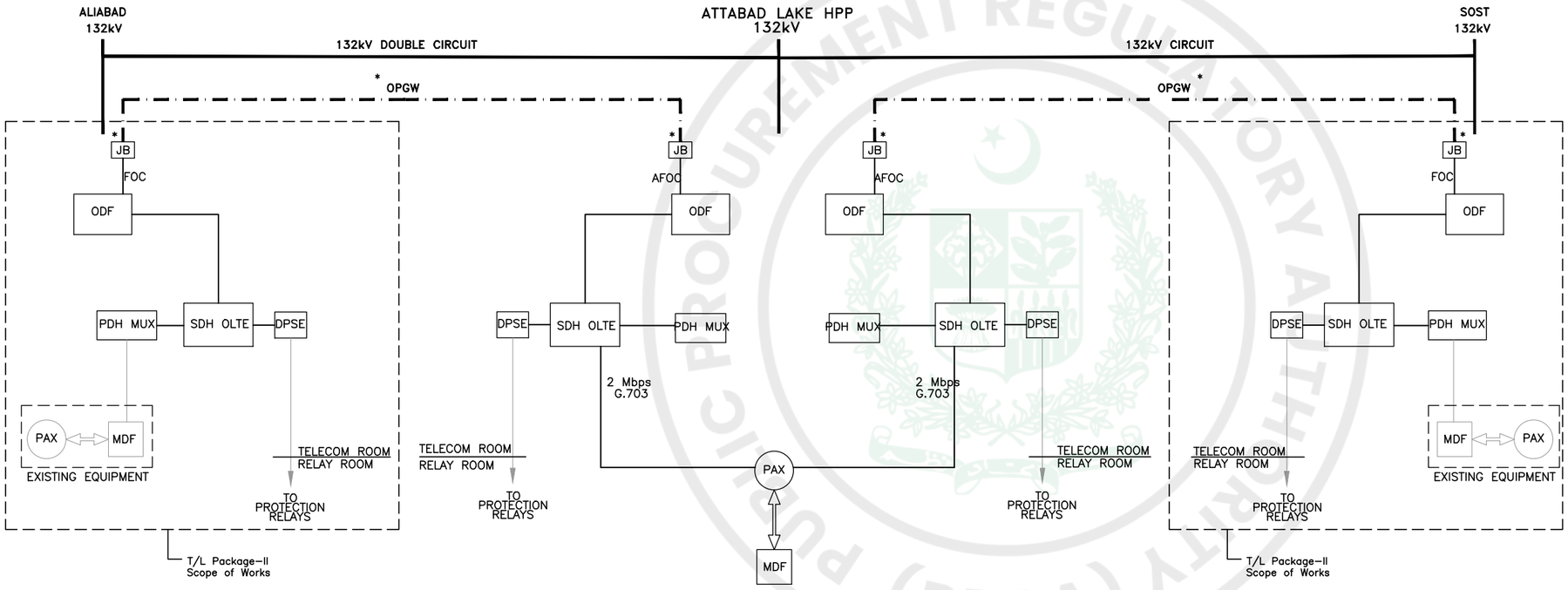


LEGEND:

| SYMBOL | DESCRIPTION |
|---|---|
| | OPGW CABLE |
| JB | JUNCTION BOX OP6W/FOC |
| JB1 | JUNCTION BOX OP6W/OPGW/OPGW |
| OA | OPTICAL AMPLIFIER 1+1 |
| SDH OLTE | OPTICAL LINE TERMINAL EQUIPMENT 1+1 |
| PDH MUX | DIGITAL MULTIPLEXER |
| DPSE | DIGITAL PROTECTION SIGNALLING EQUIPMENT |
| | VF CHANNELS |
| PAX | PRIVATE AUTOMATIC EXCHANGE |
| ODF | OPTICAL DISTRIBUTION FRAME |
| FOC | FIBER OPTIC APPROACH CABLE |
| * | TO BE SUPPLIED BY OTHERS |

**DISCLAIMER:**

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CLIENT: PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PROJECT: ATTABAD LAKE HYDROPOWER PROJECT (54 MW)

CONSULTANT: ATTABAD HYDROPOWER MANAGEMENT CONSULTANTS

JOINT VENTURE OF:
NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. (LEAD FIRM)

ASSOCIATED CONSULTING ENGINEERS (PVT.) LTD.
PAKISTAN ENGINEERING SERVICES (PVT.) LTD.
BARQAAB CONSULTING SERVICES (PVT.) LTD.
DOLSAR ENGINEERING INC.CO.

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132 kV SWITCHYARD FIBER OPTIC SYSTEM

SCALE: AS SHOWN

DATE : MARCH, 2026

DRAWING No. ALHPP-TC-0704

REV. 0

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## Check list for Technical Bid Package-III

| Sr. No. | Form | Subject |
|---|---|---|
| 1 | Form of Proposal / Bid Security | |
| 2 | Application Submission Letter | Employer's SEA and/or SH Disqualification |
| 3 | ELI 1.1 with Attachments | Nationality, Eligibility, State owned Entity of the Employer's Country, United Nations resolution or Employer's Country Law |
| 4 | ELI 1.2 with Attachments | Nationality, State owned Entity of the Employer's Country, United Nations resolution or Employer's Country Law |
| 5 | Letter of Proposal Technical Part | Conflict of Interest, Suspension Based on Execution of Bid / Proposal Securing Declaration by the Employer, Potential DAAB Members |
| 6 | PEC Standard License | PEC Licensing |
| 7 | Income Tax Certificate (Extracts of ATL) | Pakistani Firm Tax Registration |
| 8 | Form CON-2 | History of Non-Performing Contracts, Pending Litigations, Litigation History |
| 9 | Form CON-3 ES Performance Declaration | Declaration: Environmental, Social, Health and Safety (ESHS) past performance |
| 10 | Form CON-4 | Employer's SEA and/or SH Disqualification |
| 11 | Form CCC | Current Contract Commitments / Work Progress |
| 12 | Form FIN-3.1 with Attachments | Financial Capabilities |
| 13 | Form FIN-3.2 | Average Annual Construction Turnover |
| 14 | Form FIN-3.3 | Current Contract Commitments / Work Progress |
| 15 | Form EXP-4.1 with Attachments | General Experience |
| 16 | Form EXP-4.2(a) with Attachments | Specific Construction & Contract Management Experience |
| 17 | Form EXP-4.2(b) with Attachments | Experience in Key Activities |
| 18 | Form EXP-4.2(c) with Attachments | Specific Experience in managing ESHS aspects |
| 19 | Design Proposal | |
| 20 | Method Statement for Key Construction Activities | |
| 21 | Sustainable Procurement Proposal | |
| 22 | Code of Conduct for Proposer's Personnel (ES) Form along with Attachment No. 01 | |
| 23 | Work Program | |
| 24 | Proposer's Personnel Organization Chart | |
| 25 | Risk Assessment and Proposed Management Plan | |
| 26 | Form EQU | Proposer's Equipment |
| 27 | Form PER-1 | Key Personnel Qualification and Resource Schedule |
| 28 | Form PER-2 | Resume and Declaration EPC Contractor's and Key Personnel |
| 29 | Sub-Contractors (if Applicable) | Proposed Sub-contractors and / or Manufacturers |
| 30 | Sub-Contractor's Authorization | |
| 31 | Integrity Pact | Fraud and Corruption |
| 32 | Summary of Procedure for Delay Damages for Interface Milestones (Table-1 and Table-2) | |
| 33 | Appendix-A Performance Guarantees | |
| 34 | Environmental and Social (es) Metrics for Progress Reports | |
| 35 | Declaration of Ultimate Beneficial Owners Information for Public Procurement Contracts | |

## Check list for Technical Bid Package-III

| Sr. No. | Form | Subject |
|---|---|---|
| 1 | Form of Proposal / Bid Security | |
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| 34 | Environmental and Social (es) Metrics for Progress Reports | |
| 35 | Declaration of Ultimate Beneficial Owners Information for Public Procurement Contracts | |

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| 11 | Form CCC | Current Contract Commitments / Work Progress |
| 12 | Form FIN-3.1 with Attachments | Financial Capabilities |
| 13 | Form FIN-3.2 | Average Annual Construction Turnover |
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| 18 | Form EXP-4.2(c) with Attachments | Specific Experience in managing ESHS aspects |
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| 20 | Method Statement for Key Construction Activities | |
| 21 | Sustainable Procurement Proposal | |
| 22 | Code of Conduct for Proposer's Personnel (ES) Form along with Attachment No. 01 | |
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| 25 | Risk Assessment and Proposed Management Plan | |
| 26 | Form EQU | Proposer's Equipment |
| 27 | Form PER-1 | Key Personnel Qualification and Resource Schedule |
| 28 | Form PER-2 | Resume and Declaration EPC Contractor's and Key Personnel |
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| 30 | Sub-Contractor's Authorization | |
| 31 | Integrity Pact | Fraud and Corruption |
| 32 | Summary of Procedure for Delay Damages for Interface Milestones (Table-1 and Table-2) | |
| 33 | Appendix-A Performance Guarantees | |
| 34 | Environmental and Social (es) Metrics for Progress Reports | |
| 35 | Declaration of Ultimate Beneficial Owners Information for Public Procurement Contracts | |

## Check list for Technical Bid Package-III

| Sr. No. | Form | Subject |
|---|---|---|
| 1 | Form of Proposal / Bid Security | |
| 2 | Application Submission Letter | Employer's SEA and/or SH Disqualification |
| 3 | ELI 1.1 with Attachments | Nationality, Eligibility, State owned Entity of the Employer's Country, United Nations resolution or Employer's Country Law |
| 4 | ELI 1.2 with Attachments | Nationality, State owned Entity of the Employer's Country, United Nations resolution or Employer's Country Law |
| 5 | Letter of Proposal Technical Part | Conflict of Interest, Suspension Based on Execution of Bid / Proposal Securing Declaration by the Employer, Potential DAAB Members |
| 6 | PEC Standard License | PEC Licensing |
| 7 | Income Tax Certificate (Extracts of ATL) | Pakistani Firm Tax Registration |
| 8 | Form CON-2 | History of Non-Performing Contracts, Pending Litigations, Litigation History |
| 9 | Form CON-3 ES Performance Declaration | Declaration: Environmental, Social, Health and Safety (ESHS) past performance |
| 10 | Form CON-4 | Employer's SEA and/or SH Disqualification |
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| 35 | Declaration of Ultimate Beneficial Owners Information for Public Procurement Contracts | |

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| 2 | Application Submission Letter | Employer's SEA and/or SH Disqualification |
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| 5 | Letter of Proposal Technical Part | Conflict of Interest, Suspension Based on Execution of Bid / Proposal Securing Declaration by the Employer, Potential DAAB Members |
| 6 | PEC Standard License | PEC Licensing |
| 7 | Income Tax Certificate (Extracts of ATL) | Pakistani Firm Tax Registration |
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## Check List for Financial Part of Bid

| Sr. No. | Form | Subject |
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| 1 | Letter of Proposal – Financial Part | |
| 2 | Table of Adjustment Data<br>Table A : Local Currency | |
| 3 | Table of Adjustment Data<br>Table : Foreign Currency | |
| 4 | Table B: Summary of Payment Currencies | |
| 5 | Price Schedule No. 01: | Supply of Plant from Abroad (Pre-Engineered Structures) including Fixtures and other Materials, Goods and Spare Parts (if any) (Schedule of Price basis) |
| 6 | Price Schedule No. 02 | Supply of Plant from within the Employer's Country (Pre-Engineered Structures) including Fixtures and other Materials, Goods and Spare Parts (if any) (Schedule of Price basis) |
| 7 | Price Schedule No. 03 | Design Services |
| 8 | Price Schedule No. 04 | Installation and All other Services |
| 9 | Price Schedule No. 05 | Summary |
| 10 | Price Schedule No. 06 | Recommended Spare Parts |
| 11 | Priced Sub-Activity Schedule for E&M Works | (Breakdown of Prices) |
| 12 | Schedule of Payments for E&M Works | Currency Wise Break-Up of Priced Sub-Activity Schedule |
| 13 | Schedule of Payments for E&M Works | Apportionment of Contract Price According to Activity |
| 14 | Schedule of Daywork Rates | 1. Labour |
| 15 | Schedule of Daywork Rates | 2. Materials |
| 16 | Schedule of Daywork Rates | 3. EPC Contractor's Equipment |
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| 11 | Priced Sub-Activity Schedule for E&M Works | (Breakdown of Prices) |
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| 19 | Grand Summary | |

## Check List for Financial Part of Bid

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## ADDENDUM NO. 02

**Amendments to RFP/EPC Bidding Document for**
**Engineering, Procurement and Construction (EPC) of**
**Attabad Lake Hydropower Project (54 MW)**
**Package-III: Electro-Mechanical Works**

This Addendum No. 02 to RFP/EPC Bidding Document containing the following amendments to the EPC Bidding Document for Engineering, Procurement and Construction (EPC) of Attabad Lake Hydropower Project (54 MW) Package-III: Electro-Mechanical Works is issued pursuant to ITP 8.1 of Volume-I of RFP/EPC Bidding Document.

| **Volume I, Section II - Proposal Data Sheet (PDS), ITP 23.1 (Deadline for Submission of Proposals)** | | |
|---|---|---|
| **ITP No.** | **Instruction to Proposer** | **Amendment** |
| **ITP 22.1(b)** | The original Proposal shall be submitted/uploaded on EPADS v2.0 at (www.vendors.epads.gov.pk/)<br><br>Original Proposal Security / Proposal Security instrument amounting to Rs.120 Million shall be submitted to the address provided in PDS to ITP 23.1 on or before last date of submission or submission in person before the Proposal date and submission time.<br><br>The Proposer shall provide complete searchable PDF version. | The original Proposal shall be submitted/uploaded on EPADS v2.0 at (www.vendors.epads.gov.pk/).<br>Proposals not submitted / uploaded on EPADS v2.0 shall not be considered.<br>In addition to the Proposals submitted/uploaded on EPADS v2.0, the Proposer shall submit **three (03) hard copies** of Technical proposal only, in strict accordance with the procedure set forth in ITP Clause 22.1(b). In case of discrepancy between files uploaded on EPADS v2.0 and hard copies, the content of files uploaded on EPADS v2.0 shall prevail.<br>Original Proposal Security Instrument amounting to Rs.120 million shall be submitted to the address provided in PDS to ITP 23.1 on or before last date of submission or submission in person before the Proposal date and submission time.<br>The Proposer shall provide complete searchable PDF version. |
| **Volume I, Section II - Proposal Data Sheet (PDS), ITP 23.1 (Deadline for Submission of Proposals)** | | |
| **ITP No.** | **Instruction to Proposer** | **Amendment** |
| **ITP 23.1** | The Proposal/Bids shall be submitted/uploaded on EPADS v2.0 at https://vendors.epads.gov.pk/<br>Proposal/Bids not submitted/uploaded on EPADS v2.0 shall not be accepted. | The Proposal/Bids shall be submitted/uploaded on EPADS v2.0 at https://vendors.epads.gov.pk/<br>Proposal/Bids not submitted/uploaded on EPADS v2.0 shall not be accepted. |



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| | | |
|---|---|---|
| | For **Proposal Submission Purposes (Original Bid Security)** only, the Employer's address is:<br><br>**Water and Power Development Authority (WAPDA),**<br>WAPDA Auditorium, WAPDA House, Sharah-e-Quaid-e-Azam Lahore, Punjab, Pakistan<br>**Telephone:** 0092-42-99204981 0092-42-3334481116<br>**Electronic Mail Address:** gmpna01@gmail.com, pdalhpp@gmail.com<br><br>**Date:** June 16, 2026<br>**Time:** 1100 hrs. | For **Proposal Submission Purposes (Technical Part and Original Proposal Security)** only, the Employer's address is:<br><br>**Water and Power Development Authority (WAPDA),**<br>WAPDA Auditorium, WAPDA House, Sharah-e-Quaid-e-Azam Lahore, Punjab, Pakistan<br>**Telephone:** 0092-42-99204981 0092-42-3334481116<br>**Electronic Mail Address:** gmpna01@gmail.com, pdalhpp@gmail.com<br><br>**Date:** August 05, 2026<br>**Time:** 1100 hrs. |
| **Volume I, Section II - Proposal Data Sheet (PDS), ITP 26.1 (Opening of Technical Parts of Proposal)** | | |
| **ITP 26.1** | The **Electronic Bids/Proposal Opening on EPADS v2.0** shall take place on:<br>**Date:** June 16, 2026<br>**Time:** 1130 hrs.<br>**Venue:** WAPDA Auditorium, WAPDA House, Sharah-e-Quaid-e-Azam Lahore, Punjab, Pakistan | The **Electronic Bids/Proposal Opening on EPADS v2.0** shall take place on:<br>**Date:** August 05, 2026<br>**Time:** 1130 hrs.<br>**Venue:** WAPDA Auditorium, WAPDA House, Sharah-e-Quaid-e-Azam Lahore, Punjab, Pakistan |

Other terms and conditions of the RFP/EPC Bidding Document shall remain unchanged.

General Manager / PD Projects
Northern Areas (WAPDA),

Liaison Office (Attabad Lake Hydropower Project),
Sunny View Estate, Kashmir Road, Lahore, Pakistan.

Tel: (0092)-57-2640628, 2640625, (0092)-333-4229545
(0092)-42-9920498,
(0092)-333-4481116

Electronic mail address:
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pdalhpp@gmail.com



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## ADDENDUM NO. 03

**Amendments to RFP/EPC Bidding Document for Engineering, Procurement and Construction (EPC) of Attabad Lake Hydropower Project (54 MW) Package-III: Electro-Mechanical Works**

This Addendum No. 03 to RFP/EPC Bidding Document containing the following amendments to the RFP/EPC Bidding Document for Engineering, Procurement and Construction (EPC) of Attabad Lake Hydropower Project (54 MW) Package-III: Electro-Mechanical Works is issued pursuant to ITP 8.1 of Volume-I of RFP/EPC Bidding Document.

**Volume II, Part-II, Technical Provisions, Section 3, Electrical Plant Equipment, Sub-Clause 3.5, Medium Voltage Switchgear, Sub-Clause 3.5.1 "Scope"**

| Original (Data) | Amendment (Data) |
|---|---|
| The 11 kV Switchgear shall be SF6 Gas type for generating units. All other except generating units shall be vacuum type as insulating and interrupting medium and complying with IEC 62271-100 Standard and IEC 62271-200 Standard. The Generator Circuit Breakers shall be suitable for synchronizing duties and provided with interlocks to avoid incorrect operation of the Disconnector or the Earth Switches | The 11 kV Switchgear for all the generating units shall be SF6 gas-insulated Generator Circuit Breakers (GCBs) or Vacuum Circuit Breakers (VCBs). The 11 kV switchgear for all other applications shall be vacuum type using vacuum as the insulating and interrupting medium and shall comply with IEC 62271-100 Standard and IEC 62271-200 Standard.<br><br>The Generator Circuit Breakers (GCBs) shall be suitable for generator switching and synchronizing duties and shall be provided with the necessary Mechanical and Electrical interlocks to prevent incorrect operation of the associated Disconnectors and Earthing Switches. |

**Volume II, Part-II, Technical Provisions, Section 3, Electrical Plant Equipment, Sub-Clause 3.5.14.11, Spare Parts and Tools**

The list of spare parts item under maintenance equipment shall be revised in accordance with the attached Annexure-A.

Other terms and conditions of the RFP/EPC Bidding Document shall remain unchanged.

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**Table 3-9 Spare Parts and Tools** **Annex-A**

| Description | Unit | QTY |
|---|---|---|
| **Mandatory spare parts (for each type used)** | | |
| Main contacts for three poles complete with springs, bolts, nuts etc. | Sets | 4 |
| Closing and opening trip coils of each type used | Sets | 4 |
| Drive motor of each type used | Sets | 4 |
| Breaker ON/OFF control switches | Sets | 4 |
| Miniature circuit breakers (MCBs) used in control/interlock circuits of each type/rating | Sets | 5 |
| Single-phase current transformer of each type used | Sets | 3 |
| Single-phase voltage transformer of each type used | Sets | 3 |
| Single-phase lightning arrester of each type used | Sets | 3 |
| Trip units (LSIG) of each type used | Sets | 5 |
| Indicating and measuring instruments each type i.e., voltmeters, ammeters and indication lights etc. | Sets | 2 |
| Anti-condensation heaters of each type and rating. | Sets | 1 |
| **Maintenance Equipment** | | |
| Intelligent Instrument Transformer check device | Sets | 1 |
| Testing equipment for circuit breakers characteristics | Sets | 1 |
| Ratio automatic measuring instrument | Sets | 1 |
| Phase shifter | Sets | 1 |
| SF6 Gas leakage test set, Luma sense Model 3434i complète with all standards accessoires. This item shall be supplied only if the Generator Circuit Breaker (GCB) offered under the Contract is of the SF6 Gas-Insulated type. | Sets | 1 |
| Circuit Breaker test set omicron model CIBANO 500 advanced package VE000901 (complete with all connection cables, registered software's, modules etc.) | Sets | 1 |
| **Tools** | | |
| Circuit breaker handling truck/trolley of each type used | Sets | 1 |
| Feeder grounding trucks/trollies with VTs of each type used | Sets | 2 |
| Remote controlled racking assembly as per requirement cord and control station of each type used | Sets | 1 |
| Temporary earthing sticks with accessories of each type | | |



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| Description | Unit | QTY |
|---|---|---|
| used | Sets | 2 |
| Special tools for dismantling and maintenance | Lot | 1 |

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## ADDENDUM NO. 04

**Amendments to RFP/EPC Bidding Document for Engineering, Procurement and Construction (EPC) of Attabad Lake Hydropower Project (54 MW) Package-III: Electro-Mechanical Works**

This Addendum No. 04 to RFP/EPC Bidding Document containing the following amendments to the RFP/EPC Bidding Document for Engineering, Procurement and Construction (EPC) of Attabad Lake Hydropower Project (54 MW) Package-III: Electro-Mechanical Works is issued pursuant to ITP 8.1 of Volume-I of RFP/EPC Bidding Document.

| **Volume I, Section II - Proposal Data Sheet (PDS), ITP 23.1 (Deadline for Submission of Proposals)** | | |
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| **ITP No.** | **Instruction to Proposer** | **Amendment** |
| **ITP 23.1** | The Proposal/Bids shall be submitted/uploaded on EPADS v2.0 at https://vendors.epads.gov.pk/ Proposal/Bids not submitted/uploaded on EPADS v2.0 shall not be accepted.<br><br>For **Proposal Submission Purposes (Original Bid Security)** only, the Employer's address is:<br><br>**Water and Power Development Authority (WAPDA),**<br>WAPDA Auditorium, WAPDA House, Sharah-e-Quaid-e-Azam Lahore, Punjab, Pakistan<br>**Telephone:** 0092-42-99204981 0092-42-3334481116<br>**Electronic Mail Address:** gmpna01@gmail.com, pdalhpp@gmail.com<br><br>**Date:** August 05, 2026<br>**Time:** 1100 hrs. | The Proposal/Bids shall be submitted/uploaded on EPADS v2.0 at https://vendors.epads.gov.pk/ Proposal/Bids not submitted on EPADS v2.0 shall not be accepted.<br><br>For **Proposal Submission Purposes (Technical Part and Original Proposal Security)** only, the Employer's address is:<br><br>**Water and Power Development Authority (WAPDA),**<br>WAPDA Auditorium, WAPDA House, Sharah-e-Quaid-e-Azam Lahore, Punjab, Pakistan<br>**Telephone:** 0092-42-99204981 0092-42-3334481116<br>**Electronic Mail Address:** gmpna01@gmail.com, pdalhpp@gmail.com<br><br>**Date:** August 20, 2026<br>**Time:** 1100 hrs. |

| **Volume I, Section II - Proposal Data Sheet (PDS), ITP 26.1 (Opening of Technical Parts of Proposal)** | | |
|---|---|---|
| **ITP 26.1** | The **Electronic Bids/Proposal Opening on EPADS v2.0** shall take place on:<br>**Date:** August 05, 2026<br>**Time:** 1130 hrs.<br>**Venue:** WAPDA Auditorium, WAPDA House, Sharah-e-Quaid-e-Azam Lahore, Punjab, Pakistan | The **Electronic Bids/Proposal Opening on EPADS v2.0** shall take place on:<br>**Date:** August 20, 2026<br>**Time:** 1130 hrs.<br>**Venue:** WAPDA Auditorium, WAPDA House, Sharah-e-Quaid-e-Azam Lahore, Punjab, Pakistan |



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| |
|---|
| **Volume I, Part-I, SECTION-IV PROPOSAL FORMS, Appendix to Proposal, Specified Provisional Sum** |
| The referred form has been updated accordingly and is enclosed as **Annexure-A**. |

| |
|---|
| **Volume II, Part-II, Technical Provisions, Section 1, Hydro-Mechanical Equipment, Sub-Clause Tools 1.1.17.9 Additional Requirements for Abrasion Protection of Turbine Water Passage Components Against Sediment Erosion and 1.1.17.10 Coating Requirements for Spare Parts of Turbine Water Passage Components** |
| The following Sub-Clause 1.1.17.9, Sub-Clause 1.1.17.10 and Sub-Clause 1.1.17.11 have been added after Sub-Clause 1.1.17.8 Wearing Wings. The referred Sub-Clauses have been attached as **Annexure-B**. |

Other terms and conditions of the RFP/EPC Bidding Document shall remain unchanged.

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**Annexure-A**

## Specified Provisional Sums

| Item No. | Description | Amount (Million PKR) |
|---|---|---|
| 1. | Protection of the Environment GC Sub-Clause 4.18 | 20.00 |
| 2. | Health and Safety GC Sub-Clause 4.8 | |
| 3. | Security Arrangements GC Sub Clause 4.21 | 10.00 |
| 4. | Provisional Sums for the Employer's portion of DAAB costs | 15.00 |
| 5. | Adjustment for Change in Legislation, Royalties and Custom Duties GC Sub-Clause 13.6 | 20.00 |
| | **Total for Specified Provisional Sums (carried forward to Grand Summary (C), p. _____ )** | **65.00** |



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### 1.1.17.9 Additional Requirements for Abrasion Protection of Turbine Water Passage Components Against Sediment Erosion

During the tendering stage, additional information regarding the sediment characteristics of the Attabad Lake Hydropower Project (54MW) has become available. The Employer has observed that the Attbad Lake water carries significant quantum of abrasive sediment during high-flow period, which may result in accelerated wear of the hydraulic passages of the turbine, if appropriate protection measures are not incorporated into the design by the EPC Contractor.

Any sediment information supplied is for reference only and shall not relieve the EPC Contractor from carrying out its own assessment of sediment characteristics, erosion mechanisms and protective measures.

As per Sub-Clause 1.1.3 of Technical Provisions, Part-II, Volume-II, of the RFP/EPC Bidding Document, the EPC Contractor shall independently assess the sediment conditions and shall be solely responsible for selecting appropriate materials, coatings, and protective measures necessary to satisfy the guaranteed performance, efficiency, reliability, availability, and service life requirements specified in the RFP/EPC Bidding Document. No additional payment or claim shall be entertained on account of sediment-induced erosion that could reasonably have been addressed through proper design and material selection.

Accordingly, the following requirements shall form part of the Employer's Requirements and shall be considered by all Proposers in the preparation of their Technical and Financial Proposals.

#### 1.1.17.9.1 General

The EPC Contractor shall design, manufacture, and supply Vertical Shaft Francis turbines suitable for continuous operation under sediment-laden water conditions prevailing at the Attabad Lake Hydropower Project (54 MW).

The turbine design shall incorporate suitable erosion-resistant measures to minimize abrasive wear, maintain hydraulic efficiency throughout the service life, and reduce maintenance frequency.

The Proposer shall include all costs associated with such protection in the Proposal Price.

#### 1.1.17.9.2 Hard Coating Requirements

The EPC Contractor shall provide a proven abrasion-resistant protection system suitable for severe hydro-abrasive service. The proposed coating system shall be fully compatible with CA6NM stainless steel and shall not adversely affect the metallurgical, mechanical, or hydraulic performance of the base material. The Proposer shall substantiate such compatibility by submitting documentary evidence, including manufacturer's technical data, material specifications, test reports, and/or documented references demonstrating successful application on CA6NM stainless steel under comparable service conditions, for the Employer’s review.

High Velocity Oxygen Fuel (HVOF)-applied Tungsten Carbide (WC-Co, WC-CoCr) is the preferred solution.

High Velocity Oxygen Fuel (HVOF) is a thermal spray technology in which powder is fed into a spray gun. A fuel gas (such as propane) is combusted with oxygen to generate a high-



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temperature, high-velocity gas stream. The powder particles are heated and accelerated to supersonic velocity before impacting the substrate to form a dense, strongly adherent coating.

**1.1.17.9.3 Coating Test Method**

The coating system shall be tested and qualified in accordance with IEC 62364, Hydraulic Machines – Guide for Dealing with Hydro-Abrasive Erosion in Kaplan, Francis, and Pelton Turbines.

The EPC Contractor shall apply the protective coating to the turbine runner, guide vanes, facing plates, wearing rings and any other turbine water passage components identified as susceptible to hydro-abrasive erosion, in order to extend the service life of turbine runners and associated components.

After application of the coating, the coated components, including the runner and guide vanes, shall be inspected during each annual maintenance outage. Where necessary, localized repairs shall be carried out at site in accordance with the coating manufacturer's approved repair procedures.

The EPC Contractor shall state and guarantee the expected service life of the coating system under the specified sediment conditions and shall specify the expected inspection intervals, maintenance requirements, repair methodology, and recoating intervals throughout the design service life of the turbine.

**1.1.17.9.4 Minimum Coating Locations**

The EPC Contractor shall identify all erosion-prone surfaces through hydraulic analysis, sediment erosion assessment, and operating experience and provide suitable protection. As a minimum, the following locations shall be considered:

- Turbine Runner blades
  - Leading edge
  - Pressure side
  - Suction side
  - Trailing edge
  - Crown transition
  - Band transition
  - Runner outlet region
- Turbine Guide Vanes
  - Leading edges
  - Trailing edges
  - Upper and lower sealing faces
  - Side faces exposed to leakage flow
- Turbine Facing Plates
- Turbine Wearing Rings
- Turbine Labyrinth Rings



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- Stay Vanes (where considered susceptible to hydro-abrasive erosion)
- Other underwater metallic components identified by the EPC Contractor as susceptible to abrasive erosion.

**1.1.17.9.5 Coating Material and Thickness**

The coating shall consist of a Tungsten Carbide based material suitable for severe hydro-abrasive service.

Typical acceptable systems include:

| Parameters | Specifications |
|---|---|
| **Coating Material** | WC |
| **Type** | (WC-Co, WC-CoCr) |
| **Composition** | Tungsten carbide (WC) 86%, Cobalt 10%, Chrome 4% |
| **Porosity Rate of Coating** | < 1% |
| **Bonding Strength of Coating** | To be provided by the EPC Contractor and Supported by Test Certificates |
| **Thickness** | To be provided by the EPC Contractor |
| **Hardness of Coating** | To be provided by the EPC Contractor |

-The coating surface roughness after spraying: To be provided by the EPC Contractor

The EPC Contractor shall determine coating thickness based on its own assessment of sediment characteristics, including sediment concentration, particle hardness, particle size distribution, operating head, flow velocity and expected service life etc.

The proposed coating thickness shall be justified through design calculations, coating manufacturer's recommendations, laboratory test results (where available), and documented successful operating references and shall be subject to the Employer's review.

**1.1.17.9.6 Design Responsibility**

The EPC Contractor shall ensure that:

- Coating application shall not adversely affect hydraulic efficiency;
- Coating shall not alter designed hydraulic profiles;
- Coating shall remain intact throughout the guaranteed operating period
- Coating repairs, if required, can be carried out using standard maintenance procedures. There are typical criteria to determine overhaul time due to abrasion erosion in the IEC 62364 standard will be followed.

The EPC Contractor shall also specify the minimum remaining coating thickness requiring repair or recoating.

**1.1.17.9.7 Technical Requirements/ submittals by EPC Contractor**

The EPC Contractor shall submit the following for the Employer’s review:

- Method Statement for coating application
- Surface Preparation procedure
- Surface Roughness Measurement procedure
- Coating Material Specification
- Coating Chemical composition



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- Hardness test reports
- Bond Strength test reports
- Porosity test reports
- Coating Thickness measurements
- Erosion Resistance test results
- Cavitation Resistance test results
- Quality Control procedure
- Coating Inspection and Acceptance procedure
- Repair procedure for damaged coating
- Quality Certificates from the coating Manufacturer

All coating parameters shall comply with internationally recognized standards.

**1.1.17.9.8 Technical Requirements/ submittals by EPC Contractor**

The EPC Contractor shall be fully responsible for achieving the guaranteed turbine efficiency, reliability, availability, abrasion resistance, and service life under the actual sediment conditions encountered at the Project.

The selection of coating material, coating thickness, application process, coating quality and protected areas shall remain entirely the EPC Contractor's responsibility.

Any abnormal coating failure, delamination, excessive erosion, or loss of hydraulic performance during the Defects Notification Period attributable to inadequate coating design, material selection, application process, Quality Control or workmanship shall be rectified by the EPC Contractor at no additional cost to the Employer.

The EPC Contractor shall also guarantee that the coating system shall not crack, peel, blister, or delaminate under normal operating conditions during the Defects Notification Period.

### 1.1.17.10 Coating Requirements for Spare Parts of Turbine Water Passage Components

As per Sub-Clause 1.1.20.2, Mandatory Spare Parts, Technical Provisions, Part-II, Volume-II of RFP/EPC Bidding Document. The EPC Contractor shall ensure that all spare parts supplied under the Contract for the hydraulic water passage components are provided with the same erosion-resistant coating system as the corresponding installed components.

The coating material, application process, coating thickness, Quality Control requirements, inspection requirements and acceptance criteria for the spare parts shall be identical to those applied to the permanent Works parts.

The requirement shall include, but not be limited to, spare parts for the following components but not limited to,

- Turbine Runner
- Turbine Guide Vanes
- Turbine Facing Plates
- Turbine Wearing Rings
- Turbine Labyrinth Rings



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- Other coated hydraulic components supplied as recommended or mandatory spare parts.

The EPC Contractor shall adequately protect the coated spare parts during manufacturing, transportation, handling, and storage to prevent mechanical damage, corrosion, contamination, or deterioration of the coating prior to installation.

No additional payment shall be made for coating of spare parts to the EPC Contractor, and all associated costs shall be deemed to be included in the Proposal Price.

The EPC Contractor shall provide appropriate protective packing and handling procedures to ensure that the coating integrity of spare parts is maintained throughout storage till installation.

#### 1.1.17.11 Alternative Coating System – Submission, Evaluation and Approval Requirements

The Employer/Employer's Representatives may consider an alternative coating system proposed by the EPC Contractor, subject to the completion of a detailed sedimentation study and assessment of the actual sediment characteristics and operating conditions at the Project. Such alternative coating shall only be considered subject to the EPC Contractor demonstrating, through adequate technical documentation and satisfactory test results, that the proposed alternative provides performance equivalent to or superior to that of the specified hard coating system.

Any such alternative proposal shall be submitted for the Employer review and approval prior to its implementation and shall, as a minimum, include complete technical details of the proposed coating system, manufacturer's technical data, applicable standards and test procedures, coating thickness, surface preparation requirements, adhesion/bond strength, hardness, abrasion and erosion resistance, chemical and environmental resistance, expected service life, application procedure, quality control requirements, inspection and testing records, and relevant references demonstrating successful application under comparable hydropower operating conditions

The EPC Contractor shall also provide documented evidence from the coating manufacturer and/or an independent accredited testing laboratory confirming the suitability and performance of the proposed alternative under sediment-laden water conditions representative of the Project. Where considered necessary, the Employer may require additional laboratory testing, qualification testing, or verification of the proposed coating system prior to granting approval.

It is emphasized that acceptance of an alternative coating system shall be subject to the Employer satisfaction that the proposed solution does not compromise the durability, reliability, hydraulic performance, maintainability, or intended service life of the equipment. The EPC Contractor shall remain fully responsible for demonstrating the technical equivalence or superiority of the proposed alternative and for ensuring its compatibility with the base material and the operating conditions of the equipment.



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**Summary of Pre-Proposal Clarifications Requested from Potential Proposers and Replies by AHMC on Volume-I, Volume-II and Volume-III of RFP/EPC Bidding Documents for Package-III Electro-Mechanical Works of ALHPP**

| Sr. No. | Reference Sub-Clause | Clarification Description requested from Proposers | Replies by AHMC |
|---|---|---|---|
| **1. Proposer M/s CDigital (PVT) Limited Clarifications** | | | |
| **Clarification No. 01 on April 13, 2026** | | | |
| **Technical Provisions** | | | |
| TP-1 | 2026-03-11 PKG III Technical Provisions Generator bearing type specification<br>3.1.17 Bearings Page 3-6 | What backing material type and specifications are required? What are maximum allowable thrust pad pressure and temperature limits? | The conventional material combination of white metal and steel backing shall be used as specified under the requirements of RFP/EPC Bidding Document.<br>The maximum allowable thrust pad pressure and temperature limits shall be as per applicable International Standards allowable limits. |
| TP-2 | 2026-03-11 PKG III Technical Provisions<br>3.2 Excitation System<br>Page 3-20 to 3-22<br>Generator excitation system type and redundancy | Is the architecture explicitly 1-out-of-2 voting or could it be 2-out- of-3? What are the specified fault detection and failover response times? | The excitation system shall be provided with a dual-channel redundant digital excitation controller. The redundancy philosophy and operational requirements shall be as follows:<br>1. **Redundancy Philosophy:** The system shall be based on a 1oo2 (one-out-of-two) redundant configuration, consisting of one active (duty) channel and one standby (hot standby) channel.<br>2. **Voting / Arbitration Logic:** The system shall include automatic health monitoring and arbitration logic to detect failure or abnormal behavior of the active channel. Upon detection, control shall be transferred to the standby channel without disturbance to Generator Operation.<br>3. **The synchronization Between Channels:** Both channels shall operate in fully synchronized mode, with continuous tracking of all input signals, reference values, limiter outputs, and internal states to ensure bump less transfer during switchover.<br>4. **Changeover Protocol:** |



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| Sr. No. | Reference Sub-Clause | Clarification Description requested from Proposers | Replies by AHMC |
|---|---|---|---|
| | | | Automatic Changeover: The system shall automatically transfer control to the standby channel in case of failure of the active channel.<br>Manual Changeover: Provision shall also be available for manual selection/changeover between channels during operation or maintenance.<br>The final specification and philosophy shall be finalized during the design stage subject to the Employer's approval. |
| TP-4 | 2026-03-11 PKG III Technical Provisions 3.10 Cables Page 3-60 to 3-63. | Shall cables use XLPE or EPR insulation? Are fire retardant (IEC 60331-1) or fire resistance (IEC 60332) characteristics required, and what is the difference in the Contractor's scope? Shall armor be copper or steel, and shall single or double armoring be applied? What armor grounding continuity and bonding requirements must be met | As specified in Sub-Clause 3.10.3.1, all MV cables shall be XLPE insulated with LSZH sheath, and LV/Control cables shall also be LSZH, in line with IEC 60502. The same Sub-Clause requires fire-retardant or fire-resistant cables as applicable, with fire-resistant cables for critical circuits as per IEC 60331. It is further stated that copper conductor and armouring shall be used, and all cable armour shall be properly earthed and bonded with full continuity throughout the system. The final detailed specification shall be finalized during the detailed design stage subject to the approval of Employer. |
| TP-5 | 2026-03-11 PKG III Technical Provisions<br>3.7.6 Batteries Page 3-49 to 3-51<br>DC/UPS battery technology and autonomy period | • What is the minimum required DC system autonomy duration in hours at full load without AC mains? | 10 hours minimum DC system autonomy duration at full load without AC mains shall be provided. |
| TP-6 | 2026-03-11 PKG III Technical Provisions 3.4.4 Functional Specifications Page 3-27 Transformer cooling type and OLTC operation mode | At what winding temperature (in °C) shall ONAF cooling fans automatically engage? Shall fans be modulating or full on-off? What is the OLTC stepping time and maximum motor torque requirement? Shall the 132 kV neutral be solidly earthed at the | The cooling fan design will be proposed by the Transformer Manufacturer and will be finalized during detail design stage.<br>The star point of the 132 kV windings shall be solidly earthed as specified in the RFP/EPC Bidding Document. |



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| Sr. No. | Reference Sub-Clause | Clarification Description requested from Proposers | Replies by AHMC |
|---|---|---|---|
| | | transformer star point, or via a separate neutral earthing transformer? | |
| TP-7 | 2026-03-11 PKG III Technical Provisions 3.5.1 Scope Switchgear insulation type (GIS vs AIS) and IP rating | Shall the 11 kV switchgear be air-insulated (AIS) or gas-insulated (GIS), and what is the rationale? What minimum IP rating is required for the installed environment (indoor powerhouse)? Shall the design be modular cubicles or a single integrated unit? What arc-flash incident energy level (in kA at 12 inches) must be declared? | The 11 kV Switchgear shall be SF6 type for generating units. All other except units shall be vacuum type. The IP rating and the other arrangement detail shall be finalized during the detailed design stage subject to the approval of Employer. |
| TP-8 | 2026-03-11 PKG III Technical Provisions §4.5.1 Plant Control System (PCS) Page 4-4 SCADA/HMI software vendor and licensing model | Which SCADA/HMI platform is mandatory (FactoryTalk, InduSoft, Wonderware, or open)? Shall perpetual, unrestricted source code escrow be provided for all software? How many concurrent operator licenses and engineering licenses shall be included? What is the required software support and maintenance SLA period? | The PCS software shall be Microsoft Windows based in accordance with the applicable International Standards. The other details will be finalized during detailed design stage subject to the approval of Employer. |
| TP-9 | 2026-03-11 PKG III Technical Provisions 3.1.14 Fire Protection System Page 3-5 Fire detection and suppression system type in generator | Which specific inert gas medium is mandated (CO2, N2, FM200, Novec)? What is the activation sequence and logic for inert gas and water spray | The Generator Fire Protection System shall comply with the requirements of NFPA 851 and relevant NFPA standards. The inert gas, fire detection sensor type and system operation shall be finalized during the detailed design stage subject to the approval of Employer. A multi-criteria fire detection system and both automatic and manual activation with safety interlocks shall be provided. The final specification and system philosophy shall be finalized during the detailed design stage subject to the approval by the Employer. |



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| Sr. No. | Reference Sub-Clause | Clarification Description requested from Proposers | Replies by AHMC |
|---|---|---|---|
| TP-12 | 2026-03-11 PKG III Technical Provisions<br>3.4.4 Functional Specifications Page 3-27<br>Transformer oil preservation and conservator type | Shall a Buchholz relay with gas-oil discriminator be provided as a separate device? What material and expected service life (in years) shall be specified for the conservator diaphragm? What nitrogen blanket pressure (if any) shall be maintained above the oil surface, and what is the initial charge pressure when the transformer is cool? What is the air breather desiccant replacement interval? | The Double Float Buchholz Relay with Ground-Level Gas Sampler shall be provided.<br>Diaphragm material shall be NBR with minimum expectancy life of 20 years.<br>Generally, 0.05 to 0.07MPa pressure shall be used.<br>Maintenance-Free Breather (Electronic) type shall be used.<br>However, all these details shall be reviewed and finalized during detailed design stage subject to the approval of Employer. |
| TP-13 | 2026-03-11 PKG III<br>Technical Provisions<br>§3.5.7 Circuit Breaker<br>Page 3-37 onwards<br>Circuit breaker tripping time and auxiliary power supply | What is the maximum circuit breaker tripping time (from trip command to contacts separated) in milliseconds? What DC supply voltage (110V, 125V, or 220V) shall be used for trip coils, and shall automatic changeover between normal and DC backup supply be provided? What is the mechanical life expectancy in number of operations (at rated current and lightning impulse levels)? | The DC supply voltage shall be 220 VDC as specified under the requirements of RFP/EPC Bidding Document.<br>All other details shall be varied from manufacturer to manufacturer and will be reviewed and finalized during detailed design stage subject to the approval of Employer. |
| TP-15 | 2026-03-11 PKG III<br>Technical Provisions<br>1.2.6 Pressure Oil System Page 1-24<br>Governor oil pressure system filtering and contamination limits | What is the required oil cleanliness class (ISO 4406 code) that must be maintained in the governor pressure system? Shall a 5- micron or 10-micron filter be placed on the main pump discharge, and shall a return-line or offline filtration system be provided?<br>What is the maximum allowable particulate contamination (particles >4µm, >6µm, >14µm per ml) before remedial action is required? Shall oil condition monitoring (trend analysis) be mandatory? | 1. 10 µm is recommended<br>2. Particulate size Should be less than 6 µm<br>However, it will be finalized during detailed design stage subject to the approval of Employer. |



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| Sr. No. | Reference Sub-Clause | Clarification Description requested from Proposers | Replies by AHMC |
|---|---|---|---|
| TP-16 | 2026-03-11 PKG III Technical Provisions<br>6.23.3.9 Grounding System Page 6-148 onwards<br>Protection system grounding (IEEE 80 vs IEC 62305) and touch voltage limits | Shall the grounding system be designed per IEEE 80 (for AC systems) and/or IEC 62305 (for lightning protection)? What soil resistivity (ρ) shall be assumed for design, and what is the measured soil resistivity at the site? What are the acceptable step and touch voltage limits for personnel safety (at 50 kg body weight)? What is the required grounding electrode resistance to remote ground, and what is the testing interval post-commissioning? | Please note that grounding calculations and grounding mesh activity will be performed by the EPC Contractor of Package-I: Civil & Auxiliary Services Works and the same has been mentioned in the RFP/EPC Bidding Document and the same shall be followed. |
| TP-17 | 2026-03-11 PKG III Technical Provisions 1.6.3.1 Hydraulic Hoist Page 1-17 onwards Hydraulic hoist cylinder lifting and lowering speed specification | What lifting speed is required (mm/s), and what is the maximum operating pressure of the hydraulic system? Shall lowering be controlled (counterbalance valve) or free-fall, and what is the maximum descent speed? What is the pressure relief setting, and shall a pilot-operated relief protect against overload? How many hand pump strokes are needed per lift cycle, and over what height range shall lifting be possible? | It shall be provided by the Proposer as per International Standard and good engineering practice. |
| TP-18 | 2026-03-11 PKG III Technical Provisions<br>4.9.4 Data Acquisition and HMI Functions Page 4-21 onwards<br>SCADA cyber security requirements and IEC 62443 level | What is the required IEC 62443 Security Level (SL1–SL4)? Shall multi-factor authentication (MFA) or single-factor (username/password) be used for operator access? What is the minimum audit log retention period (days/years)? Shall SCADA traffic be encrypted (AES-256 or equivalent), and shall TLS 1.2+ be mandatory for remote access? Shall intrusion detection/prevention systems be provided? | The IEC 62443 Security Level SL-3 shall be required. The other details related to the PCS software, data acquisition and firewall system will be finalized during the detailed design stage subject to the approval of Employer. |



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|---|---|---|---|
| TP-19 | 2026-03-11 PKG III Technical Provisions<br>3.11 Emergency Diesel Generating Units (EDG) Page 3-56 onwards<br>Alternate energy source (fuel type and capacity) for EDG system | What fuel type (diesel, natural gas, or dual-fuel) shall the EDG use? What is the required fuel tank capacity to provide autonomy for how many hours of continuous operation at 75% load? What is the starting battery capacity (Ah) and number of cells? Shall there be interlocks between EDG startup and main circuit breaker position? What is the load shedding sequence, and are there priority classifications for essential vs non-essential loads? | The equipment titled Emergency Diesel Generating Units (EDG) which clearly specified the fuel type. Other details shall be finalized during detailed design stage subject to the approval of Employer after analyzing the load list and details by the Manufacturers. |
| TP-20 | 2026-03-11 PKG III Technical Provisions<br>2.2 Cooling Water System Page 2-1 onwards<br>Auxiliary water system pump redundancy and treatment method | Shall the cooling water pumps be duty/standby (N+1 redundancy) or single-pump design? What raw water quality standards (turbidity, pH, total dissolved solids, bacterial count) shall be assumed? Shall the system include 5-micron filtration, chemical pre-treatment (scale inhibitor, biocide), or UV sterilization? What is the design heat rejection load (MW) that the cooling system must handle at rated conditions? What pressure class (PN6, PN10, PN16) shall raw water piping be rated for? | It has been clearly mentioned in the RFP/EPC Bidding Document that the detailed studies for the design of the Cooling Water System as per requirement of Power Plant will be carried out by the Proposers. |
| TP-21 | 2026-03-11 PKG III Technical Provisions<br>4.9.3 Metering and Billing Functions Page 4-20 onwards<br>Metering transformer accuracy class and measurement uncertainty | What accuracy class (e.g., 0.2, 0.5 per IEC 61869) is required for current transformers and voltage transformers used in the metering system? Shall the metering system comply with revenue-grade accuracy or utility standards? What is the acceptable overall measurement uncertainty (±0.5% or ±1.0%)? Shall the metering panel record real energy, reactive energy, and harmonic distortion energy separately? | Please follow the requirements of the RFP/EPC Bidding Document as specified under applicable latest International Standards. The metering system shall comply with revenue-grade accuracy. |



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| Sr. No. | Reference Sub-Clause | Clarification Description requested from Proposers | Replies by AHMC |
|---|---|---|---|
| TP-22 | 2026-03-11 PKG III Technical Provisions<br>3.10 Cables Page 3-60 onwards<br>Control cable type and fiber optic vs copper specification | What cable type/category/fiber mode required for analog control signals? What is minimum separation distance from HV power cables? | The fiber mode shall be used as specified under the requirements of the RFP/EPC Bidding Document. Furthermore, distances from HV Power cables shall be followed as per allowable limits specified under International Standards specified in the RFP/EPC Bidding Document. |
| TP-23 | 2026-03-11 PKG III Technical Provisions<br>1.1.6 Speed and Balance Page 1-3<br>Runaway speed calculation assumptions and mechanical stress limits | Is runaway speed (655 rpm) based on simultaneous MIV+guide vane closure failure or MIV failure alone? What material yield strengths (MPa) apply to runner/shaft/stay ring? Shall dynamically stress amplification factor be applied? | 1. It will be based on MIV+Guide vane closure failure as Worst Case scenario<br>2. Should be same 2/3 of material yield strength.<br>3. Yes, dynamically stress amplification factor will be applied in the calculations |
| TP-24 | 2026-03-11 PKG III Technical Provisions<br>6.3 132kV Remote End Page 6-35 onwards<br>Switchyard 132 kV earthing transformer requirements | Shall the 132 kV neutral point be directly connected (solidly earthed) to a grounding electrode, or shall a separate earthing transformer be provided? If an earthing transformer is required, what is its kVA rating, and what is the impedance (ohms, %)? Shall the earthing point be directly grounded or protected by a neutral grounding resistor, and if so, what resistance value (ohms) limits earth-fault current to acceptable levels? | 132 kV neutral point shall be directly connected (solidly earthed) to a grounding electrode. No separate earthing transformer or neutral grounding resistor is required. |
| TP-25 | 2026-03-11 PKG III Technical Provisions<br>1.1.16.3 Cavitation Guarantees Page 1-11<br>Turbine cavitation guarantees and damage evaluation criteria | What is acceptable cavitation erosion rate (mg/h or mm/year)? What is maximum pit depth after 1 year? At what sigma is damage unacceptable? What inspection method is required? | The EPC Contractor, will provide Cavitation Guarantees as per International Standard IEC 60609-1. |



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| Sr. No. | Reference Sub-Clause | Clarification Description requested from Proposers | Replies by AHMC |
|---|---|---|---|
| TP-26 | 2026-03-11 PKG III Technical Provisions<br>3.1.15 Cooling System Page 3-5 to 3-6<br>Generator cooling water system material compatibility and treatment | Shall the cooling water be treated (demineralized, pH-buffered) or raw lake water? What cooling water quality limits (conductivity µS/cm, pH, total hardness mg/L) must be met to prevent cooler fouling and corrosion? Shall cooler tubes be aluminum, stainless steel (304/316), or cupronickel (90/10)? What fouling factor (m²K/W) is assumed for cooler sizing, and what is the minimum heat transfer coefficient (W/m²K)? | In Sub-Clause 1.5.1 Cooling Water System of Technical Provisions Part-II Volume-II of RFP/EPC Bidding Document of Package-III, It is specified that the Open loop cooling system has been foreseen; however, the EPC Contractor shall be required to carry out his own water, petrographic and sedimentation analysis where necessary for verification and confirmation of contractual guarantees. The EPC Contractor shall be required to take sedimentation into consideration in the design of the cooling water system. The cooler tubes shall be made of titanium material. Other data will be finalized during detailed design stage subject to the approval of Employer. |
| TP-27 | 2026-03-11 PKG III Technical Provisions<br>3.4.4 Functional Specifications Page 3-27<br>Transformer on- load tap changer (OLTC) manual control interface and settings | Shall OLTC tap control be local (at the transformer) or remote (from central control room)? What is the tap position feedback mechanism (resolver, absolute encoder, or mechanical counters)? What is the minimum time delay between consecutive tap changes to prevent hunting and transformer stress? Shall remote indication of the current tap position and secondary voltage be provided to the control system? What are the mechanical limits (forward/reverse bounds) to prevent tap position overflow? | The OLTC shall be fully automatic operated with provision of remote and local manual operation as specified in the RFP/EPC Bidding Document. |
| TP-28 | 2026-03-11 PKG III Technical Provisions<br>3.1.20.4 Unit Reliability Run Test Page 3-8<br>Commissioning test duration and performance guarantee test procedure | Is 24-hour test continuous or accumulated? What defines a defect requiring re-test (e.g., bearing temp >60°C, vibration >10 mm/s)? Are performance guarantee tests part of commissioning or separate? | The Proposer is required to follow the requirements of RFP/EPC Bidding Document.<br>Any other details shall be finalized during detailed design stage subject to the approval of Employer. |



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| Sr. No. | Reference Sub-Clause | Clarification Description requested from Proposers | Replies by AHMC |
|---|---|---|---|
| TP-29 | 2026-03-11 PKG III Technical Provisions<br>4 Plant Control and Instrumentation System Page 4-1 onwards<br>Operation and Maintenance training scope and location | How many trainees shall be trained for each discipline (operations, mechanical maintenance, electrical maintenance), and shall training be at the OEM factory, on-site, or both? What is the total training duration (man-days), and what are the specific modules to be covered (e.g., SCADA operation, turbine maintenance, protection relay settings)? Shall training materials be in English, Urdu, or both? Shall annual refresher training be provided, and if so, for how many days? | The EPC Contractor shall provide comprehensive training for operation and maintenance personnel. As a minimum, 5–8 trainees per discipline (Operations, Electrical, Mechanical, I&C) shall be at both OEM works and Project site, with a minimum duration of 1–2 weeks per system, covering operation, maintenance, troubleshooting, and safety. ] The training shall be conducted in English language. The detailed training plans shall be submitted for Employer's review and approval. |
| TP-30 | 2026-03-11 PKG III Technical Provisions<br>3.4.8 SERGI Transformer Fire Protection System Page 3-28<br>Transformer fire protection system activation logic and response time | How does the SERGI system detect faults: by monitoring the rate of pressure rise (bar/s) or absolute pressure threshold (bar)? Shall activation require a single sensor signal or dual-sensor coincidence logic? What is the gas injection response time (milliseconds) from detection to gas release? Shall manual activation (via push-button or remote) be available when the transformer is in service? How is the system reset after discharge, and what is the lead time for recharge? | The Proposer's queries are irrelevant at this stage. The SERGI design will be coordinated with the Transformer Manufacturer. These details shall be finalized during detailed design stage subject to the approval of Employer. |
| TP-31 | 2026-03-11 PKG III Technical Provisions<br>6.1 Scope of Work — 132 kV Switchyard and 132 kV Line End Bays Page 6-2 (BD-ALHPP-03 (V2-II))<br>Switchyard civil works — control house building and main ground grid | Please confirm: (a) that the construction of the 132 kV switchyard control house itself (foundations, walls, roof, doors, windows, HVAC, lighting, and internal fit-out up to the finished slab ready to receive E&M cabinets) is wholly within Package-I (Civil Contractor) scope; and (b) that the buried main ground grid of the 132 kV switchyard (ground mat conductors, ground rods, earth pits, riser straps up to each | The scope of construction of 132 kV Switchyard, Control House building, Grounding, HVAC and Lighting system etc. has been covered under EPC Contractor of Package-I: Civil & Auxiliary Services Works.<br>The protective earthing connections from grounding mesh/risers to equipment/metallic structures and lightning protection of 132 kV Switchyard bays shall be the responsibility of Package-III EPC Contractor. |



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| | | equipment's earthing pad, and the soil-resistivity<br>/ Grid-resistance / touch-and-step voltage measurements) is wholly within Package-I scope, with Package-III (E&M) responsible only for the final protective earthing connection from each piece of equipment to the Package-I-supplied riser strap. If either (a) or (b) is, in whole or in part, within Package-III scope, please specify which sub-items and identify the governing civil specification sections and design criteria to be followed. | |
| **Specific Provisions** | | | |
| SP-2 | Attabad Lake Hydropower Project (54 MW) - EPC Package-III Specific Provisions, March 2026 §1.1.1 Civil Works for 132kV Line End Bays at Remote End<br>1-2<br>132kV Line End Bays civil works scope boundary with Package-I 132kV | If discrepancies are discovered during design review, who formally approves modifications and who bears cost/schedule impacts? | The scope of Remote End Line Bays including Civil works at 132/66 kV Aliabad Regional Grid Station shall be deleted from Package-III. In this regard, an Addendum No. 01 to RFP/EPC Bidding Document shall be issued on EPADS V2.0 in due course of time. |
| SP-3 | Attabad Lake Hydropower Project (54 MW) - EPC Package-III Specific Provisions, March 2026<br>§1.8 Environmental Compliance and §4.2 ESHS Requirements 1-16 to 1-17 and 4-3<br>Environmental permits and NOC responsibility allocation | Is construction-phase Environmental Clearance an Employer responsibility? If NOC issuance is delayed, is this force majeure or Contractor liability? | NOC for the construction phase has already been issued from EPD Gilgit-Baltistan. |
| SP-4 | Attabad Lake Hyd Specific Provisions, March 2026<br>1.11 Mobilization and Demobilization; | Will the contract specify whether equipment pricing is CIF Islamabad, CFR site, or DDP (Contractor pays all duties)? Are | For Equipment Pricing, refer ITP 15.8, “Schedules of Payment for E&M Works (Schedule 1 to 6)” of Proposal forms, Section-IV, Volume- |



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| | Conditions of Contract reference1-18<br>hyrdopower Project (54 MW) - EPC Package-III Import duties, taxes, and VAT/GST | import taxes, customs duties, and VAT the Contractor's liability or are they reimbursable by the Employer? | I of RFP/EPC Bidding Document and please refer Sub-Cause 14.4 (Schedule of Payments) of Particular Conditions of Contract Part B, Special Provisions, Section-VIII, Volume-I of RFP/EPC Bidding Document with any Addenda issued thereto<br>For taxes (Local Direct and Indirect Taxes), please refer Sub-Clause 14.1(b) (The Contract Price) of Particular Conditions of Contract Part B Special Provisions, Section-VIII, Volume-I of RFP/EPC Bidding Document. |
| SP-5 | Attabad Lake Hydropower Project (54 MW) - EPC Package-III Specific Provisions, March 2026<br>§1.13 Contractor Submittals; Conditions of Contract (General)<br>1-20<br>Currency split and exchange rate fluctuation risk | What is the currency composition of the contract price (USD/PKR)? If split, what is the mechanism for exchange rate adjustment if the PKR/USD rate changes significantly during mobilization and construction? | For Currency composition of Contract Price, please refer Sub-Clause 14.15 (Currencies for Payment of Contract Price) of Particular Conditions Part A, Contract Data, Section-VIII, Volume-I of RFP/EPC Bidding Document.<br>For Mechanism of Exchange Rate Adjustment, please refer to Sub-Clause 14.4 (Schedule of Payments) of the Particular Conditions, Part B, Special Provisions, Section-VIII, Volume-I of RFP/EPC Bidding Document together with any addenda issued thereto. |
| SP-6 | Attabad Lake Hydropower Project (54 MW) - EPC Package-III Specific Provisions, March 2026<br>1.11 Mobilization; Conditions of Contract (not provided in Specific Provisions)1-18<br>Advance payment percentage and security requirements | What percentage advance payment will be allowed, and under what conditions (e.g., presentation of bank guarantee covering 100-150% of advance)? Is the advance refundable from monthly progress payments? | For Amount and Further Details related to Advance Payment, please refer Sub-Clause 14.2 “Advance Payment” of Conditions of Contract. (Section VII General Conditions and Section VIII Particular Conditions (Part A, Contract Data and Part B Special Provisions) , Volume-I of RFP/EPC Bidding Document) with any addenda issued thereto. |



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| SP-7 | Attabad Lake Hydropower Project (54 MW) - EPC Package-III Specific Provisions, March 2026 §1.11, §1.13 Contractor Submittals; Conditions of Contract 1-18, 1-20<br>Retention and milestone payment schedule clarity | What is the retention percentage from monthly invoices, and when is it fully released (e.g., at Taking-Over Certificate issuance, or after DNP completion)? Is there interest earned on retention? | •Percentage of Retention Money from each Invoice/Milestone has been mentioned at Sr. No. 31 Sub-Clause 14.3(iii), Part-A Contract Data, Section VIII, Particular Conditions, Volume-I of RFP/EPC Bidding Document<br>For Release of Retention Money Refer to Sub-Clause 14.9 of Section VII General Conditions, Volume-I, RFP/EPC Bidding Document (FIDIC Silver Book 2017 Second Edition Reprinted 2022) and Sub-Clause 14.4 Schedule of Progress Payments Part-B Special Provisions, Section VIII, Particular Conditions, Volume-I of RFP/EPC Bidding Document. |
| SP-8 | Attabad Lake Hydropower Project (54 MW) - EPC Package-III Specific Provisions, March 2026<br>1.15.6 Tests on Completion (Schedule section not provided in detail); Conditions of Contract<br>1-38 onwards Liquidated damages for schedule delay and performance shortfall | What are the liquidated damages rates for schedule delay (e.g., per day per MW output)? Is there a cap on total LD exposure? Are there separate LDs for efficiency shortfall or generation shortfall vs. availability shortfall? | Please refer to Table-1: Time Schedule for Delay Damages for Delayed Completion of Units and Sub-Clause 7.10: Performance Guarantees under Part-B Special Provisions, Section VIII Particular Conditions Volume-I RFP/EPC Bidding Document, for the applicable provisions on delay damages related to unit completion. |
| SP-9 | Attabad Lake Hydropower Project (54 MW) - EPC Package-III Specific Provisions, March 2026<br>1.15.3 Testing and Verification of Performance and Guarantees; §1.13.23.1 Factory Acceptance Tests<br>1-34, 1-38<br>Performance guarantees for turbine efficiency and generator output | What is the guaranteed minimum turbine efficiency (%) and generator output (MW) at rated head? If shortfall occurs, must Contractor replace turbine at no cost? | The requirements of Sub-Clause 7.10 “Performance Guarantees of Volume-I of RFP/EPC Bidding Document shall prevail. |



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| SP-10 | Attabad Lake Hydropower Project (54 MW) - EPC Package-III Specific Provisions, March 2026<br>1.10 Joint Operation and Defect Notification Period; §1.15.2 Tests on Site<br>1-17, 1-38<br>Warranty and defect liability period trigger and duration | Does 2-year DNP commence from first Taking-Over Certificate or when all units are operational? Do defects found in 720-hour tests extend DNP? | Refer to Sub-Clause 1.15.2 Tests at Site, Part-I, Specific Provisions, Volume-II of RFP/EPC Bidding Document for Commencement / Start of DNP<br>For extension of DNP, refer to Sub-Clause 11.3 (Extension of Defect Notification Period) of Section-VII General Conditions, Volume-I, RFP/EPC Bidding Document (FIDIC Silver Book 2017 Second Edition Reprinted 2022).<br>Warranty of equipment, if provided more than DNP by the manufacturer, then warranty of manufacturer will prevail. |
| SP-11 | Attabad Lake Hydropower Project (54 MW) - EPC Package-III Specific Provisions, March 2026<br>1.6 Provision of Field Camps and Offices; 1.11 Mobilization 1-8 to 1-9, 1-18<br>Employer-furnished items and site facilities scope | Will WAPDA provide: (a) main access road maintenance and winter snow clearance; (b) grid power connection point and capacity available to contractor camps; (c) water supply from civil works; (d) security perimeter/checkpoints? If Contractor must build all from scratch, what is the estimated cost impact? | Refer to Section 1.6 (Provision of Field Camps and Offices and Operating \Facilities) of Part-I, Specific Provisions, Volume-II of RFP/EPC Bidding Document wherein duties / responsibilities of EPC Contractor have been clearly described.<br>Cost of these facilities shall be borne by EPC Contractor in accordance with Sub-Clause 1.11 (d) (Mobilization Demobilization) of Part-I, Special Provisions, Volume-II of RFP/EPC Bidding Document. |
| SP-12 | Attabad Lake Hydropower Project (54 MW) - EPC Package-III Specific Provisions, March 2026<br>1.6.3 Security; 1.6.2 Workforce composition (not explicitly detailed) 1-9<br>Site security and military clearance for foreign personnel | Who obtains military clearance and ISI/IB security vetting for foreign contractor personnel? How many foreign expats are allowed on-site? What is the timeline for visa processing, and if visas are denied, is this treated as force majeure or Contractor liability? | Refer to Sub-Clause 4.21 (Security of Site) of Part B Special Provisions, Section VIII, Particular Conditions, ,Volume-I of RFP/EPC Bidding Document, security of Foreign Experts shall be responsibility of EPC Contractor. |



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| SP-13 | Attabad Lake Hydropower Project (54 MW) - EPC Package-III Specific Provisions, March 2026<br>4.2 ESHS Requirements; Table 4-1 Contractor's Staff for ESHS 4-3 to 4<br>Local content and minimum Pakistani workforce percentage | Is there a mandatory minimum percentage of local GB workforce? Are there targets for hiring from specific districts (Hunza, Nagar)? If targets are missed, what are the consequences (LDs, rejection of workers)? | There is no mandatory minimum percentage or fixed quota prescribed in the RFP/EPC Bidding Document for the engagement of local Gilgit-Baltistan (GB) workforce, nor are there district-specific hiring targets for Hunza, Nagar, or any other district. However, the EPC Contractor shall make all reasonable efforts to utilize the available local workforce from the project area, subject to their suitability, qualifications, and availability for the required trades and skills. Engagement of local labor shall be carried out in accordance with applicable laws, labor regulations, and the EPC Contractor's approved staffing plan |
| SP-14 | Attabad Lake Hydropower Project (54 MW) - EPC Package-III Specific Provisions, March 2026<br>4.2.3 Organization and Responsibility; Table 4-1 4-3 to 4-4<br>HSE staffing levels and qualifications HSE | What are the minimum qualifications for each ESHS expert role (degree, certification, field experience)? Are these roles budgeted for the entire construction phase + 2-year DNP, and are costs for these staff included in the Contract Price? | For the minimum Qualification and Experience of the ESHS Experts, please refer to Section 1.3 of Volume-I of RFP/EPC Bidding document (Page No. 3-23).<br>Yes, these roles have been budgeted for the entire construction period + 2-year Defects Notification Period (for DNP, intermittent input only may be considered by the Proposer), and costs for these staff have been included in the Contract Price. |
| SP-16 | Attabad Lake Hydropower Project (54 MW) - EPC Package-III Specific Provisions, March 2026<br>1.7 Quality Assurance/Quality Control; §1.13.21 Inspection and Test Plan 1-13 to 1-15, 1-24 Quality Assurance/QC plan approval and hold points | What is the Employer's target turnaround for approving QA/QC plans? If Employer approval is delayed, does the Contractor get schedule extension? | For Employer's target turnaround for approving QA/QC plans refer to Sub-Clause 5.2.2: Review by Employer of Part-B, Special Provisions, Section VIII, Particular Conditions, Volume-I of RFP/EPC Bidding Document.<br><br>For Extension of Time refer to Sub-Clause 8.5: Extension of Time for Completion Part-B, Special Provisions,, Section VIII, Particular Conditions, Volume-I of RFP/EPC Bidding Document. |



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| SP-17 | Attabad Lake Hydropower Project (54 MW) - EPC Package-III Specific Provisions, March 2026§1.7 Quality Assurance; 1.11.13.2 NCR definition 1-15, 1-29<br>Non-Conformance Report (NCR) resolution and closeout | If Employer does not approve NCR closeout, what is the dispute resolution process? Who bears cost of extended rework? | For Resolution of Disputes Refer to Sub-Clause 21.6 Arbitration, Part-B, Special Provisions, Section VIII, Particular Conditions, Volume-I of RFP/EPC Bidding Document.<br>The EPC Contractor shall be responsible for additional cost to correct Non-Conformance Report under Sub-Clause 4.1 (Contractor's General Obligations), Sub-Clause 5.1 (General Design Obligations), Sub-Clause 11.1 (Completion of Outstanding Work and Remedying Defects) and Sub-Clause 11.2 (Cost of Remedying Defects) of Section VII General Conditions , Volume-I, RFP/EPC Bidding Document (FIDIC Silver Book 2017 Second Edition Reprinted 2022). |
| SP-18 | Attabad Lake Hydropower Project (54 MW) - EPC Package-III Specific Provisions, March 2026<br>1.14.4 WAPDA/NGC Approvals 1-37 WAPDA/NGC<br>approval timeline for switchyard equipment WAPDA/NGC | What is the expected timeline for NGC approval? If NGC approval is delayed beyond Contractor's control, is this force majeure? | The approval from NGC shall not be required due to non-connectivity of ALHPP power generation with NPCC. The approval from Employer and its authorized representatives shall be mandatory. The same will be updated in upcoming Addendum No. 01 to RFP/EPC Bidding Document. |
| SP-19 | Attabad Lake Hydropower Project (54 MW) - EPC Package Specific Provisions, March 2026<br>1.13.23.3 FAT; §1.15.3 Testing and Verification of Performance 1-34, 1-39<br>Testing and commissioning | If during FAT a defect is discovered requiring rework and re-test (adding >10 days), who bears the additional cost? Is there a single allowance for FAT visits (fixed at 40 × 10 days), or is each additional day billable? | The approval from NGC shall not be required due to non-connectivity of ALHPP power generation with NPCC. The approval from Employer and its authorized representatives shall be mandatory. The same will be updated in upcoming Addendum No. 01 to RFP/EPC Bidding Document.<br>1. The stated approximately forty (40) FAT/Inspection visits are indicative only. The actual number of FAT/Inspection visits may vary depending on manufacturing schedule and equipment readiness. No separate payment shall be made |



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| | | | to EPC Contractor for any increase in number of FAT/Inspection visits.<br><br>2. Each FAT/Inspection visit shall be for up to ten (10) days including travel days. Actual duration may be shorter or longer depending on test scope. The EPC Contractor shall accommodate reasonable variations without additional cost to the Employer.<br><br>3. If any test is required to be repeated due to EPC Contractor's failure or Non-Compliance, all additional costs shall be borne by the EPC Contractor. |
| SP-21 | Attabad Lake Hydropower Project (54 MW) - EPC Package-III Specific Provisions, March 2026<br><br>1.10 Joint Operation and Defect Notification Period; §1.13.23.1 O&M Training 1-17, 1-33 Post-commissioning O&M support and staff duration | What is the minimum Contractor staffing required during 2-year DNP? Minimum numbers for operators, engineers, technicians? | It will be proposed by the Proposer as per requirements specified in RFP/EPC Bidding Document. |
| SP-22 | Attabad Lake Hydropower Project (54 MW) - EPC Package-III Specific Provisions, March 2026<br><br>1.10 JOINT OPERATION AND DEFECT NOTIFICATION PERIOD; §1.8 Environmental Compliance 1-17, 1-16<br><br>Defect correction during DNP and scope limits | If structural defect in penstock (Package-I) causes E&M damage during DNP, who is responsible? Clear scope delineation between packages? | The EPC Contractor shall remain responsible for rectifying defects within its own scope at no additional cost to the Employer. Where defects originate from Civil works and have consequential impact on Electro-Mechanical Works equipment, such matters shall be addressed under the responsibilities of the Civil & Auxiliary Services Works EPC Contractor, with coordination facilitated through the Employer to ensure timely resolution. |



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| SP-23 | Attabad Lake Hydropower Project (54 MW) - EPC Package-III Specific Provisions, March 2026<br>1.2.1.5 132kV AIS Switchyard (item j: SCADA); General Design Criteria 1-4, 1-36<br>Intellectual property and source code escrow for SCADA/protection systems | Will the Contractor be required to provide source code and documentation for SCADA/Protection system software in escrow? If the OEM restricts source code access, what is the Contractor's obligation to the Employer for O&M continuity post-DNP? | The EPC Contractor shall not be required to deposit or provide the source code of the SCADA system software in ESCROW, unless otherwise expressly stated in the Contract.<br>The EPC Contractor shall ensure that the SCADA system (Hardware / Software shall be delivered with open architecture, enabling the Employer (or any third party engaged by the Employer) to perform routine O&M and Troubleshooting etc. The EPC Contractor shall ensure that no proprietary restrictions (including licensing limitations) hinder the Employer's long-term use of the SCADA system. |
| SP-24 | Attabad Lake Hydropower Project (54 MW) - EPC Package-III Specific Provisions, March 2026<br>1.3 Detailed Design and Planning; Conditions of Contract (not provided) 1-5<br>Change orders and variation approval process | Will the Contractor be required to submit a 'Schedule of Rates' for extra work items (e.g., additional transformer bay, extra cable tray)? If Employer-requested changes occur during construction, what is the approval and billing mechanism? | Any deviations from the requirements stated in Volume- II, Part-I, Part-II and Part-III will be dealt in accordance with Clause 13 (Variation and Adjustment) of Section VII General Conditions, Volume-I, RFP/EPC Bidding Document (FIDIC Silver Book 2017 Second Edition Reprinted 2022). |
| SP-25 | Attabad Lake Hydropower Project (54 MW) - EPC Package-III Specific Provisions, March 2026<br>Conditions of Contract (not provided in Specific Provisions) N/A<br>Dispute resolution mechanism and governing law | Will disputes be resolved through international arbitration (ICC, LCIA) or local Pakistan arbitration? If international arbitration, what is the language, venue (Switzerland, Pakistan), and seat of arbitration? | Refer Sub-Clause 21.6 Part A, Contract Data, Section VIII, Particular Conditions, Volume-I of RFP/EPC Bidding Document |



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| SP-26 | Attabad Lake Hydropower Project (54 MW) - EPC Package-III Specific Provisions, March 2026<br>Conditions of Contract (not provided); General Provisions N/A<br>Force majeure definition and delay compensation | Will winter road closure (Oct-May) be treated as force majeure entitling the Contractor to schedule extension with no LD, or is this a known site condition the Contractor must plan around? | The Proposers are deemed to have informed themselves of all local conditions, including accessibility constraints, climatic conditions, and seasonal restrictions, prior to submission of their Proposals (Sub-Clause 4.10 (Use of Site data) and Sub-Clause 4.12 (Unforeseeable Difficulties) of GCC), in accordance with the Instructions to Proposers and Conditions of Contract.<br>Force Majeure events shall be administered in accordance with Clause 18 (Exceptional Events) of the Conditions of Contract. |
| SP-27 | Attabad Lake Hydropower Project (54 MW) - EPC Package-III Specific Provisions, March 2026<br>1.11 Mobilization and Demobilization; §1.13 Contractor Submittals 1-18, 1-20 Mobilization cost and advance payment linkage | If mobilization cost is estimated at 12% of contract value, what advance payment (%) will be available before site mobilization begins? Is there a milestone-based draw schedule (e.g., 10% on NTP, 5% on camp completion)? | Refer to 14.2 (Advance Payment) Part A and Part B of Section-VIII Particular Conditions ,Volume-I, RFP/EPC Bidding Document |
| SP-28 | Attabad Lake Hydropower Project (54 MW) - EPC Package-III Specific Provisions, March 2026<br>1.2.1.2 Power Intake; 1.2.1.4 Draft Tube<br>1-3 to 1<br>-Interface with Package-II Hydro- Mechanical works | What are the specific interface points between E&M (Package-III) and hydro-mechanical (Package-II) works? Clear responsibility matrix for interface defects? | **Package-I** scope of works comprises on the following systems:<br>-Civil works of Project<br>-Penstock<br>-Auxiliary systems (HVAC, Lighting and small power, firefighting and fire detection and alarm system, Sewage system, Elevators, Potable water system, Grounding system, Distribution system for colony etc)<br>**Package-II** Scope of works comprises on the following systems:<br>-132 kV Transmission Line including Remote bays at Sost and Aliabad Regional Grid.<br><br>**Package-III** Electro-Mechanical works comprises on the following systems:<br>All hydro mechanical equipment (Turbine, Generator, Governor, Unit Auxiliaries, MIV, Generator step up |



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| | | | transformer, Auxiliary T/F, and other associated systems) and hydraulic steel structures mentioned in Volume-II.<br><br>**Package-IV** comprises on the following systems:<br>Civil Works for Overflow Weir and Landslide Slope Treatment. Also, note that weir is ungated, no E&M equipment shall be installed. |
| SP-30 | Attabad Lake Hydropower Project (54 MW) - EPC Package-III Specific Provisions, March 2026<br>1.14.4 WAPDA/NGC<br>Approvals; 2.3 General Electrical Requirements 1-37, 2-48<br>Metering and tariff metering point definition | Where will the official generation metering point be located (primary/secondary of step-up transformer, or 132 kV line)? Who will own and maintain the metering equipment post-commissioning? | Tariff metering shall be installed at the 132 kV side (grid interface) of the generator step-up transformer within the 132 kV switchyard. Please refer to Section 6.3.14 of Technical Provisions, Part-II, Volume-II of RFP/EPC Bidding Document of Package-III.<br>Also refer to Conceptual Drawing No. ALHPP-SY-0601, attached in Employers Requirement., Volume-II, Part-III. |
| SP-31 | Attabad Lake Hydropower Project (54 MW) - EPC Package-III Specific Provisions, March 2026<br>1.6.2 Workforce; 4.2.4 ESHS Reporting 1-8 to 1-9, 4-5<br>Subsistence allowance rates and work hour regulations | What are the daily subsistence allowance rates for contractor employees (foreign and local)? Must the Contractor comply with Pakistani labor law work-hour restrictions (8 hrs/day, 40 hrs/week)? | Subsistence Allowance rates for Contractor Employees shall be as per Contractor's Firm Rules.<br>Refer to Sub-Clause 1.1.43 (Laws) of Part B Special Provisions of Section VIII Particular Conditions, Volume-I of RFP/EPC Bidding Document for applicable laws. |
| SP-32 | Attabad Lake Hydropower Project (54 MW) - EPC Package-III Specific Provisions, March 2026<br>1.13 Contractor Submittals; 1.13.23.5 O&M Manuals1-20, 1-35<br>Document submission language and reproduction | Should critical O&M and safety procedure documents be translated to Urdu for non-English speaking site staff to ensure safety compliance? | All Operation and Maintenance Manuals, Training Materials, and related submittals shall be prepared and submitted in English, both in hard copy and electronic formats as well, as specified in the RFP/EPC Bidding Document. The number of copies shall follow Table 1-1 requirement (e.g., (04) copies for review, six (06) copies for final issue, Ten (10) copies for O&M Manuals). No translation of these documents into other languages will be required; |



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| | | | English shall remain the official language for documentation and training. |
| SP-34 | Attabad Lake Hydropower Project (54 MW) - EPC Package-III Specific Provisions, March 2026<br>4.2.3 Organization and Responsibility (Note on C&D waste) 4-4<br>Environmental waste management responsibility and cost | Are C&D waste disposal costs included in the lump-sum contract price, or are they to be reimbursed separately by the Employer? Does this include hazardous waste (oils, solvents, batteries)? | C&D waste disposal cost including the hazardous waste must be included in the overall cost presented by the EPC Contractor. |
| SP-35 | Attabad Lake Hydropower Project (54 MW) - EPC Package-III Specific Provisions, March 2026<br>1.15.6 Tests on Completion; Conditions of Contract1-41<br>Taking-Over Certificate issuance criteria and partial TO | What constitutes a "minor defect" that does not prevent issuance of Taking-Over Certificate? Will partial TO certs be issued when each unit completes 720-hour tests, or only when all units are synchronized? | The EPC Contractor shall be fully responsible for the Testing and Operation of all Project equipment, systems, and facilities until the issuance of the associated Taking-Over Certificate. |
| SP-36 | Attabad Lake Hydropower Project (54 MW) - EPC Package-III Specific Provisions, March 2026<br>1.10 Joint Operation and Defect Notification Period<br>1-17<br>Commercial Operation Date definition and payment trigger | What is the exact definition of Commercial Operation Date (CoD)? Is it the first unit's synchronization with the grid, or the commissioning of all three units? Does final retention payment depend on CoD or on formal Taking-Over Certificate? | The EPC Contractor shall be fully responsible for the Testing and Operation of all Project equipment, systems, and facilities until the issuance of the associated Taking-Over Certificate. |



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| SP-37 | Attabad Lake Hydropower Project (54 MW) - EPC Package-III Specific Provisions, March 2026<br>1.14 General Design Criteria; §3.1 General (Section 3 Basic Design Criteria)1-36, 1-37<br>Design standards selection and approval process | If the Contractor proposes using Chinese (GB/T) standards for steel or valves instead of ASME/ISO, what is the approval turnaround, and will WAPDA accept equivalent standards, or only internationally-recognized ones? | As per RFP/EPC Bidding Document, only International Standards shall be adopted for this Project |
| **Feasibility Review Report (2022)** | | | |
| FRR-1 | 2026-03-11 PKG III VOLIII PART II (FRR)<br>(5-21 to 5-24)<br>Geotechnical – Weir foundation treatment unclear and risky | FRR §5.5.2 identifies unresolved weir foundation issues including risks of excavation-triggered landslides, impracticality of clay blanket placement, and finalization of cutoff wall method. Will the Employer confirm the preferred foundation treatment approach before EPC bidding, or will contractor bear the cost/risk of modifying the design if geotechnical conditions worsen during construction? | It has been clarified that Civil Works related to the Overflow Weir and Landslide Slope Treatment do not fall under the scope of Package-III: Electro-Mechanical Works. The detailed design for Overflow Weir & Landslide Slope Protection Works have been included in Package-IV, which is being undertaken by AHMC and the detailed design studies is currently in progress. |
| FRR-2 | 2026-03-11 PKG III VOLIII PART II (FRR)<br>§5.3.2, §5.4 (Pages 5-16<br>to 5-20) 5-17 to 5-20<br>(Geotechnical Insufficient subsurface investigations recommended before detailed design.) | FRR §5.4 recommends additional boreholes (BH-7 to BH-12) and extensive laboratory testing before detail design. Will the Employer fund and complete these investigations before EPC contract signature, or must the EPC Contractor conduct them at its own cost during detail design? What is the timeline? | It has been clarified that any Additional / Geotechnical investigations specifically required for the installation of Electro-Mechanical equipment under Package-III shall be carried out by the EPC Contractor at its own risk and cost, in accordance with Sub-Clause 1.13.18 of the Specific Provision Volume-II, Part-I of RFP/EPC Bidding Document.<br>However, Geotechnical Investigations related to overall Site Stability, Civil Structures, or foundations fall under the scope of the Package-I: Civil & Auxiliary Services Works EPC Contractor and are not part of Package-III: Electro-Mechanical Works. |



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| FRR -3 | 2026-03-11 PKG III VOL-III PART II (FRR) §6.2, §6.3 (Page 6-1) 6-1 Seismic design parameters unfinalized and require | FRR §6.2-6.3 notes that seismic design parameters (SEE, OBE) are preliminary and require finalization via detailed site-specific seismic hazard assessment, geologic fault mapping, and geophysical surveys. Will the Employer provide updated seismic parameters before EPC design, or must EPC Contractor conduct these studies and bear cost/schedule risk? | It has been clarified that finalization of seismic design parameters, including site-specific hazard assessment, geologic fault mapping, and geophysical surveys, falls under the scope of the Package-I: Civil and Auxiliary Services Works EPC Contractor and are not part of Package-III: Electro-Mechanical Works. The Package-I EPC Contractor will carry out these design studies during the engineering stage. |
| FRR -4 | 2026-03-11 PKG III VOL-III PART II (FRR) §7.5.1 (Pages 7-10 to 7-12) 7-10 to 7-12 Fault zones in tunnel alignment require clarification before excavation | FRR §7.5.1 indicates a fault zone 'assumed' in the headrace tunnel at middle section, but KKH tunnel drawings from parallel section show no fault and only moderately weathered gneiss. Which is correct? Will Employer provide geologic mapping and core data to confirm fault presence/absence before tender, or does EPC Contractor assume design risk for unknown conditions? | Volume-III of the RFP/EPC Bidding Document has been provided as supplementary information to guide proposers. The responsibility for updated geological mapping and confirmation of subsurface conditions rests with the Package-I EPC Contractor (Civil and Auxiliary Services Works), to be undertaken during their detailed investigations. |
| **FRR -5** | 2026-03-11 PKG III VOL-III PART II (FRR) §5.5.2, §7.5.1 (Pages 5-22 to 5-24, 7-10 to 7-15) 5-23; 7-10 to 7-15 Slope stability at surge tank, penstock intake portal, and powerhouse not fully analyzed | FRR Sub-Section 5.5.2 and Sub-Section 7.5.1 identify multiple slopes with incomplete stability analysis: surge tank (no borehole data), intake area, power tunnel portal (sheared rock in seismic zone), and penstock upper reach. Will Employer fund slope stability studies before tender, or does EPC Contractor design at risk with incomplete geotechnical data? | It has been clarified that slope stability analysis at the Surge Tank, Penstock, Intake Portal, and Powerhouse locations do not fall under the scope of Package-III Electro-Mechanical Works. These investigations and analysis will be undertaken during the engineering stage of Package-I Civil and Auxiliary Services Works, as part of the Level-I and Level-II design responsibilities of the Package-I EPC Contractor. |
| **FRR -6** | 2026-03-11 PKG III VOL-III PART II (FRR) §4.6, §9.5 (Pages 4-16 to 4-30, 9-3 to 9-5) 4-30; 9-5 Design flood determination: 20-year vs 10,000-year; GLOF not finalized | FRR §4.11 recommends design flood minimum of 10,000-year return period or GLOF (whichever is greater), but Feasibility Study selected Q20. Also, spillway capacity calculations (~3210 m³/s) are marginal vs design flood (3250 m³/s). Will Employer confirm which design flood | The design flood was adopted as the 10,000-year return period flood, with peak inflow of 3320 cumecs based on the hydrological dataset up to Year 2015. Reservoir routing yielded an outflow of about 3152.8 cumecs, reflecting normal flood attenuation. As noted in the Feasibility Review Report, the EPC Contractor of |



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| | | standard applies and provide GLOF estimate before tender, or does EPC assume risk of design modification? | Package-I: Civil and Auxiliary Services Works will carry out the detailed GLOF assessment and hydrological studies during the detailed design stage. The check flood shall not be less than the 10,000-year return period flood or the GLOF event, whichever is higher, ensuring spillway safety and reliability under climate change considerations. |
| **FRR -7** | 2026-03-11 PKG III VOL-III PART II (FRR) §4.11, §7.5.2 (Pages 4-30, 7-13 to 7-15) 4-30; 7-13 to 7-15 Sediment load and flushing strategy unresolved; tunnel vs undersluice choice pending | FRR §7.5.2 proposes replacing original under-sluices with a new flushing tunnel design, but explicitly states tunnel diameter, discharge capacity, and effectiveness 'must be determined with hydraulic model study'. Will Employer fund this model study before tender and confirm flushing strategy, or must EPC Contractor design and test the flushing tunnel concept at its cost, bearing risk of inadequate sediment removal? | It has been clarified that sediment load assessment and sediment flushing strategy, including the proposed sediment flushing tunnel and related hydraulic model studies, fall under the scope of the Package-I; Civil and Auxiliary Services Works EPC Contractor. The Package-I EPC Contractor will carry out the required design development, revalidation, and testing during the engineering stage as part of their Level-I and Level-II design responsibilities. These technical matters are not part of Package-III: Electro-Mechanical Works. |
| **FRR -8** | 2026-03-11 PKG III VOL-III PART II (FRR) §8.5, §11.1.5 (Pages 8-37, 4-376 to 4-379) 8-37; 4-376 to 4-379 Turbine efficiency: 91.5% vs 93% - cost and capacity impact | FRR §8.5 recommends 93% turbine efficiency vs Feasibility Study's 91.5%, potentially increasing capacity to 57 MW. Will Employer confirm which efficiency and turbine capacity specification applies to the tender: 54 MW at 91.5%, or ~57 MW at 93%? How does this affect generator, transformer, and switchyard equipment sizing? | The Turbine Efficiency must comply with the requirements of RFP/EPC Bidding Document. The efficiency of vertical Francis Turbine shall be 93% as mentioned under Sub-Clause 1.16.2.1.5 Key Technical Parameters of Turbines, Volume-II: Employer's Requirements Part-I: Specific Provisions. |
| **FRR -9** | 2026-03-11 PKG III VOL-III PART II (FRR) §11.1.3 (Pages 4-899 to 4-905) 4-902 to 4-903 Turbine shaft design standard conflict: Indian Standard vs ASTM | FRR §11.1.3 recommends ASTM A668 Class D for turbine shaft instead of Indian Standard (IS 12837, IS 12800). Which standard will the Tender Specifications require? Also clarify coupling arrangement: are turbine and generator shafts separate or | As per RFP/EPC Bidding Document only International Standards shall be adopted for this Project. No Indian standard will be allowed |



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| | | coupled? What are implications for turbine procurement and cost? | |
| **FRR -10** | 2026-03-11 PKG III VOL-III PART II (FRR) §8.4.1, §8.4.2, §8.4.3, §8.5 (Pages 8-7 to 8-37) 8-7 to 8-37 Number of generating units uncertain: 2, 3, or 4 units | FRR §8.4 presents energy calculations for 2-, 3-, and 4-unit options, endorsing 3-unit (54 MW total) as 'most optimized' but providing alternative scenarios. Will Tender Specifications fix the number of generating units at 3, or may EPC Contractors propose 2- or 4-unit alternatives with equivalent capacity? | Please comply with the specifications and requirements set forth in the RFP/EPC Bidding Document. |
| **FRR -11** | 2026-03-11 PKG III VOL-III PART II (FRR) §9.4.1, §9.4.2 (Pages 9-2 to 9-5) 9-3 to 9-4 Weir/spillway discharge capacity margin inadequate vs design flood | FRR §9.4.1 calculates total spillway/under-sluice discharge capacity as ~3210 m³/s vs design flood of 3250 m³/s, a shortfall of ~40 m³/s. FRR notes 'marginal capacity'. Will Employer confirm whether this capacity is adequate, or must spillway be redesigned to accommodate higher flood discharge with safety margin? | The observed difference between inflow (3250 cumecs) and outflow (3210 cumecs) is attributed to flood attenuation within the reservoir (Attabad lake), whereby part of the flood volume is temporarily stored, resulting in a reduction of peak discharge and a corresponding rise in maximum water level. This is a normal and expected hydraulic response of reservoir routing. Furthermore, it has been clearly stated in the Feasibility Review Recommendation, that the detail hydrological study would be taken up by EPC Contractor of Package-I: Civil and Auxiliary Services Works during the detailed design stage, that would be based on updated hydrological data, elevation area capacity based on Year 2025 hydrographic survey and revised spillway rating to ensure to pass the selected design and check flood safely over the weir structure. |



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| FRR -12 | 2026-03-11 PKG III VOL-III PART II (FRR)<br>§7.5.2 (Pages 7-15 to 7-16)<br>7-15 to 7-16<br>Powerhouse location and orientation: original vs proposed (surface vs underground) | FRR §7.5.2 proposes moving powerhouse to higher ground vs original riverside location, and mentions underground powerhouse as seismically superior alternative. Which powerhouse location/type will Tender Specifications require: original riverside surface location, elevated surface location, or underground? What are cost/schedule implications of each option? | It has been clarified that the location and orientation of the Powerhouse, whether surface or underground, fall under the scope of the Package-I: Civil and Auxiliary Services Works EPC Contractor. The Package-I EPC Contractor will revalidate the selected layout during the engineering stage and present the corresponding technical and economic analysis as part of the Level-I and Level-II design responsibilities. |
| **FRR -13** | 2026-03-11 PKG III VOL-III PART II (FRR)<br>§5.5.2, §11.9 (Pages 5- 22 to 5-24, 4-641 to 4-643)<br>5-23; 4-642<br>Penstock design contradictions: piers vs trench; material specification missing | FRR §5.5.2 notes contradictions in penstock design between sections (pier vs trench vs anchor blocks) and §11.9 identifies missing penstock material specification. Recommend ASTM A516 Gr-70. Will Tender Specifications clarify penstock support method (piers, trench, or anchored) and confirm material standard before bidding? | Please comply with the specifications and requirements set forth in the RFP/EPC Bidding Document. |
| **FRR -14** | 2026-03-11 PKG III VOL-III PART II (FRR)<br>§14 (Cost Estimates), §6.5 (Equipment Costs) (Pages 6-510 to 6-545)<br>6-525 to 6-540<br>Hydroelectric equipment cost estimates contain major gaps and unquantified risks | FRR notes cost estimates based on March 2021 rates and contain missing items (intake stoplogs, weir gates, spare parts, workshop equipment). FRR recommends 'detailed cost estimates' vs thumb-rule approach. Will Employer issue updated cost baseline reflecting FRR-proposed changes (alternative layout, flushing tunnel, powerhouse relocation) and 2026 prices before tender? | Please refer to Volume-I and Volume-II of RFP/EPC Bidding Document. |
| **FRR -15** | 2026-03-11 PKG III VOL-III PART II (FRR)<br>§12 (Electrical), §14 (Switchyard) (Pages 5-862 to 6-340)<br>5-887 to 5-968; 6-118 to 6-180<br>Electrical specifications incomplete: transformer | FRR §12 and §14 identify extensive missing electrical specifications: layout drawings, equipment standards (IEC/IEEE/BS/ASTM), cable parameters, MCCs, CT/PT details, tariff metering, SCADA/fiber optic requirements. Will Employer issue updated electrical design basis/technical | Please follow the Technical Specifications as well as Volume-II: Employer's Requirements Part-III: Conceptual Drawings of RFP/EPC Bidding Document. |



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| | ratings, cable parameters, standards missing | specifications before tender, or must EPC Contractor define these details at risk? | |
| **FRR -16** | 2026-03-11 PKG III VOL-III PART II (FRR) §12.10 (Pages 5-951 to 5-977) 5-951 to 5-967 Transformer technical details and ratings unresolved | FRR §12.10 identifies transformer specification issues: (1) 22 MVA rating is 'not standard' and may not align with turbine capacity change (54 vs ~57 MW); (2) recommends ON-Load Tap Changer vs feasibility's OFF-Load (cost impact); (3) Dry Type auxiliary transformers recommended; (4) vector group missing; (5) impedance review needed. Will Tender Specifications be updated to reflect these recommendations? | Please follow the Volume-III Part-II Technical Specifications as well as Volume-II: Employer's Requirements Part-III: Conceptual Drawings. |
| **FRR -17** | 2026-03-11 PKG III VOL-III PART II (FRR) §12.18, §13 (Transmission Line) (Pages 6-118 to 6-425) 6-118 to 6-425 132 kV Switchyard and transmission line capacity/voltage coordination unresolved | FRR §12.18-13 notes switchyard location unfinalized, transformer MVA rating dependent on colony load (data unavailable), and transmission line configuration to be decided by T/L expert. These are interdependent: if T/L capacity changes, switchyard equipment must be revised. Will Employer finalize switchyard location, load requirement, and T/L configuration before tender, or must EPC Contractor design at risk? | Please comply with the specifications and requirements set forth in the RFP/EPC Bidding Document. |
| **FRR -18** | 2026-03-11 PKG III VOL-III PART II (FRR) §12.16, §12.17 (Pages 6-329 to 6-363) 6-329 to 6-363 SCADA and communication system details missing; fiber optic requirements unspecified | What is the final specification and cost allocation for fiber optic SCADA link, CCTV, internet, and LAN systems before tender? | All Specifications have been stated in Volume-II, Part-II (Technical Provisions) of RFP/EPC Bidding Document. |



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| **FRR -19** | 2026-03-11 PKG III VOL-III PART II (FRR)<br>§11 (Environmental & Social), §3.6 (Pages 7-273 to 7-401)<br>7-282 to 7-401 Environmental and resettlement impact assessment incomplete; land acquisition status unclear | FRR §11 identifies land acquisition as 'critical issue' not adequately covered, resettlement framework incomplete, and operational environmental management plan missing. Will Employer confirm land acquisition status, provide resettlement action plan, and specify seasonal construction restrictions before tender? What cost/schedule impact on EPC works? | All land acquisition and resettlement shall be completed by the Employer before EPC Contractor mobilization at site under Package-I. Compensation payment to the locals for their land acquisition will be the responsibility of Employer, and the EPC Contractor has no resettlement obligations.<br>For Environmental Management Plan please refer to Table 9-1 of the EIA Report. |
| **FRR -20** | 2026-03-11 PKG III VOL-III PART II (FRR)<br>§5.6 (Pages 5-26 to 5-27, 3-413 to 3-481)<br>5-26; 3-413 to 3-481 Concrete aggregate and borrow material sources not confirmed; aggregate quality testing limited | FRR §5.6 notes aggregate quality testing is limited, fine aggregate testing incomplete, and sources require confirmation. Recommends ASR testing per ASTM C1260 and C295. Will Employer identify and confirm all borrow areas, quarries, and cement sources before tender, with distance/haul cost data? Or must EPC Contractor select sources during detail design at risk? | It has been clarified that identification and confirmation of borrow areas, quarries, and cement sources will be undertaken by the Package-I: Civil and Auxiliary Services Works EPC Contractor. |
| **FRR -21** | 2026-03-11 PKG III VOL-III PART II (FRR)<br>§4.5, §4.11, §9.2 (Pages 4-6 to 4-30, 9-1 to 9-2)<br>4-8; 4-30; 9-2 Hydrological data outdated: flows study limited to 1966-2015; 2022 flood event not incorporated | FRR §4.11 notes flow study covers 1966-2015 (missing 3 years of recent data) and recommends flows study 'need to be revised/updated during detail design'. Also notes 2022 flood event should be considered. Will Employer fund hydrological update including 2022 flood and recent climate trends before tender, or must EPC Contractor conduct study at its cost? | The flood estimation has been updated using the extended hydrological dataset (1966–2024), and the corresponding peak inflow for the 10,000-year return period has been determined as 3250 cumecs.<br>The flood routing shall be recomputed during the detailed design stage using the updated elevation–area–capacity curves derived from the 2025 topographic and hydrographic surveys, along with the revised spillway rating curve. This analysis will be used to determine the outflow discharge through the spillway and the corresponding maximum flood level rise within the |



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| **FRR -22** | 2026-03-11 PKG III VOL-III PART II (FRR) §4.5.3, §8.2 (Pages 4-13 to 4-15, 8-3 to 8-5) 4-13 to 4-15 Winter flow minimums and minimum flow for turbine operation unconfirmed | FRR §8.2 notes design discharge 60 m³/s available ~6 months; winter flows (Dec-April) are significantly lower. Feasibility mentions turbine operational 'certain limit of low flows' but specific value not stated. Will Employer confirm minimum winter flow data and turbine minimum operational discharge threshold before tender? How does this affect winter generation forecasts? | The hydrological analysis on a daily basis has already incorporated in the Feasibility Review Report (FRR), Volume-III, Part-III of RFP/EPC Bidding Document. |
| **FRR -23** | 2026-03-11 PKG III VOL-III PART II (FRR) §7.5.2 (Pages 7-13 to 7-17) 7-13 to 7-17 Alternative layout proposal creates design and cost uncertainty: not final | 2026-03-11 PKG III VOL- III PART II (FRR) §7.5.2 (Pages 7-13 to 7-17) 7-13 to 7-17 Alternative layout proposal creates design and cost uncertainty: not final | The EPC Contractor of Package-I: Civil and Auxiliary Services Works will revalidate the selected Project layout during the engineering stage and present the corresponding cost analysis as part of the Level-I and Level-II design responsibilities. |
| **FRR -24** | 2026-03-11 PKG III VOL-III PART II (FRR) §5.5.1 (Pages 5-21 to 5-22) 5-21 to 5-22 Rock permeability test incomplete; one borehole shows 100% water loss | FRR §5.5.1 reports extremely high permeability at weir area (100% water loss in BH-01) and recommends Lugeon tests at intake/surge tank during detail design. This affects seepage control, grouting strategy, and foundation treatment cost. Will Employer fund Lugeon testing and confirm seepage control approach before tender? | It has been clarified that geotechnical investigations concerning rock permeability, seepage control, and foundation treatment are part of the Package-I: Civil and Auxiliary Services EPC Contractor's responsibilities and do not fall under Package-III Electro-Mechanical Works. Any investigations required solely for Electro-Mechanical equipment installation under Package-III shall be carried out by the EPC Contractor at its own risk and cost, in line with Sub-Clause 1.13.18 of the Specific Provisions, Volume-II of the RFP/EPC Bidding Document. |
| **FRR -25** | 2026-03-11 PKG III VOL-III PART II (FRR) §7.5.1 (Pages 7-9 to 7-10) 7-9 to 7-10 Construction access and roads - KKH tunnel | FRR §7.5.1 notes headrace tunnel is 65 m perpendicular distance from KKH tunnel at surge tank, and proposes construction via adit with temporary rock plug. Construction access details (road conditions, load limits, KKH coordination, traffic impact) not | The construction of access arrangements, including route selection, road conditions, and traffic management, fall within the scope of the Package-I: EPC Contractor. The EPC Contractor of Package-I will be responsible for providing and maintaining the required access |



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| | proximity and load limits unspecified | specified. Will Employer confirm access route, load-carrying capacity, and KKH traffic management plan before tender? | route and coordinating with relevant authorities to ensure safe construction and traffic management in line with standards specified in Package-I RFP/EPC Bidding Document. |
| **FRR -26** | 2026-03-11 PKG III VOL-III PART II (FRR) §4.3 (Pages 4-3 to 4-5) 4-3 to 4-5 Climate and meteorological data incomplete; snow/rainfall/temperature ranges not finalized | FRR §4.3 notes climate data from Skardu/Gilgit stations (not site-specific) and wind speed assumed at 100 km/hr. No site-specific temperature extremes, snow conditions, or rainfall intensity for construction planning. Will Employer provide one year of site- specific meteorological data (temperature, wind, snow, rainfall) before tender to support construction planning? | The Employer has provided climatological data in Sub-section 4.3 of the Feasibility Review Report pursuant to Sub-Clause 2.5 (Site Data and Items of Reference) of the Section VII General Conditions. (Climatology) Volume-I, RFP/EPC Bidding Document. Notwithstanding the foregoing, pursuant to Sub-Clause 4.10 (Use of Site Data) and Sub-Clause 4.12 (Unforeseeable Physical Conditions) of Section VII General Conditions, Volume-I RFP/EPC Bidding Document, the Proposer shall be solely responsible for obtaining and satisfying itself as to all data and information necessary for the execution of the Works. |
| **FRR -27** | 2026-03-11 PKG III VOL-III PART II (FRR) §11 (Environmental & Social) (Pages 7-273 to 7-282) 7-273 to 7-282 Environmental flow requirement and post-construction environmental monitoring not detailed | FRR §11 notes environmental management plan for operational phase 'missing' and minimum environmental flow requirement not specified. Will Employer define minimum instream flow requirement and post-construction environmental monitoring protocol (responsibility, cost, duration) before tender? | Minimum environmental flow requirements have been referenced in Section 8.4.2.3 of the EIA Report as Volume-III, Part-IV, Additional Information of RFP/EPC Bidding Document. The Environmental Management Plan (EMP) has been provided in Table 9.1 of the EIA Report as Volume-III, Part-IV, Additional Information of RFP/EPC Bidding Document and will be finalized during detailed design and Employer's review in line with applicable regulatory standards. |
| **Environmental Impact Assessment (EIA) Report** | | | |



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| **EIA-1** | EIA Report, Chapter 2.3, Section 9.6.1 Compliance Procedure for Obtaining NOC from GB EPA<br>Page 2-9, 9-6<br>NOC and Environmental Approval Responsibility | Q1: Will the Employer (WAPDA) obtain all environmental NOCs (from EPA, Forest, Wildlife, Archaeology departments) before invitation to bid, or will the Contractor be required to obtain subsidiary NOCs during detailed design/mobilization? Who pays for these subsidiary NOC applications? | The Employer shall be responsible for obtaining all NOCs. In case EPC Contractor will be obtaining any NOC, the payment of said NOC will be paid by the Employer to the EPC Contractor. |
| **EIA-2** | EIA Report, Chapter 9.1-9.4 Environmental Management Plan - General and Institutional Setup<br>Page 9-1 to 9-5<br>Environmental Management Plan (EMP) Amendment and Ownership | Q2: Who has final approval authority for amendments to the EMP during construction (MC, WAPDA, GB EPA, or Contractor)? What is the approval timeline? If GB EPA or WAPDA initiates EMP changes during construction, is the Contractor responsible for implementation costs, or are they treated as variations? | The Employer will approve the amendments to the EMP.<br>The approval time for the amendments to the EMP will be Two (02) weeks. |
| **EIA-3** | EIA Report, Section 9.8-9.12, Table 9-4 Environmental Monitoring Plan and Cost Breakdown<br>Page 9-57 to 9-75<br>Environmental Monitoring Costs and Responsibility | Q3: Will the Contractor be required to fully fund all environmental monitoring costs (PKR 98.49M for 3-year construction phase) listed in Table 9-4? Are MC's HSE and environment personnel (PKR 6M/year) costs the responsibility of the Contractor or the Employer? Will third-party monitoring costs be Contractor's direct expense, and will rates be adjusted for inflation annually? | Yes, the EPC Contractor will be responsible for all environmental monitoring costs, Environment staff cost and third-party monitoring cost.<br>The Proposals shall be prepared as per the best estimation of inflation to avoid any claims. |
| **EIA-4** | EIA Report, Section 9.4.2(d), Section 9.6.1 GB EPA Responsibilities and NOC Conditions Page 9-5, 9-6<br>Environmental Permit Conditions and GB EPA Audit Authority | Q4: What specific conditions, limits, and compliance thresholds will be attached to the NOC issued by GB EPA? Can GB EPA impose new conditions or modify NOC terms after construction has commenced? What is the procedure and timeline for Contractor to remedy non-compliance findings from GB EPA audits, and who bears the cost of remedial actions? | This issue has been at the sole discretion of GBEPA which is an independent authority, beyond the control of Employer (WAPDA). Any cost and time shall be borne by the EPC Contractor. |



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| **EIA-5** | EIA Report, Section 5.2.12, 8.5.1(iv), 9.7<br>(Table 9-1, Item 11) Air Quality Monitoring and Mitigation<br>Page 5-17, 8-50 to 8-52,9-60<br>Dust and Air Quality Standards and Monitoring Frequency | Q5: What are the specific quantified dust limits (PM10 and PM2.5 in mg/m³) that the Contractor must comply with under NEQS?<br>What is the monitoring frequency (quarterly as per Table 9-4 or more frequent)? If air quality monitoring shows non-compliance, who has authority to declare exceedance, what corrective actions must Contractor implement within what timeframe, and what are the financial penalties for non-compliance? | Please refer to the NEQS attached with these responses to Post-Proposal Clarification No. 01 by Proposer for the compliance limits. The monitoring frequency shall be quarterly as per the EIA. Exceedance shall be declared by GBEPA, Employer. The corrective actions will be taken as per the instructions of the Employer. The penalties shall be decided as per the nature of exceedance. |
| **EIA-6** | EIA Report, Section 5.2.12, 8.5.1(xi), 9.7<br>(Item 11), Annex-VI(KPI) Noise and Vibration Mitigation and Monitoring<br>Page 5-17, 8-57 to 8-62<br>Noise Limits and Vibration Standards Near Sensitive Receivers | Q6: What are the specific noise limits (in dB(A)) that the Contractor must meet near sensitive receivers (schools, mosques, residences) per NEQS? Are separate vibration limits specified (in mm/s or peak particle velocity)? Will the Contractor be required to conduct baseline noise and vibration measurements before mobilization? What is the procedure if monitoring shows exceedance—who declares it, what is the remedial timeline, and what are the penalties? | Please refer to the NEQS attached with these responses to Post-Proposal Clarification No. 01 by Proposer for the compliance limits. For vibration limits please consider the IFC guidelines. Yes, the EPC Contractor shall conduct baseline noise and vibration monitoring. The exceedance shall be declared by GBEPA, Employer. The corrective actions will be taken as per the instructions of the Employer. The penalties shall be decided as per the nature of exceedance. |
| **EIA-7** | EIA Report, Section 3.10.6, 8.5.1(vii), 9.7<br>(Item 7)<br>Wastewater Generation and Treatment<br>Page 3-17, 8-37 to 8-47, 9-22<br>Wastewater Treatment and Discharge Standards | What are the specific quantified NEQS standards (BOD, TSS, fecal coliforms, pH in mg/L) and monitoring frequency (daily/weekly/monthly) for wastewater discharge? Who is responsible if septic systems fail or overflow during heavy rains? | Please refer to the NEQS attached with these responses to Post-Proposal Clarification No. 01 by Proposer for limits. Whereas monitoring frequency shall be as per the EIA report. The septic system failure and operations shall be the responsibility of the EPC Contractor. |
| **EIA-8** | EIA Report, Section 3.10.6, 8.5.1(viii), 9.7<br>(Item 8), 9.33<br>Solid Waste Management and Waste Disposal Sites<br>Page 3-17, 8-48 to 8-63, | Who designates and provides the construction waste disposal site(s)—Employer or Contractor? What are the tipping/disposal fees (if any) and who bears the cost? | The EPC Contractor will designate and provide the construction waste disposal site(s) for approval by the Employer/ . The EPC Contractor will estimate required cost and include in its Proposal Price. |



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| | 9-67<br>Construction Waste Disposal Sites and Tipping Fees | | |
| **EIA-9** | EIA Report, Section 3.10.2, 8.5.1(ii), 9.31, 9.32<br>Borrow Area Management and Restoration Plan<br>Page 3-15, 8-38 to 8-43, 9-66<br>Borrow Pits and Quarry Restoration Obligations | Will the Employer designate borrow pit and quarry sites, or will the Contractor identify and acquire them? Who owns/controls the land—Employer, Contractor, or private owners? | The concerns of the E&M Contractor regarding borrow pits and quarry sites are noted.<br>The Environmental Impact Assessment (EIA) Report covers the entire Project, including Civil Works and Transmission Line Works. Matters pertaining to borrow pits and quarry sites as addressed in the EIA Report relate to the scope of the Contractor responsible for Civil Works and do not fall within the scope of the E&M Contractor. |
| **EIA-10** | EIA Report, Section 8.5.1(v), 8.5.1(viii), 9.39, Annex-IV (HSE Plan)<br>Hazardous Waste and Good Engineering Practices<br>Page 8-48 to 8-63, 9-70<br>EIA Report, Section 8.5.1(v), 8.5.1(viii), 9.39, Annex-IV (HSE Plan)<br>Hazardous Waste and Good Engineering Practices<br>Page 8-48 to 8-63, 9-70 | Who arranges and approves disposal of hazardous waste (used oil, batteries, solvents)—the Contractor independently or must approval be obtained from environmental/regulatory authority? What is the prescribed disposal method and final disposal location? | The disposal of hazardous waste is carried out by the EPC Contractor through GBEPA approved vendors and/or after the approval from Employer. The EPC Contractor shall provide the details of disposal method and final disposal location in detailed design. |
| **EIA-12** | EIA Report, Section 3.7.12, 8.5.1(i), 9.32<br>Restoration and Rehabilitation Plan Page 3-7, 8-36 to 8-37, 9-67<br>Camp Decommissioning and Restoration | Q11: What specific restoration standards must be met for construction camps and compound sites (e.g., topography restoration, soil clean-up criteria, surface testing requirements)? What is the timeline for completion of site restoration after construction ends? Will the Contractor be required to conduct soil and groundwater testing to certify no contamination remains? If restoration is deemed inadequate, can the Employer withhold Defects Liability Period | The site should be restored to the original state or better than original. The restoration time is one month after completion. The EPC Contractor will be required to conduct soil and groundwater testing to certify no contamination remains. Yes, the Employer can withhold Defects Notification Period (DNP) funds or require additional remediation at EPC Contractor's cost. |



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| | | (DLP) funds or require additional remediation at Contractor's cost? | |
| **EIA-14** | EIA Report, Section 3.7.12, 8.5.1(i), 9.7 (Item 9) Temporary Land Acquisition and Camp Site Selection Page 3-7 to 3-8, 8-31 to 8-32, 9-14 to 9-15 Worker Camp Location Criteria and Environmental Siting | Who has final approval authority over the contractors camp site selection- Management Consultants, WAPDA, GP EPA or District Administration? | The EPC Contractor's camp proposals shall be submitted to the Employer and based on the approval, it shall be decided/instructed to obtain approvals from GB-EPA and District Administration (based on the nature, extent and land requirements of camp). |
| **EIA-15** | EIA Report, Section 5.3.5, 8.5.2, 8.6.2 Fauna Protection and Construction Impacts Page 5-29 to 5-31, 8-23 to 8-27, 8-40 to 8-43 Protected Species and Hunting Restrictions | What are the specific seasonal construction restrictions (dates for bird nesting season, other critical periods)? Who approves construction schedules relative to wildlife protection periods? | The EPC Contractor shall conduct a site specific assessment of the critical breeding periods (if any) in its site-specific Environmental and Social Management Plans and propose mitigation measures accordingly (if required). This will be subject to approval from Employer. |
| **EIA-16** | EIA Report, Section 8.5.1(iii), 9.7 (Item 3) Landslide Mitigation and Blasting Management Page 8-33 to 8-37, 9-18 to 9-21 Blasting Management and Community Notification | Q15: What are the quantified noise and vibration limits for blasting operations per NEQS and engineering standards? Must the Contractor obtain advance government approvals for blasting activities? What is the community notification protocol—how many days in advance must notice be given, and how will notices be distributed to affected residents? If vibrations from blasting cause structural damage to nearby buildings or heritage sites, who is liable for repairs? | Yes, the EPC Contractor shall obtain advance approval for blasting activities from relevant department. The community notification protocol depends on the timing of Explosive, quantum of explosive and the location of receptors. If vibrations from blasting cause structural damage to nearby buildings or heritage sites the EPC Contractor shall be responsible for repairs. |



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| **EIA-17** | EIA Report, Section 5.2.3-5.2.4, 8.4.1(i), 8.5.1(iii) Seismicity, Land Erosion, and Geotechnical Issues Page 5-5 to 5-8, 8-6 to 8-9, 8-33 to 8-37 Geology and Geotechnical Investigations | Q16: Will the Contractor be required to conduct additional detailed geotechnical investigations along the headrace tunnel and other critical components, or will these be Employer-funded pre-bid investigations? If unforeseen geological conditions (weak rock, high water inflow, fault zones) are discovered during construction, will these be treated as variations entitling the Contractor to extension of time and cost recovery? | It has been clarified that geotechnical investigations related to the headrace tunnel, overall site stability, and other Civil Works components do not fall under the scope of Package-III: Electro-Mechanical Works EPC Contractor. These investigations are the responsibility of the Package-I" Civil and Auxiliary Services Works EPC Contractor.<br>Any additional geotechnical investigations specifically required for the installation of Electro-Mechanical Equipment under Package-III shall be carried out by the EPC Contractor at its own risk and cost, in accordance with Sub-Clause 1.13.18 of the Specific Provisions, Volume-II of the RFP/EPC Bidding Document. |
| **EIA-18** | EIA Report, Section 8.5.1(ix), 9.7 (Item 8), 9.6.2 Land Acquisition and Resettlement Process Page 8-34 to 8-37, 9-13 to 9-16, 9-47 to 9-50 Resettlement and Land Acquisition Completion | Q17: Will all land acquisition and resettlement be completed before the Contractor mobilizes, or will the Contractor need to work on phased land availability? Is resettlement and compensation the sole responsibility of the Employer and District Administration, or will the Contractor have any resettlement obligations? If affected persons challenge compensation or resist relocation during construction, who is responsible for resolution and any resulting construction delays? | All land acquisition and resettlement will be completed by the Employer/GoGB before Contractor mobilization under Package-I. Compensation is the responsibility of GoGB, and the Contractor has no resettlement obligations. |
| **EIA-19** | EIA Report, Chapter 7, Section 9.7 Grievance Redress Mechanism and Committee Page 7-1 to 7-2, 9-30 Community Grievance Redress Mechanism and GRC Funding | Will the Grievance Redress Committee (GRC) be fully funded by the Employer, or must the Contractor contribute? What is the target timeline for GRC resolution of complaints? | All the activities, tools and equipment required for GRC (Grevience Redressal Committee) will be funded by the EPC Contractor. For GRC nomination from EPC Contractor, existing staff of EPC Contractor can be utilized. |



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| **EIA-20** | EIA Report, Section 8.5.3(xix), 9.7 (Item 19) Labour Influx and Local Employment Page 8-68 to 8-71, 9-36 to 9-39 Local Employment and Skilled Labor Requirements | Q19: What are the minimum targets or requirements for local employment (% of workforce to be sourced from Hunza district or local communities)? Must the Contractor meet gender participation targets for women in the workforce? Will the Contractor be required to provide vocational training to local workers to qualify them for higher-skilled positions? What wage equity requirements apply between local and non-local workers? | The maximum unskilled labor shall be acquired from Hunza district or local communities. The E[C Contractor shall maintain the record of local and non-local labor and will share the same with Employer from time to time.<br>Yes, the EPC Contractor has to meet gender participation targets for women in the workforce (staff level).<br>Yes, the EPC Contractor shall be required to provide vocational training to local workers to qualify them for higher-skilled positions. The minimum wage must be given to every worker and relevant labor laws shall be implemented. |
| **EIA-21** | EIA Report, Annex-VII (Key Performance Indicators), Table 9-4 Environmental Monitoring Frequency and Standards 9-71 to 9-75 Specific Environmental Performance Standards and KPIs | What are the specific quantified environmental performance targets/KPIs that the Contractor must meet (e.g., PM10 ≤ 150 mg/m³, Noise ≤ 65 dB(A), TSS, BOD limits, etc.)? Are these defined in Annex-VII? | The EPC Contractor has to prepare KPIs in the site specific ESHS plans and will be subject to approval from Employer. The KPIs must be aligned with the EIA report. |
| **EIA-22** | EIA Report, Section 5.2.6, 5.2.7, 8.4.2(i), Executive Summary Flooding and Natural Disaster Management Page 5-8, 5-22, 8-8 to 8-10 Glacial Lake Outburst Flood (GLOF) Risk and Climate Adaptation | Q21: What responsibility does the Contractor have for protecting the construction camp and project assets from potential GLOF events? Will there be a glacier monitoring and early warning system in place, and who operates it? If a GLOF event damages the Contractor's camp or construction assets, who bears the loss? Must the Contractor implement specific design measures or protocols to mitigate GLOF impact (e.g., elevated structures, evacuation routes)? | The EPC Contractor will select the location of construction colonies and camps at sites most protected from potential GLOF events. Regional glacier monitoring and early warning will be coordinated by the Employer, while the Contractor remains responsible for precautionary measures at its facilities. |



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| **EIA-23** | EIA Report, Section 10.2 (Recommendations), Table 9-4, Executive Summary Environmental Cost Estimates and Project Budget<br>Page 10-3, 9-71 to 9-75, Page 1<br>Environmental Cost Recovery and Contract Payment Linkage | How will the PKR 126.5 Million environmental cost be incorporated into the Contract as a separate lumpsum item, proportionally allocated, or linked to environmental performance milestones? | The ESHS cost will be linked to the ESHS performance milestones as per EIA Table 9.4. |
| **EIA-24** | EIA Report, Section 3.11, Table 9-4, Section 9.8<br>Project Implementation Schedule and Monitoring Timeline<br>Page 3-18, 9-71 to 9-75, 9-57 to 9-60<br>Construction Schedule vs. Environmental Compliance Monitoring Periods | Q23: If the construction period extends beyond the estimated 36 months (due to delays, natural disasters, or scope changes), are environmental monitoring and management costs for the extended period the responsibility of the Contractor or the Employer? Are environmental monitoring obligations capped at 3 years, or do they extend for the actual construction period plus DLP? Will the Contractor be entitled to extensions of time and cost recovery if environmental remediation activities cause construction delays? | The matters related to Extension of Time Will be Dealt in accordance with Sub-Clause 8.5 (Extension of Time), Part B Special Provisions, of Particular Conditions, Volume-I, RFP/EPC Bidding Document. |
| **Contractor Clarifications & Responses** | | | |
| 1. | 2026-03-11 Volume-I, Package-III Final (With Remote Ends) (1)<br>Page-I | To ensure the bid proposal is as comprehensive as possible, we are requesting an extension of the bid submission deadline. Would you agree to this? | The matter of Proposal submission deadline has already been addressed and incorporated in the upcoming Addendum No.01 TO RFP/EPC Bidding Document shall be issued on EPADS V2.0 in due course of time. The Proposers are advised to comply with the revised provisions as set forth therein. |
| 2. | 2026-03-11 PKG III Specific Provisions (with remote ends) Page 1-1<br>SECTION 1 SCOPE OF WORK | The bidding documents do not specify the design requirements for the fire protection water supply, plumbing for restrooms, ventilation, air conditioning, and heating systems, or lighting in the main powerhouse of the | The scope of works is already included in Package-I (Civil and Auxiliary Services Works). |

| Sr. No. | Reference Sub-Clause | Clarification Description requested from Proposers | Replies by AHMC |
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| | | hydroelectric power plant. Please clarify whether the scope of this bid includes the design, supply, and installation of the aforementioned systems. | |
| **3.** | 2026-03-11 PKG III Specific Provisions (with remote ends) Page 1-5<br>1.2.1.6: 132 kV Line End Bays at Remote End | Is it necessary to expand two 132 kV AIS bay connections within the 132/66 kV Aliabad Regional Grid Station? This includes the expansion and integration of electrical equipment, busbars, protection, control, earthing, and SCADA (Supervisory Control and Data Acquisition) systems required for the two extended bays.<br>(If required, please provide relevant documents such as the single-line diagram for the 132 kV side and the layout drawing of the 32/66 kV Aliabad Regional Grid tation.) | The scope of Remote End Line Bays including Civil works at 132/66 kV Aliabad Regional Grid Station shall be deleted from Package-III. In this regard, an upcoming Addendum No.01 TO RFP/EPC Bidding Document shall be issued on EPADS V2.0 in due course of time. |
| **4.** | | Please specify the point of measurement for electricity consumption: is it at the generator outlet or the switchyard outlet? | The Tariff metering shall be installed at the 132 kV Switchyard side (Grid Interface) of the Generator Step-Up Transformer within the 132 kV switchyard. |
| **5.** | | Please specify the scope of welding work for the short pipe connecting the pressure steel pipe to the upstream side of the turbine inlet butterfly valve. | It will be finalized and provided by the Proposer during detailed design phase. |



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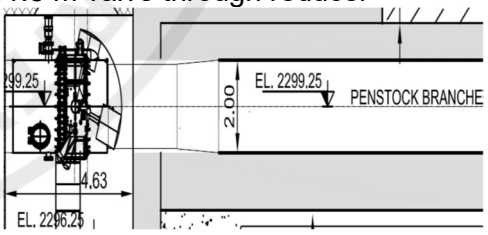
| **6.** | | Please provide principal diagrams of the cooling water system, drainage system, dewatering system, turbine oil operating system, and compressed air system. | It will be finalized and provided by the Proposer during detailed design phase |
| **7.** | 2026-03-11 PKG<br>III Specific Provisions (with remote ends)<br>Page 1-6<br>1.3.1. Detailed Design | Are there any regulations regarding software used for Hydraulic Transient Analysis? | HTA shall be carried out using a well-reputed International and Industry-accepted software to ensure the accuracy and credibility of the analysis. |
| **8.** | 2026-03-11 PKG<br>III Technical Provisions (With Remote Ends)<br>Page 1-2<br>Table 1-2 Parameters, 1.1.4: Technical Parameters of Turbines | There is no such thing as a “minimum efficiency” for water turbines. Please clarify if it refers to “the minimum value required for the turbine rated efficiency is 93%” | The minimum turbine efficiency means that rated efficiency shall not less than 93% for Guarantee purpose and to comply the requirement of Proposal. |
| **9.** | 2026-03-11 PKG<br>III Technical Provisions (With Remote Ends)<br>Page 1-30<br>1.3 Turbine Main Inlet Valves (MIV) | The inlet diameter of the turbine spiral case is approximately 2.15 m. Please confirm that the selected inlet butterfly valve will have the same diameter. If not, a reducer will be required, which will necessitate increasing the width of the plant building. | As per Conceptual drawing No. ALHPP-PH-0806, it has been clearly shown that branch pipe penstock diameter is 2.0 m and it is going to 1.8 m valve through reducer<br>  |
| **10.** | 2026-03-11 PKG<br>III Technical Provisions (With Remote Ends)<br>Page 1-49<br>1.5.3.2 Description | It is recommended to eliminate the high- pressure compressed air system and instead use a 16 MPa high-pressure nitrogen accumulator to store energy for the governor and inlet valve. | A high-pressure nitrogen accumulator option has already been provided in the RFP/EPC Bidding Document. |



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| **11.** | 2026-03-11 PKG<br>III Technical Provisions (With Remote Ends))<br>Page 3-6<br>3.1.14 Fire Protection System | Please specify the fire extinguishing's method for the generator. | The Generator Fire Protection system shall comply with NFPA 851 requirements and relevant NFPA standards. The inert gas, fire detection sensor type and system operation shall be finalized during the detailed design stage. A multi-criteria fire detection system. Both automatic and manual activation with safety interlocks shall be provided.<br>The final specification and system philosophy shall be finalized during the detailed design stage subject to approval by the Employer. |
| **12.** | 2026-03-11 PKG<br>III Technical Provisions (With Remote Ends)<br>Page 6-1<br>Section 6 132kV Switching Station and 132kV Line Terminal Cubicle<br>6.1 Scope of Work | Whether the construction of a new 132kV transmission line is included in this project?<br>If confirmed, is the design length of the line 14.5 km?<br>Shall the line transmission capacity be designed and checked against the 54MW installed capacity of the hydropower station?<br>Given that the current-carrying capacity of a single circuit already meets the 54MW transmission requirement, shall a single- circuit or double-circuit configuration be finally adopted? | The construction of the new 132 kV transmission line is not part of the Package-III: Electro-Mechanical Works. It is included under the scope of Package-II 132 kV Transmission Line Works. |
| **-** | 2026-03-11 PKG<br>III Technical Provisions (With Remote Ends)<br>Page 6-1<br>SECTION 6, SCOPE OF WORK: | Please provide the current protection manufacturer, communication gateway model, and version for the remote substation. It is necessary to confirm whether the newly supplied protection equipment can achieve differential protection cross-switching with the existing station, and whether the communication protocol can seamlessly integrate with the original monitoring system of the old station. | The scope of Remote End Line Bays including Civil works (132/66 kV Aliabad Regional Grid Station) shall be deleted from Package-III. In this regard, an upcoming Addendum No.01 to RFP/EPC Bidding Document shall be issued on EPADS V2.0 in due course of time. |



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| | 2026-03-11 PKG III Technical Provisions (With Remote Ends) Page 3-48 SECTION 3, DC AND UPS SYSTEM | Is a dual-battery dual-charger configuration (two battery banks + two charging units) mandatory for DC systems? Additionally, does the UPS system for this project have specific backup time requirements (e.g., 2 hours or 4 hours)? | Regarding dual battery banks + dual charging units, please follow the requirements as specified in the RFP/EPC Bidding Document. |
| | 2026-03-11 PKG III Technical Provisions (With Remote Ends) Page 5 SECTION 5, Fiber Optic Link: Cable Installation & Joint | Please clarify whether the terminal junction box for OPGW entering the central control room is provided by this tender section or the line section. Where exactly is the boundary between the design and construction phases for optical cable communication between both parties? | The provision of Junction/Joint box shall not be the part of this Package |
| **13.** | Page 2-4 **2.2.2 Stoplogs** | The pressure equalization method for the stoplog gate is not specified. Shall the pressure equalization by filling water through a filling valve or a bypass valve be determined by the Bidder at its own discretion? | Yes, It will be provided by the Proposer. |
| **15.** | Page 2-4 **2.2.2 Stoplogs** | The pressure equalization method for the stoplog gate is not specified. Shall the pressure equalization by filling water through a filling valve or a bypass valve be determined by the Bidder at its own discretion? | Yes, It will be provided by the Proposer. |
| **16.** | Page 2-7 **2.2.4. Moving Gantry Cranes Main Data** | Please Provide a single line drawing showing the turning points and turning radii of the curved rails for the mobile gantry crane | It Will be finalized at detailed design stage by the EPC Contractor, |



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| **17.** | Page 2-9, **2.2.4.4.6 Drums** | The lifting height of the gantry crane is 52 m, which falls into the category of high lifting height. If the steel wire rope is arranged in single layer winding on the drum, it will inevitably result in an excessively large drum diameter and length.<br>Therefore, we propose adopting no more than 3 layers of winding together with a polygonal rope groove drum design to avoid rope entanglement. Please confirm whether this proposal is acceptable. | it will be finalized during detailed design phase by the Contractor or Manufacturer. |
| **18.** | Page 2-14, 2-17 | 1、According to the drawing "ALHPP- HSS-0402", the frame of the hydraulic cylinder is arranged below the maximum water level of El. 2421.00 m.<br>Is a tight water seal required between the frame and the top of the gate slot? Please clarify.<br>2、Due to the high design head of the emergency gate, it shall be closed under flowing water and opened under still water.<br>The gate is expected to be closed by means of water column, and opened after pressure equalization through the water filling valve. Closing by water column will result in a relatively large holding force, which leads to a higher lifting capacity requirement for the mobile gantry crane. Therefore, the capacity of the gantry crane shall be determined based on this holding force.<br>Please confirm whether this understanding is correct.<br>3、It is proposed that a set of stoplog gates may not be required. | 1. Yes, your understanding is correct. The Tight seal is required to stop the water to the water level<br><br>2. Yes, your understanding is correct. It will be finalized during detailed design phase<br><br>3. it will be finalized during detailed design phase |



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| **19.** | PROCEDURES AND CONDITIONS OF CONTRACT of book 1 Page 4-12 | In Schedule 1&2, a total of 26 items are listed, each of which includes several sub- equipment. The bidding document requires the bid price to include FAT costs. Please clarify:<br>1. Which specific equipment and components of the equipment's require FAT?<br>2. The exact information regarding the number of representatives attending FAT, subsidy amounts, air ticket class, and accommodation standards? | Please follow the requirements of RFP/EPC Bidding Document Volume-II, Part-I, Specific provisions. |
| **20.** | Procedure for Delay Damages for Interface Milestones book 1 page 8-9, 8-10, 8-11, 8-12 | The bidding document only specifies penalties and rules related to delays in the interface between E&M and civil works, as well as overall schedule delays, but includes no exemption clauses.<br>It is clear that hydropower project site construction can be affected by many factors beyond civil and E&M work, such as adverse weather conditions, security situations and requirements by army or Pakistan government, local social factors, or prior breaches by the owner. However, no relevant exemption clauses are found in the bidding document. Please clarify. | Issues related to Delay Damages will be dealt in accordance with Sub-clause 8.8 (Delay Damages) of Section VII General Conditions, Volume-I RFP/EPC Bidding Document and Part A Contract Data and Part-B Special Provisions, Section VIII Particular Conditions, Volume-I RFP/EPC Bidding Document. |
| **21.** | 2026-03-11 PKG III Specific Provisions (with remote ends) Page 1-2 **1.1.1Civil Works for 132kV Line End Bays at Remote End** | This description only covers the civil engineering work required; please provide a bill of quantities for the civil engineering work and the relevant drawings. | The scope of Remote End Line Bays including Civil works at 132/66kV Aliabad Regional Grid Station shall be deleted from Package-III. In this regard, an upcoming Addendum No.01 TO RFP/EPC Bidding Document shall be issued on EPADS V2.0 in due course of time. |



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| **22.** | 2026-03-11 PKG<br>III Technical Provisions (With Remote Ends)<br>**Section 1.1.2、3.1.3、4.2** | Do you agree to adopt GB/T Chinese national standards or ISO equivalent standards? Please clarify. | As per the requirements of RFP/EPC Bidding Document, only International Standards will be adopted for this Project. |
| **23.** | 2026-03-11 PKG<br>III Technical Provisions (With Remote Ends) Page 1-2<br>**1.1.5 Life of Plant, Maintenance Cycles and Reliability** | Generally, water turbines require maintenance and upkeep, including Level A, B, and C overhauls, with a typical cycle of 3 to 5 years, depending on the operational status and conditions of the equipment. Standards such as DL/T 2574 and DL/T 817 provide corresponding technical procedures for equipment maintenance. Does the statement "no disassembly of equipment in the first ten years" mean that no equipment is allowed to be disassembled? Please clarify. | The requirement does not imply that maintenance activities have been prohibited. Routine and preventive maintenance like inspections, lubrication, adjustments, replacement of consumables, and minor repairs<br>Secondly, the design shall be proven and based on good engineering practices as per site specific conditions such that Level C maintenance (major overhaul involving dismantling of main components such as runner, shaft, bearings, etc.) → shall not be required within first Ten (10) years |
| **24.** | 2026-03-11 PKG<br>III Technical Provisions (With Remote Ends) Page 1-5～1-6<br>**Section 1.1.12.1 & 1.1.13** | Is it understood that without considering the correction of real machine efficiency, the performance guarantee is based on the model efficiency guarantee and meets the requirements of the bidding documents? Please clarify. | Please fully comply the IEC 60193-2019 Standard in this regard |
| **25.** | 2026-03-11 PKG<br>III Technical Provisions (With Remote Ends) Page 1-21<br>**1.1.21.1 Assembly and Tests in The Workshop** | Is it necessary to require the entire hydroelectric turbine unit to be pre- assembled in the manufacturing plant? Generally, it is pre-assembled in the plant in parts. Please clarify. | A Separate testing will be carried out in Manufacturer Workshop |

| Sr. No. | Reference Sub-Clause | Clarification Description requested from Proposers | Replies by AHMC |
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| **26.** | 2026-03-11 PKG<br>III Technical Provisions (With Remote Ends)<br>Page 1-21<br>**1.1.21.1 Assembly and Tests in The Workshop** | Here is a requirement for all welds on the spiral case to undergo ultrasonic and radiographic inspection<br>Can it be changed to: The weld seam of the spiral case undergoes 100% ultrasonic flaw detection, and radiographic flaw detection is used for verification in areas where multiple flaw detection methods yield suspicious results. Please clarify. | Please follow the requirement as per RFP/EPC Bidding Document. |
| **27.** | 2026-03-11 PKG<br>III Technical Provisions (With Remote Ends)<br>Page 3- 10<br>**Table 3-5: Spare Parts and Tools** | The bidding documents do not specify specific requirements or provide a list of tools specifically for hydro-generator units. Please provide a detailed list of specialized tools or clarify whether corresponding specialized tools can be provided in accordance with GB/T standards. | The special tools details shall be finalized during detailed design stage.<br>For standards, please follow the RFP/EPC Bidding Document requirements as specified. |
| **Clarification No. 02 on April 18, 2026** | | | |
| 1 | Volume-II: Employer's Requirements, Part-I: Specific Provisions Sub-Section 1.2.1.6 | Regarding Sub-Section 1.2.1.6 of Volume-II: Employers Requirements, Part-I: Specific Provisions, is it required to expand two 132 kV AIS remote end line bays within the 132/66 kV Aliabad Regional Grid Station, including all associated electrical equipment, busbars, protection systems, control systems, grounding, and expansion and integration of the SCADA system? (If required, please provide the 132-kV side single-line diagram, site layout plan, and related documentation for the 132/66 kV Aliabad Regional Grid Station.) | The scope of Remote End Line Bays, including civil works at the 132/66 kV Aliabad Regional Grid Station, shall be deleted from Package-III. In this regard, an upcoming Addendum No. 01 to the RFP/EPC Bidding Document will be uploaded on EPADS V2.0 in due course. |
| **2.** | Volume-II: Employer's Requirements, Part-I: Specific Provisions Sub-Section 1.2.1.1-k | Clarify the spatial relationship between the 132 kV Switchyard and the main plant. As specified in Sub-Section 1.2.1.1-k of Volume-II: Employer's Requirements, Part-I: Specific Provisions, the | The routing has already been indicated in the Overall Project Layout Plan. The final routing shall be developed by the EPC Contractor and finalized during the detailed design stage, subject to approval by |



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| | | connection from the Generator outlet Bus to the Low-Voltage side of the Main Transformer employs Isolated Phase Bus (IPB). Please define the routing layout of this IPB and specify the required length (per phase in meters) for each of the Three Generating Units. | the Employer. The specifications of the Segregated Phase Bus shall be in accordance with the Technical Provisions, Part-II, Volume-II of the RFP/EPC Bidding Document. |
| **3.** | Volume-II: Employer's Requirements, Part-I: Specific Provisions Layout Optimization Proposal | Is it feasible to optimize the layout by co-locating the Main Transformer with the Main Plant and adopting GIS for the 132 K Switchyard equipment? This configuration can significantly reduce land footprint and Civil Construction costs, shorten the length of the Generator outlet Isolated Phase Bus (IPB) connections, and enhance operational reliability. GIS's fully enclosed design is immune to contamination, moisture, and small animals, resulting in markedly lower failure rates and reduced environmental risks. Maintenance is limited to periodic monitoring of Gas Density and partial discharge, eliminating the need for frequent cleaning, corrosion protection, and insulator washing required by AIS—thereby, substantially reducing maintenance workload and unplanned outages, while improving the reliability of the 132 kV Grid Station.<br>Reference layout is shown below<br> | The Proposal of GIS Switchyard at Attabad is not accepted.<br>The Proposers are required to strictly follow the layout and equipment configuration plan of 132 kV Switchyard specified in the RFP/EPC Bidding Document. Any deviation, including the adoption of GIS in place of AIS or the relocation of the main Generator Step-up- Transformers, will not be considered at this stage. Accordingly, the reference layout for 132 kV Switchyard provided in the RFP/EPC Bidding Document shall remain unchanged and shall be adhered to by all Proposers. |



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| **4.** | 2026-03-11 PKG III, Technical Provisions, (With Remote End Line Bays) Sub-Clause 2.1.17.3 and Sub-Clause 2.2.8 | Clarification on Corrosion Protection, Coating Thickness & Painting Requirements for Hydraulic Steel Structures and Equipment.<br>1. Clarification on Metallic Coating (Section 2.1.17.3)<br>Clause 2.1.17.3 Metallic Coating (Hot Dip Galvanizing) does not clearly specify which equipment or components shall be applied with hot dip galvanizing or zinc metal spraying.<br>Sub-Clause 2.2.8 Surface Preparation & Painting does not specify the required coating thicknesses (dry film thickness) for any components.<br>We therefore request the following clarifications: | The painting schedule has now been provided in an upcoming Addendum No. 01 to the RFP/EPC Bidding Document will be uploaded on EPADS V2.0 in due course of time<br>All bolts, studs, nuts, washers, screws, etc., above size M-10, shall, if not made of stainless steel or other corrosion-resistant material, be hot-dip galvanized.<br>Galvanized wire shall comply with the requirements of ASTM A641 standard. Nuts, bolts, and small components shall be coated in accordance with ISO 1461 standard |
| **5.** | 2026-03-11 PKG III, Technical Provisions (With Remote End Line Bays) Gate Leaves / Trash Rack Leaves | **2.** Corrosion Protection for Gate Leaves and Trash Rack Leaves<br>Please confirm the Corrosion Protection Scheme for Gate Leaves (including Trash Rack Leaves):<br>1 Shall zinc metal spraying be adopted for corrosion protection?<br>2 Shall the thickness of zinc spray be not less than 0.060 mm?<br>3 Shall paint systems be applied over the zinc-sprayed surface?<br>4 If yes, how many paint coats are required, and what is the specified dry film thickness (DFT) for each coat? | The painting schedule has now been provided in an upcoming Addendum No. 01 to the RFP/EPC Bidding Document will be uploaded on EPADS V2.0 in due course of time. |
| **6.** | 2026-03-11 PKG III, Technical Provisions (With Remote End Line Bays) Paint coating — various items | 1. Paint Coating Thickness Requirements<br>Please clarify the required total dry film thickness and layer-by layer DFT for paint coatings on the following items:<br>（1） Gate Recesses (Trash | The painting schedule has now been provided in an upcoming Addendum No. 01 to the RFP/EPC Bidding Document will be uploaded on EPADS V2.0 in due course of time. |



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| | | Rack Recesses)<br>（2） Mobile Gantry Crane and Trash Rack Cleaning Crane<br>（3） Hydraulic Hoist Cylinders | |
| 7. | 2026-03-11, PKG III, Technical Provisions (With Remote End Line Bays) | Can the Proposer recommend the rated speed of the Hydro-Generator set, for example, if the speed is increased, choose 428.6rpm? Please clarify. | The specified rated speed is based on feasibility studies and system requirements; therefore, no deviation is permitted at this stage, and the Proposers shall comply accordingly. |
| **8.** | 2026-03-11, PKG III, Technical Provisions (With Remote End Line Bays) Page 1-32 and Page 1- 33 | When the butterfly plate is connected to the valve shaft vide bolted connection, the valve shaft must be reinforced, leading to increased driving torque, more complex structure, and higher maintenance costs in future. Can the butterfly plate and valve shaft be connected vide pin connection? This method features a simpler structure and mature technology. | If OEM/Vendor has proven design practices and validated operating experience for the pin connection of plate with valve shaft, it may be finalized during detailed design phase subject to the approval by the Employer. |
| **9.** | 2026-03-11, PKG III, Technical Provisions (With Remote End Line Bays) Page 1-31 and Page 1- 33 | The discrepancies in the RFP/EPC Bidding Document<br><br>It is recommended that the inlet valve be equipped with an independent hydraulic system. If the bypass needle valve is hydraulically actuated, the oil pressure shall also be supplied from the hydraulic system of the inlet valve. | The final arrangement shall be determined by the EPC Contractor, during the detailed design stage, subject to the Employer's approval. |
| **Clarification No. 03 on April 29, 2026** | | | |
| 1 | The Proposer M/s C-Digital respectfully requests a one (01) month extension in the Proposal submission deadline from May 14, 2026 currently notified on EPADS V2.0 for Package-III: Electro-Mechanical Works of the Attabad Lake Hydropower Project (54 MW).<br>The principal ground for this request is the pending issuance of Addendum No. 01 to the RFP/EPC Bidding Document, which AHMC had confirmed with the replies to Pre-Proposal Clarification No. 01 wherein it was committed that Addendum No. 01 to RFP/EPC Bidding Document will be uploaded on EPADS V2.0 "in | | a) The request for an extension in Proposal submission deadline by One (01) Month from Proposer has been under consideration. The decision for extension in Proposal submission deadline will be addressed through an upcoming Addendum No. 01 to the RFP/EPC Bidding Document, which will be uploaded on EPADS v2.0 in due course of time. |



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| | due course". The Addendum No. 01 to RFP/EPC Bidding Document carries material changes to the Scope of Works and the technical specifications (ref. AHMC Replies to the Pre-Proposal Clarification No. 01 Item No. 01, Item No 04, Item No 05 and Item No 06, and the Priced Proposal cannot be finalized until it is issued/uploaded.<br>Additional time is also required after issuance/uploading of the Addendum No. 01 to RFP/EPC Bidding Document to incorporate the revised scope into the Proposal and obtain updated Quotations from OEMs. The requested extension in Proposal submission date is therefore driven by the Employer's own pending Addendum No. 01 to RFP/EPC Bidding Document and will allow all bidders an equal opportunity to submit fully responsive Proposals on the Post-Addendum No. 01 to RFP/EPC Bidding Document scope.<br>It is accordingly requested that:<br>a) the Proposal submission deadline be extended by one (01) month,<br>b) the Proposal validity and Proposal security validity be correspondingly adjusted, and<br>c) the revised Proposal submission deadline be notified on EPADS V2.0 in the usual manner. | | b) Refer PDS to ITP 20.1 of Section-II, Proposal Data Sheet, Volume-I of RFP/EPC Bidding Document, wherein it has been stipulated that the Proposal shall be valid until 180 days from the date of Submission of Proposal. The Proposal Validity and Proposal Security validity shall be in accordance with the provisions of Contract.<br><br>c) Noted. |
| **Clarification No. 04 on May 14, 2026** | | | |
| **1.** | Part-II Technical Provisions, Volume-II Employer's Requirements, RFP/EPC Bidding Document Page No. 2-9 | It is suggested to amend to: "No more than Three layers of rope winding shall be allowed when the hook is at highest position."<br>Please confirm whether this suggestion is acceptable. | Noted. The Proposal is not acceptable as the original provisions of RFP/EPC Bidding Document shall prevail at this stage. However, this arrangement will be finalized during detailed design phase. |
| | | Please provide a location relationship diagram in CAD format of the Powerhouse building and the 132 kV AIS Switchyard with detailed distance scales, so as to measure the length of the Segregated Phase Busbar from the Generator outlet to the Low-Voltage side of the main Generator Step-Up Transformer. | Noted. The distance between 132 kV AIS Switchyard boundary wall and Powerhouse left side wall has been worked out approximately 80 m. Within the Powerhouse from where the Segregated Phase Buses will emanate from each Generating Unit Outlet to Generator step up Transformers primary side could be estimated roughly for Proposal purpose. However, the final measurement of Segregated Phase Bus will be finalized during detailed design Stage. |
| **Clarification No. 05 on June 18, 2026** | | | |
| | Sub-Clause 1.1.15 Efficiency, Technical Provisions, Part-II, Volume-II, RFP/EPC Bidding Document | For a low-output, medium-head Francis Turbine, a Guaranteed Weighted Average Efficiency above 92.8% is not available from qualified Turbine Manufacturers for this class; | The Proposer's request has been noted. However, the Employer maintains the minimum Guaranteed Weighted Average Turbine |

| Sr. No. | Reference Sub-Clause | Clarification Description requested from Proposers | Replies by AHMC |
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| | Table 8-6 Turbine and Generator Guaranteed Weighted Average Efficiency, A-1 Guaranteed Characteristics, Appendix-A Performance Guarantees. Part B Special Provisions, Section-VIII Particular Conditions, Volume-I, RFP/EPC Bidding Document | the best-efficiency-point efficiency already approaches the technological limit for this specific speed, and the weighted average is necessarily reduced by the inherently lower part-load (60% / 40%) efficiencies. For the Attabad Lake Hydropower Project (54MW) (Turbine Output about 18.94 MW, rated net head 104 m, 375 rpm), we request to amend the guaranteed turbine weighted-average efficiency requirement to 92.15%, for a Turbine that otherwise fully meets the guaranteed rated output, the minimum rated point Efficiency (Table 1-2) and all functional and technical requirements. | Efficiency specified in the RFP/EPC Bidding Document.<br>The specified Efficiency requirement has been established considering the Project characteristics, performance objectives, and long-term energy generation requirements. It is the responsibility of the EPC Contractor to select and optimize suitable turbine equipment capable of meeting all Guaranteed Performance requirements.<br>Accordingly, no amendment to the specified Guaranteed Weighted Average Turbine Efficiency requirement will be made. Hence, the provision of RFP/EPC Bidding Document shall prevail. |
| **Clarification No. 06 on July 13, 2026** | | | |
| 1 | Reference is made to the Volume-II, Part-II, Technical Provisions, Sub-Clause 3.5.1, wherein the Generator Circuit Breakers (GCBs) are specified as vacuum type. However, Addendum No.01 requires the 11kV switchgear for the generating units to be of $SF_6$ Gas type, while all other 11 kV switchgear remains specified as vacuum type.<br><br>The Proposer respectfully request the Employer to confirm that vacuum-type Generator Circuit Breakers (GCBs), as originally specified under Sub-Clause 3.5.1, shall remain acceptable, provided they comply with all specified ratings and technical requirements.<br><br>Generator Circuit Breakers (GCBs) are specially designed to interrupt Generator fault currents, system faults, synchronization switching, and other Generator operating duties. Vacuum Type Generator Circuit Breakers are widely used and proven for these applications at the 11 kV level and fully satisfy the required performance and interrupting capabilities.<br><br>We also note that the Schedules of Technical Particulars continue to specify "Arc Quenching Medium (Vacuum)/$SF_6$ Gas Type Breakers" for the Generator Circuit Breakers (GCBs), indicating that both technologies are acceptable.<br><br>Using vacuum type technology for the Generator Circuit Breakers (GCBs) also provides the benefit of maintaining common equipment with the remaining 11 kV switchgear, | Noted. The Proposers request to accept vacuum-type Generator Circuit Breakers (GCBs) instead of $SF_6$ Gas-type Generator Circuit Breakers (GCBs) for the 11 kV Generator Switchgear is under consideration by the Employer which will be incorporated in the upcoming Addendum No. 03 to the RFP/ EPC Bidding Document and will be issued/uploaded on EPADS V2.0 in due course of time. |



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| | simplifying operation, maintenance, and spare parts management. In addition, vacuum type Generator Circuit Breakers (GCBs) require no gas handling or gas density monitoring and offer high reliability and long service life.<br><br>In view of the above, we kindly request the Employer to confirm that vacuum-type Generator Circuit Breakers (GCBs) are acceptable for the 11 kV Generator Switchgear, provided they meet all requirements of the RFP/EPC Bidding Document.<br><br>The Employer clarification will be appreciated to enable Proposers to prepare technically compliant and competitive Proposals. | | |
| **Clarification No. 07 on July 17, 2026** | | | |
| | Volume-II, Employer's Requirements, Technical Provisions Part-II, Sub-Clause 1.1.15, Efficiency, ,, RFP/EPC Bidding Document of Package-III<br><br>"Guaranteed Turbine Weighted Average Efficiency shall be greater than 92.8%.", Turbine and Generator Guaranteed Weighted Average Efficiency Table 8-6, Particular Conditions Section-VIII, Volume-I, RFP/EPC Bidding Document | The guaranteed turbine weighted average efficiency is governed by the weighting factors specified in Sub-Clause 1.1.15 , Technical Provisions Part-II, Volume-II, RFP/EPC Bidding Document, (59 / 20 / 12 / 9 at 100 / 80 / 60 / 40% turbine power), which place substantial weight on the part-load points (60% and 40%), where Vertical Shaft Francis Turbine Efficiency inherently declines. The resulting weighted average is therefore highly sensitive to the reference runner design and to the net head at which the load points are evaluated.<br><br>To enable all Proposers to guarantee on a common and demonstrable basis, we request the Employer to clarify:<br><br>Whether the Guaranteed Turbine Weighted Average Efficiency >92.8% requirement is derived strictly by applying the Sub-Clause 1.1.15, Part-II, Volume-II, RFP/EPC Bidding Document, weighting factors (59/20/12/9) to the four load points, and at what reference net head / reservoir condition these points are defined. | Noted. The guaranteed turbine weighted-average efficiency (>92.8%) shall be determined by applying the weighting factors specified in Sub-Clause 1.1.15, Technical Provisions Part-I, RFP/EPC Bidding Document, Package-III, to the corrected prototype efficiencies derived from the model test results of the proposed homogeneous turbine, after applying the prototype efficiency correction in accordance with IEC 60193. The guaranteed efficiency shall be demonstrated by the successful Proposer based on the model tests of its proposed turbine design. The Employer has not based this requirement on any specific reference runner, manufacturer, or model designation. |



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| | | The specific reference runner, model designation and manufacturer, and the model / prototype test from which the 92.8% Guaranteed Turbine Weighted Average Efficiency value was obtained, so that all Proposers may benchmark against a demonstrated, achievable figure. | |
| **Clarification No. 08 on August 04, 2026** | | | |
| 1 | a. The Proposer M/s CDigital, gratefully acknowledges the Employer's extension in the Proposal submission deadline of Package-III to August, 20 2026. This extension has been of material assistance, and the Technical and Financial Proposals are presently at an advanced stage of preparation.<br>b. The changes introduced vide Addendum No. 03 require corresponding confirmations to be obtained afresh from the equipment manufacturers and sub-suppliers, including revised technical particulars, performance guarantees, type-test and model-test references, delivery schedules and price validities. These confirmations involve sequential engineering and commercial reviews at the manufacturer's works and, despite continuous follow-up by the Consortium, cannot be completed responsibly within the time now available.<br>c. In addition, the ongoing armed conflict between the United States and Iran has severely disrupted shipping, insurance and logistics worldwide. Re-routing of vessels, elevated war-risk premiums, port congestion and constrained banking and communication channels have delayed the responses of manufacturers and suppliers in respect of freight, delivery schedules and price confirmations. These circumstances are entirely beyond the control of the Proposers.<br>d. In view of the foregoing, it is respectfully requested that the Proposal submission deadline be further extended by a period of two (02) months beyond August, 20 2026, that is, up to October 20, 2026, with corresponding adjustment of the Proposal validity and Proposal security periods.<br>e. The extension requested is of general application and would enable all Potential Proposers to submit complete, competitive and fully responsive Proposals, to the ultimate | Noted. It is hereby clarified that the request for extension in Proposal submission deadline has already been under consideration to facilitate Prospective Proposers. This request is being reviewed after due consideration of the prevailing circumstances, including the need for Proposers to coordinate with E&M Equipment Manufacturers and Suppliers, prepare technically responsive and commercially competitive Proposals. The extended Proposal submission date will be communicated through upcoming Addendum to RFP/EPC Bidding Document which will be uploaded on EPADS v2.0 in due course of time. |



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| | benefit of the Attabad Lake Hydropower Project (54MW) and of the proposal evaluation process. | | |
| **2. Proposer M/s Ghulam Rasool & Company Clarifications** | | | |
| **Clarification No. 01 on April 28, 2026** | | | |
| 1. | We are extremely pleased to participate in the bidding process for the subject Package of the Project. In order to comprehensively analyze all aspects of the RFP/EPC Bidding Document, Proposal, and various other factors, we respectfully request an extension of the submission date of Proposal by six weeks i.e from May 14, 2026.<br><br>We believe that a six-week extension in Proposal Submission date will facilitate us in preparing a more vigilant and thorough Proposal for this esteemed Package of the Project. | | The request for an extension in Proposal submission deadline by Six (06) week from Proposer has been under consideration. The decision for extension in Proposal submission deadline will be addressed through an upcoming Addendum No. 01 to the RFP/EPC Bidding Document, which will be uploaded on EPADS v2.0 in due course of time. |
| **Clarification No. 02 on June 03, 2026** | | | |
| **1.** | Criteria 4.2(b) Experience in Key Construction Activities, Section-III, Evaluation and Qualification Criteria, Volume-I, RFP/EPC Bidding Document | The Proposer request to amend this Criteria to "The proposed Suppliers must demonstrate at least Twenty (20) years of business starting from January 01, 2006 on International Projects outside their Home Countries with similar Equipment designed according to International Standards" for Hydraulic Steel Structure Gates, Transformers and 132kV Switchyard Equipment.<br>The Proposer assure Employer to use OEMs who have previously supplied 132 kV HV Switchgear Equipment, Transformers in Pakistan and Hydraulic Steel Structure Gates in Pakistan. | Noted. The provisions of RFP/EPC Bidding Document shall prevail. |
| **2.** | Section 3 Electrical Plant Equipment -<br>Under Generator Specifications - 3.1.6 Efficiency and Losses, Part-II Technical Provisions, Volume-II, RFP/EPC Bidding Document | For low speed low output Generators Efficiency is usually less. For Attabad Lake Hydropower Project (54MW) Generator capacity is about 18 MW and speed is 375 rpm. We request to amend the Generator Efficiency requirement to 97%. | Noted. The provisions of RFP/EPC Bidding Document shall prevail. |
| **3.** | Section 6.3 Switchyard and Line End Bays Design -<br>Sub-Section 6.3.3 Electrical Design Parameters, Part-II | Could you please clarify what this clearance means? If this means phase-ground clearance, this requirement of 1750 mm is beyond | Noted. It is clarified that 1300 mm is the minimum clearance from live part to ground as per IEC Standard and 1750 mm is Project requirement for |

| Sr. No. | Reference Sub-Clause | Clarification Description requested from Proposers | Replies by AHMC |
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| | Technical Provisions, Volume-II, RFP/EPC Bidding Document | the 132 kV AIS Equipment. To meet this requirement 252 kV Equipment rating shall be used. | clearance from live part to ground. Pease follow the provisions of RFP/EPC Bidding Document without changing the voltage level. |
| **Clarification No. 03 on June 08, 2026** | | | |
| **1.** | | The Proposer is extremely pleased to participate in the bidding process for the Package-III: Electro-Mechanical Works of the subject Project. In order to comprehensively analyze all aspects of the RFP/EPC Bidding Document, Proposal requirements, and other relevant factors, the Proposer would like to request the Employer good office to kindly extend the Proposal submission date by two months.<br>It is further submitted that the current Economic situation of the Country, reduced working hours, continuous fluctuation in fuel prices, transportation costs, and market rates are directly affecting the process of obtaining firm and competitive quotations from E&M Manufacturers and Suppliers, Sub-Contractors, and Vendors. Additional time is therefore required to properly evaluate these factors and prepare a realistic and competitive Proposal.<br>The Proposer believe that a two-month extension in Proposal submission date will enable the Proposer to prepare his proposal more carefully, accurately, and competitively for this esteemed Project. | Noted. It is hereby clarified that the extension in Proposal submission deadline has already been under consideration to facilitate Prospective Proposers. This request is being reviewed after due consideration of the prevailing circumstances, including the need for Proposers to coordinate with E&M Equipment Manufacturers and Suppliers, prepare technically responsive and commercially competitive Proposals. The extended Proposal submission date will be communicated through Addendum No. 02 to RFP/EPC Bidding Document which will be uploaded on EPADS v2.0 in due course of time. |
| **3. Proposer M/s Umer Jan & Co. Clarifications** | | | |
| **Clarification No. 01 on April 28, 2026** | | | |
| 1 | | With reference to the RFP/EPC Bidding Document issued by WAPDA, we hereby express our sincere commitment to participate in the bidding process of Package-III (Electro-Mechanical Works) of the Attabad Lake Hydropower Project (54 MW) and intend to submit a comprehensive and competitive Proposal/bid. However, we wish to highlight that the prevailing security situation in the region has raised significant concerns among potential foreign EPC Proposers, many of whom are now reluctant or unwilling to participate in infrastructure Projects in Pakistan under current circumstances.<br>In this regard, we respectfully request a minimum extension in Proposal submission deadline for 60 days in the current Proposal Submission Deadline, to allow adequate time for preparation of responsive Proposal and to encourage wider participation from both national and international firms.<br>We trust that the requested Proposal submission date extension will contribute towards a more technically sound and inclusive procurement process, ultimately enhancing competition and ensuring the selection of the most qualified Proposer for successful Project delivery. | The request for extension in Proposal submission deadline by sixty (60) days from Proposer has been under consideration. The Employer considers this duration excessive. The matter of Proposal submission deadline will be addressed through an upcoming Addendum No. 01 to the RFP/EPC Bidding Document, which will be uploaded on EPADS v2.0 in due course of time. |



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| **Clarification No. 02 on April 29, 2026** | | | |
| 1. | | With reference to the RFP/EPC Bidding Document (RFP No.: BD/ICB-ALHPP-03) issued/uploaded for Package-III for the Attabad Lake Hydropower Project (54 MW), we would like to seek clarification and request reconsideration of certain Payment provisions stipulated under Sub-Clause 14.4 (Schedule of Payments) of Section-VIII, Particular Conditions (Part B – Special Provisions).<br>It has been noted that the RFP/EPC Bidding Document provide for a deduction of 2.5% of retention money from each section of Payment under the Payment Schedules, to be released upon issuance of the Defects Notification Certificate (DNC). We further observe that this Contractual Provision has also been applied to the Design Services Payment Schedule.<br>In this regard, we respectfully submit that, as per established Engineering practice and standard Contract frameworks, Design Services are typically paid in full upon approval by the Employer, as they are not subject to Post-Construction defects in the same manner as physical works. The withholding of a portion of Design Services Payments until the Defects Notification stage does not align with standard industry practices and may adversely impact the design development process.<br>Furthermore, the RFP/EPC Bidding Document also stipulate a 5% retention money deduction from each Payment Schedule. We would like to highlight that, under standard FIDIC conditions, retention money is primarily associated with construction (Civil) Works to ensure performance and remedy of defects during the Defects Notification Period (DNP).<br>Given that the present scope predominantly relates to Electro-Mechanical (E&M) works and design, the application of retention in the same manner as civil works requires clarification. Typically, for E&M works, performance securities, warranties, and defect liability obligations adequately cover the Employer's risk without necessitating substantial retention deductions.<br>In view of the above, we kindly request the Employer to:<br>1. Clarify the applicability of the 2.5% deduction on design payments; and<br>2. Review and amend the retention provisions to align with standard Engineers practices, particularly considering the nature of E&M works and design services.<br>We shall appreciate your clarification on the above matters at the earliest, to enable us to proceed with a clear understanding of the commercial framework. | 1. The provisions stipulated under Sub-Clause 14.4 Schedule of Payments, Part-B Special Provisions, Section-VIII Particular Conditions, Volume-I, RFP / EPC Bidding Document shall prevail.<br>2. The provisions stipulated under Sub-Clause 14.4 Schedule of Payments, Part-B Special Provisions, Section-VIII Particular Conditions, Volume-I, RFP / EPC Bidding Document shall prevail. |
| **Clarification No. 03 on June 03, 2026** | | | |



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| Sr. No. | Reference Sub-Clause | Clarification Description requested from Proposers | Replies by AHMC |
|---|---|---|---|
| 1. | The Proposer respectfully refer to the bidding process for the Package-III of Attabad Lake Hydropower Project (54MW) and would like to request a second extension of the Proposal submission deadline (June 16, 2026) for a minimum period of eight (08) weeks.<br>As Employer is aware, the successful preparation of a competitive and technically sound Proposal requires extensive coordination with International Manufacturers and suppliers for major Electro-Mechanical and associated Equipment. Despite the Proposer continuous efforts and follow-ups, the Proposer has received a relatively limited response from several Foreign Manufacturers.<br>The primary reasons communicated by these E&M Manufacturers include:<br>a. Concerns regarding the prevailing conditions in the power sector, which have affected their willingness to participate in new Projects in the region.<br>b. Financial and Commercial uncertainties that have resulted in extended internal review and approval processes by potential suppliers.<br>c. Security-related concerns associated with the region, leading some E&M Equipment Manufacturers to undertake additional risk assessments before committing to quotations and technical Proposals.<br>These factors have significantly affected the timely receipt of firm quotations and technical inputs necessary for the preparation of a comprehensive and competitive Proposal.<br>In view of the above circumstances, the Proposer kindly request the Employer to grant a second extension of at least eight (08) weeks for the Proposal submission date. This additional time will enable Proposers to secure meaningful participation from reputable International E&M Equipment Manufacturers and submit more competitive and technically optimized Proposals, ultimately benefiting the Package of the Project and the Employer. | | Noted. It is hereby clarified that the extension in Proposal submission deadline has already been under consideration to facilitate Prospective Proposers. This request is being reviewed after due consideration of the prevailing circumstances, including the need for Proposers to coordinate with E&M Equipment Manufacturers and Suppliers, prepare technically responsive and commercially competitive Proposals. The extended Proposal submission date will be communicated through Addendum No. 02 to RFP/EPC Bidding Document which will be uploaded on EPADS v2.0 in due course of time. |
| **3. Proposer M/s Al-Fajr International Pvt. Ltd. Clarifications** | | | |
| **Clarification No. 01 on April 21, 2026** | | | |
| 1 | We, M/s Al-Fajr International along with our Joint Venture Partners, are interested to participate in “Engineering, Procurement and Construction (EPC) of Package-III: Electro-Mechanical Works of Attabad Lake Hydropower Project (54 MW). We, along with our JV Partners are working to prepare the Bidding Proposals for Package-III: Electro-Mechanical Works of the Attabad Lake Hydropower Project (54MW), but in order to comply the requirements mentioned in the RFP/EPC Bidding Document of Package-III, particularly keeping in view that comprehensive EPC design has to be submitted with the Proposal which is itself time consuming, we need more time to submit a comprehensive, technically sound and financially competitive Proposal. | | The request for an eight (08) week extension in proposal submission by Proposer M/s Al Fajr International has been reviewed. The Employer considers this duration excessive. The matter of proposal submission deadline has already been discussed during the Pre-Proposal Meeting held on April 14, 2026 and will be addressed through Addendum No. 01 to the RFP/EPC Bidding Document of Package-III, which will be issued on EPADS v2.0 in due |



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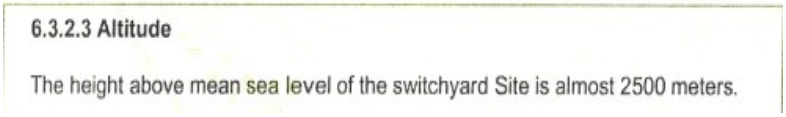
| Sr. No. | Reference Sub-Clause | Clarification Description requested from Proposers | Replies by AHMC |
|---|---|---|---|
| | In light of above, It is requested that the Proposal submission date may please be further extended at least for 8 (eight) weeks beyond May 14, 2026, enabling us to submit a responsive and precisely prepared Proposal | | course. Proposers are advised to comply with the provisions of the forthcoming addendum to the RFP/EPC Bidding Document of Package-III. |
| **Clarification No. 02 on June 03, 2026** | | | |
| **1.** | The Proposer refer to the bidding process for the Package-III: Electro-Mechanical Works of Attabad Lake Hydropower Project (54MW) and would like to express his appreciation for the opportunity to participate in this prestigious Package of the Project.<br><br>The Proposer respectfully request an extension in the Proposal submission deadline to allow prospective Proposers sufficient time to prepare a technically responsive Proposal. Given the complexity and significance of the Project, additional time is required for detailed review of the RFP/EPC Bidding Document, coordination with the Equipment Manufacturers and Suppliers, finalization of technical solutions, and preparation of a comprehensive Proposal that fully meets the critical Employer's requirements.<br>Furthermore, the Proposer note that the Employer has issued an Addendum No. 01 to RFP/EPC Bidding Document dated May 21, 2026 containing numerous Contractual and Technical amendments and revisions to the RFP/EPC Bidding Document. These changes require careful review and assessment by Proposers to ensure full compliance with the revised requirements. Additional time is therefore necessary to adequately incorporate the amendments into the technical and financial proposals and to obtain updated quotations, commitments, and supporting documentation from relevant stakeholders and Equipment Manufacturers. | Noted. It is hereby clarified that the extension in Proposal submission deadline has already been under consideration to facilitate Prospective Proposers. This request is being reviewed after due consideration of the prevailing circumstances, including the need for Proposers to coordinate with E&M Equipment Manufacturers and Suppliers, prepare technically responsive and commercially competitive Proposals. The extended Proposal submission date will be communicated through Addendum No. 02 to RFP/EPC Bidding Document which will be uploaded on EPADS v2.0 in due course of time. |
| **2.** | **Explanation Regarding the Replacement of Equipment in the Step-up Sub-Station with Higher Voltage Class Products by the Manufacture**<br><br>Technical Specification content:<br><br>Part-II, Technical Provisions, Volume-II, RFP/EPC Bidding Document<br><br>  <br>6.3.2.3 Altitude<br>The height above mean sea level of the switchyard Site is almost 2500 meters.<br><br>Part-II Technical Provisions, Volume-II, RFP/EPC Bidding Documents | Noted. It is clarified that 1300mm is the minimum clearance from live part to ground as per IEC standard whereas 1750 mm is the Project requirement. Pease follow the provisions of RFP/EPC Bidding Document without changing the voltage level. |



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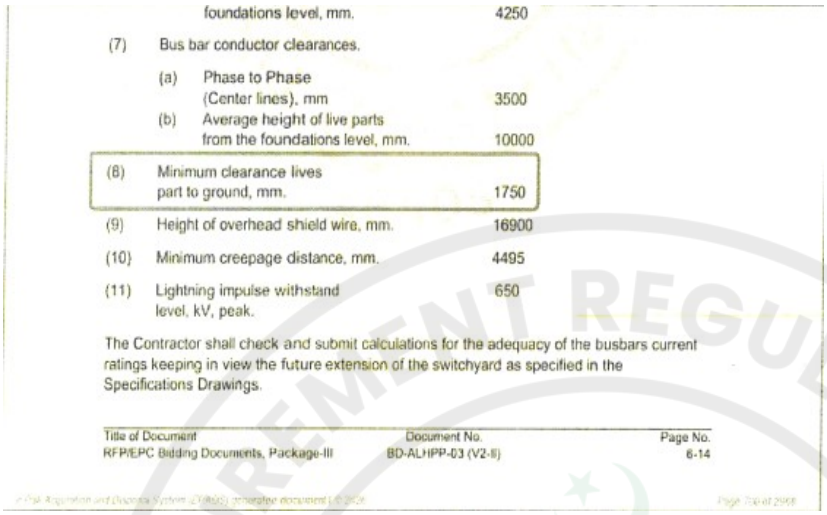
| Sr. No. | Reference Sub-Clause | Clarification Description requested from Proposers | Replies by AHMC |
|---|---|---|---|
| |  <br>foundations level, mm. 4250<br>(7) Bus bar conductor clearances.<br>(a) Phase to Phase (Center lines), mm 3500<br>(b) Average height of live parts from the foundations level, mm. 10000<br>(8) Minimum clearance lives part to ground, mm. 1750<br>(9) Height of overhead shield wire, mm. 16900<br>(10) Minimum creepage distance, mm. 4495<br>(11) Lightning impulse withstand level, kV, peak. 650<br>The Contractor shall check and submit calculations for the adequacy of the busbars current ratings keeping in view the future extension of the switchyard as specified in the Specifications Drawings.<br>Title of Document: RFP/EPC Bidding Documents, Package-III; Document No.: BD-ALHPP-03 (V2-II); Page No.: 6-14<br><br>From the RFP/EPC Bidding Technical Document, the Proposer have identified that the Project is actually located at a high altitude and has special clearance requirements (higher than those specified in IEC Standards). Therefore, Proposers have to quote Equipment rated for a higher voltage level.<br><br>The Proposer has selected a voltage level of 145 kV. Based on this requirement, the minimum clearance from live parts to ground would be only 1,300 mm, which does not meet the RFP/EPC Bidding Document requirement of 1,750 mm minimum clearance from live parts to ground. Therefore, the Proposer now intend to select 200 kV product. For this product, the minimum clearance from live parts to ground is 2,100 mm, which satisfies the RFP/EPC Bidding Document requirement.<br><br>Whether upgrading the voltage level of 200 kV complies with the RFP/EPC Bidding Document requirements remains to be confirmed. | | |
| **3.** | **Regarding the Addendum No. 01 to RFP/EPC Bidding Document issued for selecting SF6 Gas Type Circuit Breakers for the 11 kV Generator Outlet**<br>The Addendum No. 01 to RFP/EPC Bidding Document issued by the Employer requires that the 11 kV Generator outlet Circuit Breaker be of the SF6 Gas type. The specifications required in the drawings and the technical specification are 1600A–40kA. Based on Proposer inquiries, no Domestic or International Equipment Manufacturer produces an SF6 Gas Type Circuit Breaker that achieves this current rating and breaking capacity. The commonly available models are SF6-12/1250–31.5kA. For example, a Manufacturer has a 1600 A model, but its breaking capacity is only 31.5 kA, and these are all conventional SF6 Gas Type Circuit Breakers. | | Noted. The 11 kV Generator outlet Circuit Breaker shall be permitted to have SF6/VCB type. The current carrying capacities of 1600A-40kA shall be followed as specified under Technical Specifications, Volume-II, Part-II of the RFP/EPC Bidding Document. |



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| Sr. No. | Reference Sub-Clause | Clarification Description requested from Proposers | Replies by AHMC |
|---|---|---|---|
| | The Generator outlet Circuit Breakers have high requirements for DC component, rate of rise of transient recovery voltage (RRRV), and out-of-step breaking capacity. Therefore, it is recommended to select a vacuum type Generator Circuit Breaker specifically intended for Generator Outlet applications. | | |
| **4. Proposer M/s SINOTEC Pvt. Ltd. Clarifications** | | | |
| **Clarification No. 01 on April 19, 2026** | | | |
| 1. | This is with reference to the Invitation to Bid/ Proposal for the Attbad Lake Hydropower Project (54 MW). We have initially gone through the RFP/EPC Bidding Document and request the Employer for the following:<br>1. Sr. No. 4.2(a) of Section-III [Evaluation and Qualification Criteria] requires that "A maximum number of Contracts specified below that have been satisfactory completed as a Prime Contractor, Joint Venture Member, Management Contractor or Sub-Contractor between January 01, 2005 and Proposal Submission deadline. Either<br>One Contract of Hydropower Project of 45 MW or Higher and should be in successful Commercial Operation for one year<br>Or<br>Two (02) separate Contracts of Hydropower Project totaling 45 MW or higher and at least one should be in successful Commercial Operation for one year.<br>Keeping in view the true spirit of EPC Contract, we hereby request the Employer to modify the said Criteria as follows:<br>One Contract of Hydropower Project of 45 MW or higher and should be in in successful Commercial Operation for one year<br>Or<br>Three (03) separate Contracts of Hydropower Projects Totaling 45 MW or higher and with one of the Contracts must be at least 35 MW and at least one Contract should be in successful Commercial Operation for one year. | Noted. The suggestion in the modification in Sub-Clause 4.2(a) of Evaluation and Qualification Criteria under Section-III, Volume-I of the RFP/EPC Bidding Document is not acceptable, the provisions stipulated under original Sub-Clause 4.2(a) of Evaluation and Qualification Criteria, Section-III of Volume-I of the RFP/EPC Bidding Documents shall prevail. |
| 2. | Furthermore, due to Eid-ul-Azha Holidays in the week and other unforeseen circumstances, we are finding it challenging to meet the current Proposal submission deadline and in dire need of extension in Proposal Submission date. We believe that an extension will allow us to submit a more comprehensive Proposal that aligns with your requirements. Therefore, the Employer is requested to kindly extend the date for Proposal Submission for one month and oblige. | Noted. It is apprised that the Proposal submission date has already been formally notified on EPADS v2.0 as June 16, 2026, in accordance with the Employer's instructions. Any request for further extension will be discussed after the forthcoming Eid-ul-Azha holidays, and the said duration may be granted subject to request from other |



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| Sr. No. | Reference Sub-Clause | Clarification Description requested from Proposers | Replies by AHMC |
|---|---|---|---|
| | | | proposer and approval from the competent authority. |
| **5. Proposer M/s Shaheen & Sons. Clarifications** | | | |
| **Clarification No. 01 on June 08, 2026** | | | |
| **1.** | The Proposer intends to participate in the bidding process for the Package-III: Electro-Mechanical Works of Attabad Lake Hydropower Project (54 MW).<br><br>Due to the detailed and comprehensive nature of the bidding requirements, extensive coordination with Foreign E&M Equipment Manufacturers and Suppliers is required for the preparation of a responsive. and competitive Proposal. Furthermore, the ongoing General Election activities in Gilgit-Baltistan have also affected the timely completion of the necessary documentation and consultations.<br><br>In view of the above, the Proposer e respectfully request that the Proposal submission deadline may kindly be extended by four (04) weeks to enable prospective Proposers to complete all Technical and Commercial requirements and submit competitive Proposals. The Employer favorable consideration of this request will be highly appreciated. | | Noted. It is hereby clarified that the extension in Proposal submission deadline has already been under consideration to facilitate Prospective Proposers. This request is being reviewed after due consideration of the prevailing circumstances, including the need for Proposers to coordinate with E&M Equipment Manufacturers and Suppliers, prepare Technically responsive and Commercially competitive Proposals. The extended Proposal submission date will be communicated through Addendum No. 02 to RFP/EPC Bidding Document which will be uploaded on EPADS v2.0 in due course of time. |
| **5. Other Proposer Clarifications** | | | |
| **Clarification No. 01 on April 18, 2026** | | | |
| 1. | Volume-III Specific Provisions RFP/EPC Bidding Document, Package-III: Electro Mechanical Works **Metallic Coating (Sub-Section 2.1.17.3)** | **Corrosion Protection for Gate Leaves and Trash Rack Leaves** 。<br>Please confirm the Corrosion Protection scheme for Gate Leaves (including Trash Rack Leaves):<br>(1) Shall zinc metal spraying be adopted for Corrosion Protection?<br>(2) Shall the thickness of zinc spray be not less than 0.060 mm?<br>(3) Shall paint systems be applied over the zinc-sprayed surface?<br>(4) If yes, how many paint coats are required, and what is the specified dry film thickness (DFT) for each coat? | The painting schedule has now been provided in an upcoming Addendum No. 01 to the RFP/EPC Bidding Document will be uploaded on EPADS V2.0 in due course of time..<br>All bolts, studs, nuts, washers, screws, etc., above size M-10, shall, if not made of stainless steel or other corrosion-resistant material, be hot dip galvanized.<br>The Galvanized wire shall comply with the requirements of ASTM A641 standard. Nuts, bolts and small components shall be coated in accordance with ISO 1461 standard. |



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| Sr. No. | Reference Sub-Clause | Clarification Description requested from Proposers | Replies by AHMC |
|---|---|---|---|
| | | **Paint Coating Thickness Requirements**<br>Please clarify the required total dry film thickness and layer-by-layer DFT for paint coatings on the following items:<br>1 Gate Recesses (Trash Rack Recesses)<br>2 Mobile Gantry Crane and Trash Rack Cleaning Crane<br>3 Hydraulic Hoist Cylinders | |
| **Clarification No. 01 on April 18, 2026** | | | |
| **1.** | 2026-03-11, PKG III, Technical Provisions (With Remote Ends)<br>Page 1-32, Page 1-33<br>Sub-section 1.3.11 & Sub-section 1.3.12 | When the butterfly plate is connected to the valve shaft vide bolted connection, the valve shaft must be reinforced, leading to increased driving torque, more complex structure, and higher maintenance costs in future. Can the butterfly plate and valve shaft be connected vide pin connection? This method features a simpler structure and mature technology. | If the OEM/Vendor demonstrates proven design practices and validated operating experience in the use of pin connections between the butterfly plate and valve shaft, this option may be considered and finalized during the detailed design stage by EPC Contractor, subject to Employer's approval and compliance with the overall Project requirements. |
| **2.** | 2026-03-11, PKG III, Technical Provisions (With Remote End Line Bays)<br>Page1-31, Page 1-33<br>Sub-section 1.3.6 & Sub-section 1.3.13.1 | The discrepancies in the RFP/EPC Bidding Document.<br>It is recommended that the inlet valve be equipped with an independent hydraulic system. If the bypass needle valve is hydraulically actuated, the oil pressure shall also be supplied from the hydraulic system of the inlet valve. | The final arrangement shall be determined by the EPC Contractor during the detailed design stage, subject to approval by the Employer |
| **Clarification No. 05 on May 19, 2026** | | | |
| 1. | With due respect, it is submitted that your office advertised the bidding for Electrical and Mechanical (E&M) Works of the Attabad Lake Hydropower Project (54MW). We have noted that the Proposal submission date has been extended; however, no Addendum or Corrigendum to the RFP/EPC Bidding Document of Package-III, in this regard has been found on the EPADS v2.0 Application or any other available source. | | Noted., it is hereby clarified that Addendum No. 01 to the RFP/EPC Bidding Document for Package-III (E&M Works) of the Attabad Lake Hydropower Project (54 MW) will be issued/uploaded on the EPADS v2.0 Application soon. The Addendum No. 01 to the RFP/EPC Bidding |



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| Sr. No. | Reference Sub-Clause | Clarification Description requested from Proposers | Replies by AHMC |
|---|---|---|---|
| | In this connection, it is kindly requested to clarify the following points:<br>Whether Proposers are requested to obtain manually issues RFP/EPC Bidding Document from the office of the Project Director, ALHPP WAPDA or if the soft copy downloaded from EPADS v2.0 Application shall be considered sufficient for participation in the Bidding process.<br>Since no updated notice regarding the revised Addendum is currently available on the EPADS v2.0 Application, it is requested that the complete bidding procedure and updated schedule and all Addendum may kindly be communicated. | | Document for Package-III (Electro-Mechanical Works**)** will include the all necessary amendments made in Volume-I and Volume-II of the RFP/EPC Bidding Document**.**<br>Furthermore, Proposers are advised that the RFP/EPC Bidding Documents uploaded on EPADS v2.0 shall be downloaded directly from the application, and such downloaded copies will be considered sufficient and valid for participation in the bidding process. |
| **Clarification on July 17, 2026** | | | |
| 1 | It has been found that Sole proprietorship firms are not allowed to submit Proposal, requested to relax this restriction please. | | Noted. It is clarified that the provisions of Part-D, Experience, Eligibility and Qualification Criteria, Section-III, Volume-I, RFP/EPC Bidding Document shall prevail. |
| **Clarification on July 17, 2026** | | | |
| 1. | The Past Experience required by the Proposer can be met by a specialized Sub-Contractor for Qualification purpose? Please Clarify. | | Noted. The Provisions of Sub-Clause 4.1 to Sub-Clause 4.2(c) of Part-D, Experience, Eligibility and Qualification Criteria, Section-III, Volume-I, RFP/EPC Bidding Document shall prevail. |



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# Past Experience / Contracts

| Contracts over *[insert amount]* during the last three years: | | | | |
|---|---|---|---|---|
| Procuring Agency | Value | Year | Goods/Services Supplied | Country of Destination |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

# Historical Contract Non-Performance, and Pending Litigation and Litigation History

*[The following table shall be filled in for the Applicant and for each member of a Joint Venture]*

Applicant's Name: *[insert full name]*
Date: *[insert day, month, year]*
Joint Venture Member Name: *[insert full name]*
IFP No. and title: *[insert IFP number and title]*
Page *[insert page number]* of *[insert total number]* pages

| | | | |
|---|---|---|---|
| ☐ Not debarred due to deviation from commitment of Bid Securing Declaration-☐ Not debarred due to non-performance | | | |
| **Year** | **Non-performed portion of contract** | **Contract Identification** | **Total Contract Amount (current value, currency, exchange rate and PKR equivalent)** |
| *[insert year]* | *[insert amount and percentage]* | Contract Identification: *[indicate complete contract name/ number, and any other identification]*<br>Name of Procuring Agency: *[insert full name]*<br>Address of Procuring Agency: *[insert street/city/country]*<br>Reason(s) for nonperformance: *[indicate main reason(s)]* | *[insert amount]* |
| Pending Litigation, in accordance with Section III, Qualification Criteria and Requirements | | | |
| ☐ Pending litigation in accordance with Section III, Qualification Criteria and Requirements, Sub-Factor 2.3 as indicated below. | | | |

| **Year of dispute** | **Amount in dispute (currency)** | **Contract Identification** | **Total Contract Amount (currency), ~~US$~~ PKR Equivalent (exchange rate)** |
|---|---|---|---|

| | | | |
|---|---|---|---|
| *[insert year]* | *[insert amount]* | Contract Identification: [indicate complete contract name, number, and any other identification]<br>Name of Procuring Agency: *[insert full name]*<br>Address of Procuring Agency: *[insert street/city/country]*<br>Matter in dispute: *[indicate main issues in dispute]*<br>Party who initiated the dispute: *[indicate "Procuring Agency" or "Supplier"]*<br>Status of dispute: *[Indicate if it is being treated by the Adjudicator, under Arbitration or being dealt with by the Judiciary]* | *[insert amount]* |

☐ No consistent history of court/arbitral award decisions in accordance with Section III, Qualification Criteria and Requirements, Sub-Factor 2.4.

☐ Consistent history of court/arbitral award decisions in accordance with Section III, Qualification Criteria and Requirements, Sub-Factor 2.4 as indicated below.

| **Year of award** | **Outcome as percentage of Net Worth** | **Contract Identification** | **Total Contract Amount (currency), PKR Equivalent (exchange rate)** |
|---|---|---|---|
| *[insert year]* | *[insert percentage]* | Contract Identification: [indicate complete contract name, number, and any other identification]<br>Name of Procuring Agency: *[insert full name]*<br>Address of Procuring Agency: *[insert street/city/country]*<br>Matter in dispute: *[indicate main issues in dispute]*<br>Party who initiated the dispute: *[indicate "Procuring Agency" or "Supplier"]*<br>Court/ arbitral award decision: *[Indicate if the award decision was against the Applicant or any member of a joint venture.]y]* | *[insert amount]* |

# Current Contract Commitments / Works in Progress

Bidders and each member to a JV should provide information on their current commitments on all contracts that have been awarded, or for which a letter of intent or acceptance has been received, or for contracts approaching completion, but for which an unqualified, full completion certificate has yet to be issued.

| Current Contract Commitments | | | | | |
|---|---|---|---|---|---|
| No. | Name of Contract | **Employer's Contact Address, Tel, Fax** | **Value of Outstanding Work [Current Eq. PKR]** | **Estimated Completion Date** | **Average Monthly Invoicing Over Last Six Months [Eq. PKR/month)]** |
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| | | | | | |

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

# Financial Situation and Performance

*[The following table shall be filled in for the Applicant and for each member of a Joint Venture]*

Applicant's Name: *[insert full name]*
Date: *[insert day, month, year]*
Joint Venture Member Name: *[insert full name]*
IFP No. and title: *[insert IFP number and title]*
Page *[insert page number]* of *[insert total number]* pages

**1. Financial data**

| **Type of Financial information in (currency)** | **Historic information for previous _[insert number] years, [insert in words] (amount in currency, currency, exchange rate*, PKR equivalent)** | | | | |
|---|---|---|---|---|---|
| | Year 1 | Year 2 | Year 3 | | |
| Statement of Financial Position (Information from Balance Sheet) | | | | | |
| Total Assets (TA) | | | | | |
| Total Liabilities (TL) | | | | | |
| Total Equity/Net Worth (NW) | | | | | |
| Current Assets (CA) | | | | | |
| Current Liabilities (CL) | | | | | |
| Working Capital (WC) | | | | | |
| Information from Income Statement | | | | | |
| Total Revenue (TR) | | | | | |
| Profits Before Taxes (PBT) | | | | | |
| Cash Flow Information | | | | | |
| Cash Flow from Operating Activities | | | | | |

* Refer ITA 14 for the exchange rate

**3. Financial documents**

The Applicant and in case of JV, members of JV shall provide copies of financial statements for *[number]* years pursuant Section III, Qualifications Criteria and Requirements. The financial statements shall:

(a) reflect the financial situation of the Applicant or in case of JV member, and not an affiliated entity (such as parent company or group member).

(b) be independently audited or certified in accordance with local legislation.

(c) be complete, including all notes to the financial statements.

(d) correspond to accounting periods already completed and audited.

☐ Attached are copies of financial statements[1] for the *[number]* years required above; and complying with the requirements.

[1] If the most recent set of financial statements is for a period earlier than 12 months from the date of Application, the reason for this should be justified.

# Average Annual Turnover (Annual Sales Value)

*[The following table shall be filled in for the Applicant and for each member of a Joint Venture]*

Applicant's Name: *[insert full name]*
Date: *[insert day, month, year]*
Joint Venture Member Name: *[insert full name]*
IFP No. and title: *[insert IFP number and title]*
Page *[insert page number]* of *[insert total number]* pages

| **Annual Turnover Data** | | | |
|---|---|---|---|
| **Year** | **Amount**<br>**Currency** | **Exchange rate***<br>**(If applicable)** | **PKR equivalent** |
| *[indicate calendar year]* | *[insert amount and indicate currency]* | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | Average Annual Turnover ** | |

* Refer ITA for date and source of exchange rate.

** Total PKR equivalent for all years divided by the total number of years. See Section III, Qualification Criteria and Requirements, ITA.

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

# CONSTRUCTION EXPERIENCE

## Form EXP - 4.1
## General Construction Experience

Bidder's Name: _____
Date: _____
JV Member's Name_____
Bid Reference No. (if any) and title: _____
Page _____of _____pages

| Starting Year | Ending Year | Contract Identification | Role of Bidder |
|---|---|---|---|
| | | Contract name: _____<br>Brief Description of the Works performed by the Bidder: _____<br>Amount of contract: _____<br>Name of EMPLOYER: _____<br>Address: _____ | |
| | | Contract name: _____<br>Brief Description of the Works performed by the Bidder: _____<br>Amount of contract: _____<br>Name of EMPLOYER: _____<br>Address: _____ | |
| | | Contract name: _____<br>Brief Description of the Works performed by the Bidder: _____<br>Amount of contract: _____<br>Name of EMPLOYER: _____<br>Address: _____ | |

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

Form EXP - 4.2(a)

# Specific Construction and Contract Management Experience

Bidder's Name: _____
Date: _____
JV Member's Name_____
Bid Reference No. (if any) and title: _____
Page _____of _____pages

| **Similar Contract No.** | **Information** | | | |
|---|---|---|---|---|
| Contract Identification | | | | |
| Award date | | | | |
| Completion date | | | | |
| Role in Contract | Prime Contractor ☐ | Member in JV ☐ | Management Contractor ☐ | Sub-contractor ☐ |
| Total Contract Amount | | | PKR equivalent | |
| If member in a JV or sub-contractor, specify participation in total Contract amount | | | | |
| EMPLOYER's Name: | | | | |
| Address:<br><br>Telephone/fax number<br><br>E-mail: | | | | |

## Form EXP - 4.2(a) (cont.)
## Specific Construction and Contract Management Experience (cont.)

| **Similar Contract No.** | **Information** |
|---|---|
| Description of the similarity in accordance with Sub-Factor 4.2(a) of Section III: | |
| 1. Amount | |
| 2. Physical size of required works items | |
| 3. Complexity | |
| 4. Methods/Technology | |
| 5. Construction rate for key activities | |
| 6. Other Characteristics | |

PUBLIC PROCUREMENT REGULATORY AUTHORITY (PPRA) EPADS

# Form EXP - 4.2(b)
# Construction Experience in Key Activities

Bidder's Name: _____
Date: _____
Bidder's JV Member Name: _____
Sub-contractor's Name (if any): _____
Bid Reference No. (if any) and title: _____

Page _____of _____pages

All Sub-contractors for key activities must complete the information and Qualification Criteria and Requirements, Sub-Factor 4.2.

1. Key Activity No One: _____

| | **Information** | | | |
|---|---|---|---|---|
| Contract Identification | | | | |
| Award date | | | | |
| Completion date | | | | |
| Role in Contract | Prime Contractor ☐ | Member in JV ☐ | Management Contractor ☐ | Sub-contractor ☐ |
| Total Contract Amount | | | PKR equivalent | |
| Quantity (Volume, number or rate of production, as applicable) performed under the contract per year or part of the year | Total quantity in the contract (i) | Percentage participation (ii) | | Actual Quantity Performed (i) x (ii) |
| Year 1 | | | | |
| Year 2 | | | | |
| Year 3 | | | | |
| Year 4 | | | | |
| EMPLOYER's Name: | | | | |
| Address:<br><br>Telephone/fax number | | | | |

| | Information |
|---|---|
| E-mail: | |

2. Activity No. Two

3. ……

| | Information |
|---|---|
| Description of the key activities in accordance with Section III: | |
| | |
| | |
| | |
| | |
| | |

Form EXP - 4.2 (c)
# Specific Experience in Managing ES aspects

*[The following table shall be filled in for contracts performed by the Bidder, and each member of a Joint Venture]*

Bidder's Name: *[insert full name]*
Date: *[insert day, month, year]*
Joint Venture Member Name: *[insertfull name]*
Bid Reference No. (if any) and title: *[insert ICB/NCB number and title]*
Page *[insert page number]* of *[insert total number]* pages

1. Key Requirement no 1 in accordance with 4.2 (c): _____

| | | | | |
|---|---|---|---|---|
| Contract Identification | | | | |
| Award date | | | | |
| Completion date | | | | |
| Role in Contract | Prime Contractor ☐ | Member in JV ☐ | Management Contractor ☐ | Subcontractor ☐ |
| Total Contract Amount | | | PKR | |
| Details of relevant experience | | | | |

**2.** Key Requirement no 2 in accordance with 4.2 (c): _____

**3.** Key Requirement no 3 in accordance with 4.2 (c): _____

**4.** [PA define key requirements]

# Contractor's Representative and Key Personnel Schedule

Bidders should provide the names and details of the suitably qualified Contractor's Representative and Key Personnel to perform the Contract. The data on their experience should be supplied using the Form PER-2 below for each candidate.

**Contractor' Representative and Key Personnel**

| | | |
|---|---|---|
| **1.** | **Title of position:** | |
| | **Name of candidate:** | |
| | **Duration of appointment:** | [*insert the whole period (start and end dates) for which this position will be engaged*] |
| | **Time commitment: for this position:** | [*insert the number of days/week/months/ that has been scheduled for this position*] |
| | **Expected time schedule for this position:** | [*insert the expected time schedule for this position (e.g. attach high level Gantt chart*] |
| **2.** | **Title of position:** | |
| | **Name of candidate:** | |
| | **Duration of appointment:** | [*insert the whole period (start and end dates) for which this position will be engaged*] |
| | **Time commitment: for this position:** | [*insert the number of days/week/months/ that has been scheduled for this position*] |
| | **Expected time schedule for this position:** | [*insert the expected time schedule for this position (e.g. attach high level Gantt chart*] |
| **3.** | **Title of position:** | |
| | **Name of candidate:** | |
| | **Duration of appointment:** | [*insert the whole period (start and end dates) for which this position will be engaged*] |
| | **Time commitment: for this position:** | [*insert the number of days/week/months/ that has been scheduled for this position*] |
| | **Expected time schedule for this position:** | [*insert the expected time schedule for this position (e.g. attach high level Gantt chart*] |
| **4.** | **Title of position:** | |
| | **Name of candidate:** | |
| | **Duration of appointment:** | [*insert the whole period (start and end dates) for which this position will be engaged*] |

| | | |
|---|---|---|
| | **Time commitment: for this position:** | [*insert the number of days/week/months/ that has been scheduled for this position*] |
| | **Expected time schedule for this position:** | [*insert the expected time schedule for this position (e.g. attach high level Gantt chart*] |
| **5.** | **Title of position:** | |
| | **Name of candidate** | |
| | **Duration of appointment:** | [*insert the whole period (start and end dates) for which this position will be engaged*] |
| | **Time commitment: for this position:** | [*insert the number of days/week/months/ that has been scheduled for this position*] |
| | **Expected time schedule for this position:** | [*insert the expected time schedule for this position (e.g. attach high level Gantt chart*] |
| **6.** | **Title of position:** *[insert title]* | |
| | **Name of candidate** | |
| | **Duration of appointment:** | [*insert the whole period (start and end dates) for which this position will be engaged*] |
| | **Time commitment: for this position:** | [*insert the number of days/week/months/ that has been scheduled for this position*] |
| | **Expected time schedule for this position:** | [*insert the expected time schedule for this position (e.g. attach high level Gantt chart*] |

## Form PER-2:
## Resume and Declaration
## Contractor's Representative and Key Personnel

| **Name of Bidder** |
|---|
| |

| **Position [*#1*]: [*title of position from Form PER-1*]** | | |
|---|---|---|
| **Personnel information** | **Name:** | **Date of birth:** |
| | **Address:** | **E-mail:** |
| | | |
| | **Professional qualifications:** | |
| | **Academic qualifications:** | |
| | **Language proficiency:***[language and levels of speaking, reading and writing skills]* | |
| **details** | | |
| | **Address of Employer:** | |
| | **Telephone:** | **Contact (manager / personnel officer):** |
| | **Fax:** | |
| | **Job title:** | **Years with present Employer:** |

Summarize professional experience in reverse chronological order. Indicate particular technical and managerial experience relevant to the project.

| **Project** | **Role** | **Duration of involvement** | **Relevant experience** |
|---|---|---|---|
| *[main project details]* | *[role and responsibilities on the project]* | *[time in role]* | *[describe the experience relevant to this position]* |
| | | | |
| | | | |
| | | | |

**Declaration**

I, the undersigned *[ insert either "Contractor's Representative" or "Key Personnel" as applicable]* , certify that to the best of my knowledge and belief, the information contained in this Form PER-2 correctly describes myself, my qualifications and my experience.

I confirm that I am available as certified in the following table and throughout the expected time schedule for this position as provided in the Bid:

| **Commitment** | **Details** |
|---|---|
| **Commitment to duration of contract:** | *[insert period (start and end dates) for which this Contractor's Representative orKey Personnel is available to work on this contract]* |
| **Time commitment:** | *[insert period (start and end dates) for which this Contractor's Representative orKey Personnel is available to work on this contract]* |

I understand that any misrepresentation or omission in this Form may:

(a) be taken into consideration during Bid evaluation;

(b) result in my disqualification from participating in the Bid;

(c) result in my dismissal from the contract.

**Name of** Contractor's Representative or **Key Personnel: [*insert name*]**

Signature: _____

Date: (day month year): _____

**Countersignature of authorized representative of the Bidder:**

Signature: _____

Date: (day/month/year): _____

# Financial Resources

Specify proposed sources of financing, such as liquid assets, unencumbered real assets, lines of credit, and other financial means, net of current commitments, available to meet the total construction cash flow demands of the subject contract or contracts as specified in Eligibility and Qualification Criteria.

| | | |
|---|---|---|
| **No.** | **Source of financing** | **Amount (Eq. PKR)** |
| 1 | | |
| 2 | | |
| 3 | | |
| | | |

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